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Tourism comfort and sustainable urban development in 38 Chinese tourist cities: coupling coordination, spatial spillovers, and key drivers

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Abstract

Tourism-oriented urban development increasingly depends on the coordinated advancement of tourism comfort and sustainable urban development. From a host–guest sharing perspective, this study examines the spatiotemporal coupling, spatial spillovers, and driving mechanisms between these two systems in 38 popular tourist cities in China from 2000 to 2023. A comprehensive evaluation framework is constructed, and the coupling coordination model, kernel density estimation, Global Moran’s I, and the Spatial Durbin Model are applied. The results show that both systems improved markedly, while their coupling coordination shifted steadily from mild dysfunction toward barely coordinated development. Spatially, eastern and coastal cities generally outperformed western and inland cities. Significant positive spatial autocorrelation and spillovers were identified, indicating clustering and intercity interaction. Transport accessibility was the strongest positive driver, with indirect effects exceeding direct effects, underscoring the regional importance of connectivity. Industrial upgrading and healthcare provision also exerted robust positive effects. In contrast, excessive economic dependence on tourism produced negative local and spillover effects, revealing a tourism dependence paradox. The findings suggest that sustainable tourist-city development depends not simply on visitor growth, but on connectivity, economic diversification, and shared urban services, thereby linking tourism development to broader processes of urban governance and regional sustainability.

Keywords tourism comfort; sustainable urban development; host–guest sharing; coupling coordination; popular tourist cities; China

Introduction

In popular tourist cities, residents and visitors increasingly share the same transport systems, public spaces, cultural facilities, commercial services and ecological environments (Ashworth and Page 2011). This host–guest sharing can enhance urban vitality and destination attractiveness, but it may also intensify congestion, environmental pressure and competition for public resources (Andereck et al. 2005; Russo 2002). The sustainable development of tourist cities therefore depends not only on attracting more

visitors, but also on whether cities can provide high-quality comfort conditions that support tourism activities without undermining residents' everyday wellbeing.

The rise of the consumer city has shifted urban competition from production-oriented capacity towards broader attractiveness based on consumption, culture, convenience and quality of life (Glaeser and Gottlieb 2006; Theurillat 2022). For tourist cities, this means that visitors no longer evaluate destinations only through scenic attractions. Instead, their experiences are shaped by the city as a whole, including transport accessibility, public service quality, environmental livability, cultural atmosphere and perceived safety.

Tourism activities rely on the integrated support of urban infrastructure, public services, spatial environments and governance capacity. However, existing studies have often treated the city mainly as a spatial container for tourism activities, paying insufficient attention to how urban development quality shapes tourism conditions and how tourism is embedded in broader urban processes (Ashworth and Page 2011). Against this background, tourism comfort provides a useful concept for linking urban development with tourism experience. In this study, tourism comfort refers to the objective, city-level conditions that support comfortable, convenient and safe tourism activities. It is evaluated through observable macro-level indicators related to climatic suitability, tourism resources, service facilities, transport accessibility, public services and social atmosphere, rather than tourists' perceptions. In this sense, tourism comfort represents the supply-side capacity of a city to create a comfort-rich environment for visitors. This supply-side understanding links tourism comfort with sustainable urban development, as tourism environments depend not only on tourism resources, but also on infrastructure, public services, ecological conditions and governance capacity.

Sustainable urban development provides the fundamental support for the formation of tourism comfort. In this study, sustainable urban development does not refer only to the quality of economic growth. Rather, it denotes the comprehensive improvement of a city in terms of economic efficiency, innovation capacity, social wellbeing, ecological environment, openness and cooperation, and governance capability. This understanding is closely related to international debates on inclusive development and quality-oriented urban transformation (Tan et al. 2014; T. Liu and Zhou 2023; Ma et al. 2024).

However, tourism comfort and sustainable urban development do not necessarily improve in tandem. If the outcomes of urban development cannot be translated into service quality and spatial experiences that are perceptible to visitors, tourism comfort may lag behind the overall level of urban development. Conversely, if the provision of tourism amenities is excessively oriented towards visitors while neglecting residents' everyday needs, it may lead to imbalanced public resource allocation, the commodification of living spaces and increasing pressure on urban governance. This tension is particularly evident in popular tourist cities, where visitor flows are highly concentrated and residents' living spaces substantially overlap with tourist consumption spaces. In such contexts, tourism development may enhance urban vitality and service quality, but it may also generate overtourism, environmental pressure and tensions in host–guest relations. It is therefore necessary to examine, from

the perspective of host–guest sharing, whether tourism comfort and sustainable urban development have formed a coordinated relationship, and to identify the key factors that constrain their synergistic improvement.

Existing research provides important insights into tourism comfort, destination competitiveness and sustainable urban development. However, three gaps remain. First, studies on urban development quality have mainly focused on economic performance, ecological efficiency, innovation and public services, while paying insufficient attention to how these development outcomes are transformed into city-level comfort conditions that support tourism activities, such as transport accessibility, service provision, ecological quality and social governance (Shen et al. 2011; Wearing and Foley 2017). Second, research on tourism comfort has largely adopted a demand-side perspective, with limited consideration of the urban supply system that supports visitor experience (Gottlieb 1994; Gu and Zhao 2025; S. Wang and Park 2026). Third, although host–guest sharing and overtourism have attracted growing attention, few studies have examined the long-term spatiotemporal coupling between tourism comfort and sustainable urban development across comparable tourist cities. China’s popular tourist cities provide a particularly relevant context for addressing these gaps. They are not only destinations with highly concentrated visitor flows, but also regional central cities where population, industries, public services and governance resources are concentrated. Whether tourism comfort and sustainable urban development are coordinated, how their relationship evolves over time and space, and which factors constrain their coordination are directly related to the enhancement of urban tourism attractiveness, the improvement of residents’ quality of life and the pursuit of sustainable urban development.

Building on this discussion, this study adopts a coupling perspective to develop an analytical framework for the tourism comfort–sustainable urban development composite system. Focusing on 38 popular tourist cities in China, this study examines the spatiotemporal evolution, coupling coordination and key constraints of the coordinated development of the composite system. This study addresses three research questions:

- (1) How have tourism comfort and sustainable urban development evolved across China’s popular tourist cities from 2000 to 2023?
- (2) How has their coupling coordination evolved over time and space, and does it exhibit spatial dependence?
- (3) What are the key local drivers, spatial spillover effects, and interaction mechanisms shaping coupling coordination?

The findings provide empirical evidence and policy implications for improving host–guest sharing, optimising urban public service provision, enhancing urban tourism attractiveness and promoting sustainable urban development.

Coupling mechanisms and measurement indicators of tourism comfort and sustainable urban development

Coupling mechanisms between the tourism comfort system and the sustainable urban development system

In popular tourist cities, tourism comfort and sustainable urban development are closely interrelated rather than independent systems. Tourism comfort represents the integrated provision of urban natural conditions, tourism resources, public services and social atmosphere relevant to tourism activities. Sustainable urban development provides the fundamental supply conditions for tourism comfort through economic efficiency, innovation capacity, green transformation, shared services, openness and connectivity, and governance capability. Their coupling relationship can therefore be examined through three dimensions: element-level embeddedness, structural synergy and functional feedback (Figure 1).

Element-level embeddedness refers to the matching of tourism-related demand with the supply capacity generated through sustainable urban development (Andergassen et al. 2013; Chekalina et al. 2018; Beritelli et al. 2020). Green development and ecological governance improve environmental quality and climatic comfort, while innovation, fiscal investment, and human capital enhance cultural facilities and tourism resources (Florida 2003; Gössling et al. 2012; Richards 2020; Scott et al. 2016). Transport, accommodation, catering, public facilities, and social governance serve both visitors and residents, so improvements in accessibility, inclusiveness, safety, and openness can simultaneously strengthen tourism comfort and urban wellbeing (Koens et al. 2021; Romão and Bi 2021). Tourism demand may also encourage cities to improve environmental governance, public services, and cultural provision, creating a reciprocal relationship between demand and supply.

Structural synergy arises when the components of the two systems become aligned in their development objectives, resource allocation, and functional configuration. As tourism consumption shifts from sightseeing towards service-, leisure-, and experience-oriented activities, tourism comfort increasingly depends on the combined provision of environmental quality, cultural resources, public services, and social atmosphere (Benur and Bramwell 2015; de Freitas 2003; Konecnik and Gartner 2007). Urban development has similarly moved beyond economic growth towards a model shaped by green transformation, innovation, shared services, and openness. Changing tourism demand encourages cities to improve governance, facilities, and industrial structures, while stronger urban systems reduce tourism's dependence on natural resources and support more diversified comfort provision (Andergassen et al. 2013; Järvi et al. 2020; Sorokina et al. 2022).

Functional feedback represents the broader outcome of element-level and structural interactions. Improved tourism comfort strengthens destination attractiveness, consumption, service-sector development, cultural exchange, and factor mobility, thereby contributing to urban development. In return, sustainable urban development provides a long-term foundation for tourism comfort through better ecological conditions, infrastructure, public services, innovation capacity, and governance (J. Liu et al. 2017; Sorokina et al. 2022). This two-way process forms a reinforcing cycle in which urban development enhances tourism comfort, while tourism-related demand and activity generate further incentives for service upgrading and urban governance.

Together, these mechanisms show that tourism comfort and sustainable urban development are mutually embedded, structurally aligned, and dynamically reinforcing. Their coupling coordination helps tourist cities move beyond resource exploitation and visitor-volume growth towards a development model centred on comprehensive comfort, shared public services, and stronger urban governance.

Figure 1. Interactive coupling between the urban tourism comfort system and the sustainable urban development system

Measurement indicators of tourism comfort and sustainable urban development

Measurement indicator system for tourism comfort

The concept of comfort was initially closely associated with population mobility, environmental perception and urban attractiveness. Ullman (1954) argued that comfortable living conditions could become an important factor attracting population movement, defining comfort as a pleasant condition of life that encourages mobility (Ullman 1954). Nicol and Humphreys (1973) further suggested that human comfort in relation to the environment is a dynamic process of adaptation rather than a simple stimulus–response relationship (Nicol J.F and Humphreys M.A. 1973). Clark et al. (2004) expanded the notion of comfort to include cultural scenes, social atmosphere and consumption experiences, making it an important concept for understanding the logic of urban development in post-industrial society (Clark T N 2004). In urban studies, Lynch (1960) also highlighted the socio-psychological dimensions of urban experience, including safety, convenience, legibility and aesthetic perception (Kevin Lynch 1960). These studies suggest that comfort involves not only objective environmental conditions, but also subjective perception, spatial experience and socio-cultural meaning. Introducing this concept into tourist city research helps move beyond the limitations of conventional tourism resource evaluation and provides a perspective for understanding the relationship between tourism attractiveness and urban development quality through visitor-city interactions (Bramwell 1998; Buch et al. 2014).

Based on the relevant literature, this study constructs an urban tourism comfort indicator system comprising climatic suitability, tourism resource richness, tourism service provision, and social atmosphere (Clark T N 2004; Tian et al. 2022). These dimensions capture the main city-level conditions shaping tourism activities: climatic suitability reflects physical and environmental comfort; tourism resource richness represents destination attractiveness and cultural supply; and tourism service provision measures the capacity of urban facilities and services to support visitor mobility and consumption. Social atmosphere is included because tourism comfort also depends on the broader social environment in which visitors interact with the city. As this dimension is difficult to observe directly, it is operationalised through objective indicators of safety, civility, vitality, and friendliness. In particular, official happy-city designation is treated as a proxy for the institutional and social conditions associated with a welcoming urban environment. The specific indicators, measurement units, directions, and weights are reported in Table 1.

Measurement indicator system for sustainable urban development

Although sustainable urban development has no universally accepted definition (Y. Chen et al. 2020; T. Liu and Zhou 2023), this study adopts China's High-Quality Development framework, which emphasises green, open, coordinated, shared, and innovation-driven development (M. Wang et al. 2023). These five dimensions capture the environmental, external-connectivity, socioeconomic, public-service, and knowledge-based foundations of urban sustainability. Green development reflects ecological quality and resource efficiency; open development represents a city's integration into wider economic, information, and mobility networks; coordinated development captures the balance among economic growth, urbanisation, and household welfare; shared development evaluates the inclusiveness and accessibility of public services; and innovation-driven development reflects knowledge production, human capital, and technological capacity. Some indicators, particularly inbound tourist arrivals and Internet use, are included under open development because they reflect not only tourism activity or digital infrastructure, but also a city's external connectivity and capacity for cross-regional exchange. The specific indicators, measurement units, directions, and weights are presented in Table 1.

Indicator weights

Considering the spatial and temporal limitations of a single weighting method when applied to long time-series data, this study introduces the Game Theory Combination Model to determine indicator weights. In this model, subjective weighting based on the analytic hierarchy process (AHP) and objective weighting based on the entropy weight method are treated as two players in a game. By minimising the deviation between the two weight vectors, the model identifies an optimal set of consistent weights through Nash equilibrium, as shown in Equations (1)–(4).

This approach is used to calculate the weights of the tourism comfort system and the sustainable urban development system at both the criterion and factor levels, as reported in Table 1. The combined weighting method avoids the excessive dependence of the entropy weight method on data variation, while also using AHP to ensure the logical consistency of the evaluation framework over a long time period. It therefore achieves an effective balance between expert judgement and data characteristics, as well as between subjective cognition and objective information.

$$W = \sum_{k=1}^L \alpha_k w_k^T (\alpha_k > 0) \quad (1)$$

$$\begin{pmatrix} w_1 \cdot w_1^T & w_1 \cdot w_2^T \\ w_2 \cdot w_1^T & w_2 \cdot w_2^T \end{pmatrix} (\alpha_1 \alpha_2) = (w_1 \cdot w_1^T w_2 \cdot w_2^T) \quad (2)$$

$$\alpha_k^* = \frac{|\alpha_k|}{\sum_{k=1}^L |\alpha_k|} \quad (3)$$

$$W^* = \sum_{k=1}^L \alpha_k^* w_k^T \quad (4)$$

Where W^* denotes the integrated subjective-objective weight vector derived from the game theoretic combination model; α_k is the linear combination coefficient, w_k^T represents the transpose of the weight vector, w_1 denotes the weight vector calculated using the analytic hierarchy process, while w_2 denotes the weight vector calculated using the entropy weight method. The term $w_1 \cdot w_1^T$ represents the inner product of the vector.

Table 1. Indicator system for urban tourism comfort and sustainable urban development

	Standardized Layer	Factor Layer	Code	Direction	AHP weight	Entropy weight	Combined weight
Urban tourism comfort system (U1)	Climate suitability A (0.097)	Temperature-humidity index	A1	Interval	0.065	0.010	0.045
		Wind-effect index	A2	Interval	0.011	0.012	0.012
		Clothing index	A3	Interval	0.013	0.006	0.010
		Share of days with air quality at Grade II or above	A4	Positive	0.045	0.007	0.031
	Tourism resource richness B (0.427)	A-rated scenic areas per 100 km ²	B1	Positive	0.312	0.087	0.228
		Museums per 100 km ²	B2	Positive	0.111	0.105	0.109
		Performing arts groups per 10,000 residents	B3	Positive	0.059	0.145	0.091
		Star-rated hotels per 10,000 residents	C1	Positive	0.132	0.050	0.102
	Tourism service provision C (0.310)	Share of accommodation and catering employees in the resident population	C2	Positive	0.038	0.081	0.054
		Travel agencies per 10,000 residents	C3	Positive	0.014	0.122	0.054
		Number of high-speed rail stations	C4	Positive	0.075	0.144	0.101
		Criminal cases per 10,000 residents	D1	Negative	0.053	0.001	0.034
	Social atmosphere D (0.165)	Public toilets per 10,000 residents	D2	Positive	0.029	0.044	0.034
		Share of culture, sports, and entertainment employees in the resident population	D3	Positive	0.029	0.053	0.038
		Happy-city designation	D4	Positive	0.015	0.132	0.059
		Urban sewage treatment rate	E1	Positive	0.010	0.009	0.009
Sustainable urban development system (U2)	Green E (0.058)	Urban park green space per capita (m ² /person)	E2	Positive	0.056	0.014	0.031
		Annual mean PM2.5 concentration	E3	Negative	0.030	0.009	0.018
	Openness F (0.308)	Air passenger trips per 10,000 residents	F1	Positive	0.011	0.097	0.061

Coordinated G (0.231)	Internet subscriber accounts per 10,000 residents	F2	Positive	0.007	0.042	0.028
	Inbound tourist arrivals per km ²	F3	Positive	0.042	0.343	0.219
	GDP per capita (CNY)	G1	Positive	0.178	0.047	0.101
	Urbanization rate of permanent residents	G2	Positive	0.059	0.010	0.031
	Per capita consumption expenditure of urban residents (CNY)	G3	Positive	0.178	0.044	0.099
	Unemployment insurance participants per 10,000 residents	H1	Positive	0.023	0.030	0.027
	Hospitals and health centers per 10,000 residents	H2	Positive	0.051	0.122	0.093
	Theaters and cinemas per 10,000 residents	H3	Positive	0.111	0.079	0.092
	Public libraries per 10,000 residents	H4	Positive	0.064	0.030	0.044
	Higher education institutions per 10,000 residents	I1	Positive	0.054	0.024	0.036
	Share of science and technology expenditure in public budget	I2	Positive	0.030	0.072	0.055
	Human capital level	I3	Positive	0.098	0.027	0.056

Materials and Methods

Study area

This study selects 38 popular tourist cities in China as the research sample. The selection refers to several influential tourism rankings and reports, including the list of “must-visit cities among China’s top tourist destinations in 2023” released by World Travel Market London, the Top 20 Value Recommendation List of National Cultural Tourism Internet-famous Check-in Places released by the People’s Cultural Tourism Research Institute of People’s Daily, the 2023 National Tourist Satisfaction Survey Report issued by the China Tourism Academy, and the 2023 Tourism Big Data Report published by Mafengwo. Data continuity, consistency in statistical standards and cross-city comparability were also considered. The sample covers China’s eastern, central and western regions and includes both provincial capitals or municipalities, such as Beijing, Tianjin, Shanghai and Guangzhou, and non-capital tourist cities with high tourism visibility, such as Qingdao, Xiamen, Ningbo and Weihai. Provincial capitals and municipalities are major carriers of regional tourist flows, population flows and capital flows, and generally have stronger agglomeration capacity and public service provision. Non-capital popular tourist

cities, by contrast, are important nodes in China's destination system. The selected cities therefore reflect the regional differences and gradient characteristics of tourist city development in China, and provide a suitable basis for examining the coupling coordination between tourism comfort and sustainable urban development across different locations and city types (Figure 2).

Figure 2. Study area and spatial distribution of the 38 popular tourist cities in China (Review No. GS(2023)2767)

Data sources

The data used to measure tourism comfort and sustainable urban development were mainly obtained from the China Statistical Yearbook, China City Statistical Yearbook, China Urban Construction Statistical Yearbook, China Culture and Tourism Statistical Yearbook, China Statistical Yearbook on Culture, Cultural Relics and Tourism, urban air quality data released by the Ministry of Ecology and Environment, public information from culture and tourism authorities at national and local levels, the National Museum Directory of the National Cultural Heritage Administration, and provincial or municipal statistical yearbooks and statistical bulletins. Meteorological data for climate-related indicators were collected from the China Meteorological Data Service Centre and the daily dataset of surface climate data in China. Missing values were treated by linear interpolation. All indicators were transformed into positive indicators and standardised before being entered into the comprehensive evaluation model. For scale comparability, F1, F2, and I1 were expressed per 10,000 residents, F3 per square kilometre of urban land area, while C2 and D3 were calculated as employee shares of the resident population.

Methods

Composite index method

After deriving the combined weights using the game-theoretic weighting model, this study calculates the comprehensive development level of each subsystem, namely the tourism comfort subsystem and the sustainable urban development subsystem. Let U_1 represent the tourism comfort subsystem and U_2 represent the sustainable urban development subsystem. The composite index of the tourism comfort subsystem is calculated as follows:

$$C_{it} = \sum_{j=1}^n w_{1j}^* z_{1ijt} \quad (5)$$

The composite index of the sustainable urban development subsystem is calculated as follows:

$$S_{it} = \sum_{j=1}^m w_{2j}^* z_{2ijt} \quad (6)$$

Where C_{it} denotes the tourism comfort level of city i in year t , and S_{it} denotes the sustainable urban development level of city i in year t ; w_{1j}^* and w_{2j}^* are the game theoretic combined weights of the j -th indicator in the tourism comfort subsystem and the sustainable urban development, respectively, while z_{1ijt} and z_{2ijt} are the corresponding standardised indicator values. A larger composite index indicates a higher level of tourism comfort or sustainable urban development in a given city and year. The calculated C_{it} and S_{it} are subsequently used as input variables in the coupling coordination degree model to analyse the coordination relationship and temporal evolution between the two subsystems.

Coupling coordination degree model

The coupling coordination degree model is widely used to assess the interaction and coordinated development between multiple systems. Coupling degree captures the strength of interaction and mutual influence between systems, while coordination degree reflects the extent to which the systems develop harmoniously. This study applies the coupling coordination degree model to measure the coordinated relationship between the tourism comfort subsystem and the sustainable urban development subsystem. The model is specified as follows:

$$D = \sqrt{C \times T} \quad (7)$$

$$T = \beta_1 U_1 + \beta_2 U_2 \quad (8)$$

$$C(U_1, U_2) = 2 \times \frac{\sqrt{U_1 \times U_2}}{U_1 + U_2} \quad (9)$$

Where D denotes the coupling coordination degree between the tourism comfort subsystem and the sustainable urban development subsystem. C represents the coupling degree, while U_1 and U_2 denote the composite evaluation indices of tourism comfort and sustainable urban development, respectively. T is the overall evaluation index of the two subsystems, β_1 and β_2 are weighting coefficients. Given that the two subsystems may differ in the extent to which they promote each other, and that their interaction is shaped by the combined effects of multiple factors, this study follows relevant previous research and assigns β_1 and β_2 values of 0.5 and 0.5, respectively.

Following the classification criteria commonly adopted in previous studies (Xie et al. 2021), D was classified as extreme dysfunction [0.0, 0.1), severe dysfunction [0.1, 0.2), moderate dysfunction [0.2, 0.3), mild dysfunction [0.3, 0.4), near dysfunction [0.4, 0.5), barely coordinated [0.5, 0.6), primary coordination [0.6, 0.7), intermediate coordination [0.7, 0.8), well coordinated [0.8, 0.9), and high-quality coordination [0.9, 1.0].

Kernel density estimation

Kernel density estimation (KDE) is a non-parametric method used to describe the distributional dynamics of a variable. To examine the spatiotemporal evolution of coupling coordination degree, this study applies KDE to analyse the distribution patterns of coupling coordination across the sample cities. Unlike

parametric estimation methods, KDE does not require prior assumptions about the underlying distribution, and is therefore able to capture the actual shape and changes of the data distribution more flexibly. By observing the number, location and shape of the peaks in the kernel density curves, this study identifies the polarisation tendency and dynamic evolution of coupling coordination degree. The KDE function is expressed as follows:

$$f_h(x) = \frac{1}{nh} \sum_{i=1}^n K\left(\frac{x-x_i}{h}\right) \quad (10)$$

Where n is the number of observations, h denotes the bandwidth or smoothing parameter, and $K(\cdot)$ is the kernel function, typically specified as a symmetric and unimodal probability density function. The term $x-x_i$ represents the distance between the estimation point and the sample point.

Spatial autocorrelation test

Before constructing the spatial econometric model, this study first tests whether the coupling coordination degree exhibits spatial dependence. Global Moran's I is used to measure the overall spatial autocorrelation of the coupling coordination degree across the sample cities. A row-standardized K -nearest-neighbor spatial weight matrix is constructed, with K set to 4, to capture the spatial relationships among cities. Compared with administrative adjacency matrices, the K -nearest-neighbor matrix is more suitable for the present sample because the selected cities are not necessarily geographically contiguous but may still be spatially connected through distance-based proximity.

Global Moran's I is calculated as follows:

$$I = \frac{n}{\sum_{i=1}^n \sum_{j=1}^n w_{ij}} \cdot \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} (D_i - \bar{D})(D_j - \bar{D})}{\sum_{i=1}^n (D_i - \bar{D})^2} \quad (11)$$

Where n denotes the number of cities, D_i and D_j represent the coupling coordination degree of cities i and j , respectively, $\bar{D}$ is the mean value of the coupling coordination degree, and w_{ij} is the element of the spatial weight matrix W . A positive Moran's I indicates that cities with similar coordination levels tend to cluster spatially, whereas a negative value suggests spatial dispersion. The statistical significance of Moran's I is evaluated using the corresponding standardized Z -statistic and p -value. This test provides the empirical basis for introducing spatial econometric models into the analysis.

Spatial Durbin Model

The coordinated development between the tourism comfort system and the sustainable urban development system may be affected not only by local socioeconomic conditions, but also by neighbouring cities through factor mobility, intercity competition, infrastructure connectivity and demonstration effects. To capture both local effects and spatial spillovers, this study employs the Spatial Durbin Model (SDM). Compared with the spatial autoregressive model and the spatial error model, the SDM includes both the spatially lagged dependent variable and the spatially lagged explanatory variables, making it suitable for identifying direct effects, indirect effects and total effects.

The SDM is specified as follows:

$$D_{it} = \rho \sum_{j=1}^n w_{ij} D_{jt} + X_{it}\beta + \sum_{j=1}^n w_{ij} X_{jt}\theta + \mu_i + \varepsilon_{it} \quad (12)$$

Where D_{it} denotes the coupling coordination degree of city i in year t ; $w_{ij}D_{jt}$ is the spatially lagged dependent variable; X_{it} represents the vector of explanatory variables; $w_{ij}X_{jt}$ denotes the spatially lagged explanatory variables; ρ is the spatial autoregressive coefficient; β measures the effects of local explanatory variables; θ captures the effects of neighbouring cities' explanatory variables; μ_i represents city fixed effects; and ε_{it} is the random error term.

Results

Spatiotemporal characteristics of tourism comfort development

As shown in Figure 3, tourism comfort in the sample cities followed a fluctuating but overall upward trend, with the mean value increasing from 0.147 in 2000 to 0.295 in 2023. This indicates a substantial improvement in tourism comfort across China's popular tourist cities during the study period.

Clear regional differences remained throughout the period. Eastern cities generally recorded the highest levels and stayed above the sample average, followed by central cities, while western cities remained at comparatively lower levels. The overall spatial pattern was characterised by higher tourism comfort in eastern and coastal areas than in western and inland areas. Beijing and Shanghai consistently ranked among the leading cities, whereas Xining and Urumqi remained in the lower group. Although the gap between regions persisted, tourism comfort improved in most cities over time.

Figure 3. Evolution of tourism comfort in China's popular tourist cities, 2000–2023

Spatiotemporal characteristics of sustainable urban development

As shown in Figure 4, sustainable urban development also displayed a clear upward trend accompanied by persistent spatial imbalance. Eastern coastal cities maintained the highest levels throughout most of the study period, central cities showed steady improvement, and several western cities experienced relatively rapid catch-up growth.

Beijing, Shenzhen and Guangzhou consistently remained in the leading group, while western cities generally stayed below the sample average. Nevertheless, cities such as Chongqing and Xining recorded notable improvements after 2005, indicating a gradual narrowing of the development gap in some parts of western China. Overall, the spatial pattern remained characterised by higher levels in eastern and coastal cities and lower levels in western and inland cities, although regional disparities showed signs of partial convergence.

Figure 4. Evolution of sustainable urban development across China's popular tourist cities, 2000–2023

Coupling coordination between tourism comfort and sustainable urban development in tourist cities

Temporal evolution characteristics

Figure 5 shows a sustained increase in the coupling coordination degree between tourism comfort and sustainable urban development from 2000 to 2023. Its temporal evolution can be divided into four stages: mild dysfunction during 2000–2005, near dysfunction during 2006–2012, transition from near dysfunction to barely coordinated development during 2013–2019, and barely coordinated development during 2020–2023.

During 2000–2005, the period average was 0.366, corresponding to mild dysfunction. The CV increased from 0.103 to 0.117, indicating widening intercity disparities and limited synergy between the two systems. During 2006–2012, the mean coupling coordination degree rose to 0.420, and the overall system entered near dysfunction. The CV began to decline, suggesting that coordination improved rapidly and intercity differences started to converge, although substantial spatial disparities remained. During 2013–2019, the period average increased to 0.485, and the annual value reached 0.511 in 2019, marking a transition from near dysfunction to barely coordinated development. The CV decreased from 0.116 to 0.111, indicating gradual convergence alongside continued improvement in coordination. During 2020–2023, the period average reached 0.528 and remained within the barely coordinated stage, while the annual value peaked at 0.539 in 2023. The CV temporarily rebounded because recovery differed across cities, but the overall coordination level remained stable, demonstrating greater resilience to external shocks.

Overall, the coupling relationship evolved from mild dysfunction towards barely coordinated development, accompanied by long-term improvement and a general tendency towards convergence.

Figure 5. Heatmap of the coupling coordination between tourism comfort and sustainable urban development across 38 popular tourist cities

Spatial evolution characteristics

From a spatial perspective, the coupling coordination degree displayed a clear east–west and coastal–inland gradient (Figure 6). Eastern and coastal cities generally recorded higher coordination levels, while western and inland cities remained comparatively lower. Shenzhen and Beijing consistently belonged to the leading group, whereas Xining remained among the lower-ranked cities. Although coordination improved across most of the sample, substantial regional differences persisted.

During 2000–2010, coupling coordination remained predominantly within the dysfunctional categories. By 2010, four cities had reached barely coordinated development, forming a spatial pattern of “point-based breakthroughs”, while 21 remained near dysfunction and 13 remained mildly dysfunctional. From 2010 to 2015, coordination levels increased steadily across the sample. Several previously lagging cities, represented by Chongqing, recorded relatively rapid improvements and

approached near dysfunction. No city had reached primary coordination by 2015, indicating that broad-based coordination had not yet emerged. During 2015–2023, the numbers of cities in the barely coordinated and primary coordination stages increased substantially. The spatial pattern consequently shifted from isolated “point-based breakthroughs” towards broader “area-based expansion”. By 2023, 24 cities were barely coordinated, 6 had reached primary coordination, and 8 remained near dysfunction, although parts of northwestern and northeastern China continued to lag behind.

Overall, the spatial evolution was characterised by widespread improvement and an expanding coordinated area, but the persistent east–west gradient indicates that regional disparities in the interaction between tourism comfort and sustainable urban development have not been fully eliminated.

Figure 6. Evolution of coupling coordination between tourism comfort and sustainable urban development, 2000–2023 (Review No. GS(2024)0650)

Kernel density estimation

To further explore the temporal evolution of coupling coordination between tourism comfort and sustainable urban development in China’s major popular tourist cities, kernel density estimation is used to generate density curves (Figure 7). These curves provide a visual representation of the distributional characteristics and dynamic changes in coupling coordination degree across different periods.

Overall, the kernel density curves for the coupling coordination degree between tourism comfort and sustainable urban development in the 38 major popular tourist cities shifted clearly to the right from 2000 to 2023. This corresponds to the increase in the mean coupling coordination degree from 0.355 in 2000 to 0.539 in 2023, indicating a steady improvement in the overall coordination level and the gradual strengthening of positive interactions between the two systems. The curve shape changed from a sharp peak to a broader peak, and the standard deviation increased from 0.037 to 0.053, suggesting that absolute disparities among cities widened to some extent. Leading cities such as Beijing and Shanghai continued to maintain high development levels and widened their gap with other cities. Nevertheless, the coefficient of variation (CV) declined from its peak of approximately 0.119 (in 2010) to 0.097 as the mean value increased. This indicates that, although intercity disparities remained, relatively lagging cities achieved catch-up through higher marginal growth rates, showing a tendency towards β -convergence. Regional development therefore gradually shifted from uneven expansion towards endogenous balance.

Figure 7. Intra-regional and inter-regional disparities in coupling coordination across China’s popular tourist cities

Regionally, eastern China displayed a low-peak and broad-tail distribution, reflecting the coexistence of high coordination levels and high internal dispersion. The rightward shift of the curve indicates that eastern cities maintained their leading position, while the flatter curve and wider distribution range suggest persistent internal disparities. A core–periphery structure remains evident, with high-capacity cities such as Shanghai, Shenzhen and Suzhou maintaining substantially higher

coordination levels than ordinary prefecture-level cities.

In central China, the curve evolved from a sharp unimodal distribution to a bimodal pattern. This indicates that the region moved from low-level equilibrium towards improving but increasingly differentiated development. With the advancement of the Rise of Central China Strategy, the main peak shifted rightward and flattened, while a secondary peak emerged. Core cities such as Wuhan, Changsha and Zhengzhou increasingly diverged from other cities by drawing on factor agglomeration, transport hub functions and stronger industrial foundations.

In western China, the density curves were characterised by jagged fluctuations and multiple low-level peaks. The main peak remained in the low-value range, indicating that the overall coupling coordination level was still relatively lagging. Although Chongqing and Xi'an formed local growth poles and played a certain leading role, geographical constraints, resource endowments, limited accessibility and weaker economic foundations continued to restrict broader regional improvement. The leading effects of core cities have not yet been effectively converted into a regional gradient transmission mechanism, resulting in slow overall improvement and some local polarisation.

Spatial dependence of coupling coordination

The coordination level between the urban tourism comfort system (U1) and the urban sustainable development system (U2) is shaped not only by local socioeconomic conditions but also by intercity interactions arising from factor mobility, spatial competition, and demonstration effects. To systematically identify the driving factors and further reveal the mechanisms of spatial spillover, this study employs the spatial Durbin model (SDM). From an econometric perspective, the SDM estimates the direction, magnitude, and direct and indirect spatial effects of each influencing factor, providing evidence for understanding the determinants and spatial spillover mechanisms of coordinated development between U1 and U2.

The dependent variable is the coupling coordination degree (D) between the two systems. Its values range from 0.27 to 0.66, with a mean of approximately 0.44, indicating that the overall coordination level lies between the stages of near dysfunction and barely coordinated development, while showing a gradual upward trend over time. Eight core drivers were selected: economic density, industrial upgrading, tourism intensity, transport accessibility (measured by expressway network density), government intervention, healthcare provision, financial development, and tourism's economic contribution. All variables had variance inflation factors (VIFs) below 4, indicating no serious multicollinearity concerns (Table 2).

Table 2. Definitions and descriptive statistics of the driving factors

Variable	Definition	Mean	S.D.	Min	Max	VIF
Coupling coordination degree (D)	Coupling coordination degree between U1 and U2 (dependent variable)	0.443	0.076	0.269	0.656	—
Economic density	Natural logarithm of GDP per unit of administrative land area	8.047	1.462	2.725	12.063	3.51
Overall industrial upgrading	Industrial structure upgrading index, Σ	2.473	0.121	2.168	2.846	3.22

	$i \times (\text{share of sector } i), i=1,2,3$					
Tourism intensity	Ratio of domestic tourist arrivals to permanent resident population	7.318	5.779	0.337	43.359	3.28
Transport accessibility	Expressway length per unit of administrative land area (km/km ²)	0.048	0.035	0.002	0.213	2.48
Degree of government intervention	Ratio of local general public budget expenditure to GDP	0.132	0.062	0.044	0.591	2.01
Healthcare level	Hospital and health-center beds per 100 registered residents	0.606	0.223	0.190	1.328	2.60
Financial development level	Ratio of the sum of year-end deposits and loans of financial institutions to GDP	4.182	1.601	0.999	13.530	3.00
Economic contribution of tourism	Ratio of total tourism revenue to GDP	0.135	0.083	0.008	0.761	2.74

Using a row-standardized K-nearest-neighbor spatial weight matrix with $K = 4$, the global Moran's I statistic for the coupling coordination degree was calculated on an annual basis. The results, reported in Table 3, show that spatial autocorrelation was generally insignificant before 2008. Since 2008, however, Moran's I has remained significantly positive, and after 2009 it is significant at the 1% level in most years. The magnitude of Moran's I increased from approximately 0.10 in 2000 to 0.32 in 2023, despite a temporary dip in 2015.

These findings indicate that the spatial clustering effect of the coupling coordination degree has strengthened over time. Cities with high coordination levels and those with low coordination levels increasingly tend to cluster separately, thereby providing empirical justification for the use of spatial econometric models.

Table 3. Global Moran's I of the coupling coordination degree in representative years

Year	Moran's I	Z-statistic	P-statistic	Significance
2005	0.143	1.81	0.071	*
2008	0.180	2.19	0.029	**
2010	0.284	3.28	0.001	***
2015	0.147	1.83	0.067	*
2018	0.304	3.48	<0.001	***
2020	0.306	3.50	<0.001	***
2023	0.324	3.69	<0.001	***

Spatial driving effects based on the Spatial Durbin Model

Model specification tests

To determine the appropriate spatial econometric specification, a series of diagnostic tests were conducted. The Lagrange multiplier (LM) tests indicate significant spatial dependence in the data. Specifically, the LM statistic for the spatial lag term is 196.87 ($p < 0.001$), while that for the spatial error term is 34.83 ($p < 0.001$). After accounting for potential model misspecification, the robust LM test

further shows that the spatial lag term remains highly significant, with a Robust LM statistic of 163.81 ($p < 0.001$), whereas the corresponding robust LM statistic for the spatial error term is not significant (1.78, $p = 0.183$). These results suggest that spatial dependence is primarily manifested through the dependent variable, indicating that a spatial lag framework is more appropriate.

On this basis, the choice between fixed effects and random effects was further examined. The spatial Hausman test yields a statistic of 14.59 with 8 degrees of freedom ($p = 0.068$), which rejects the null hypothesis of random effects at the 10% significance level. Considering the pronounced city-specific heterogeneity in the macro-level urban panel data, this study adopts city fixed effects to control for unobserved time-invariant differences across cities.

Finally, given that spatial interaction may occur not only through the dependent variable but also through the explanatory variables, the spatially lagged terms of the explanatory variables ($W \cdot X$) were incorporated into the spatial lag framework to construct a spatial Durbin model (SDM). Before estimation, the panel observations were arranged in the same city order as the spatial weight matrix, so that both spatial lag terms ($W \cdot y$ and $W \cdot X$) refer to the correct neighbouring cities. The model was estimated using the maximum likelihood method. The estimated spatial autoregressive coefficient ρ is 0.225 and significant at the 1% level ($p < 0.001$), confirming the presence of a significant positive spatial spillover effect in the coupling coordination degree.

Decomposition of direct, indirect and total effects

Because the spatial Durbin model allows for spatial feedback effects, the estimated regression coefficients cannot be interpreted directly as marginal effects. Following the approach proposed by LeSage and Pace, the impact of each explanatory variable is decomposed into direct effects, indirect effects—that is, spatial spillover effects—and total effects. The statistical significance of these effects is assessed using a parametric bootstrap procedure with 1,000 replications. The results are reported in Table 4.

Table 4. Decomposition of effects from the Spatial Durbin Model

Driving factor	Direct effect	Indirect effect	Total effect
Transport accessibility	0.355***	0.689***	1.044***
Overall industrial upgrading	0.080***	0.074**	0.154***
Healthcare level	0.025***	0.092***	0.116***
Tourism intensity	0.001**	0.002***	0.002***
Economic density	0.008***	0.007	0.015***
Financial development level	-0.004***	0.003*	-0.001
Degree of government intervention	-0.025	-0.014	-0.039
Economic contribution of tourism	-0.041***	-0.095***	-0.136***

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Interpretation of spatial spillover effects

In terms of total effects, transport accessibility emerges as the most important positive driver of the

coupling coordination degree, with a total effect as high as 1.044. Its indirect effect (0.689) exceeds its direct effect (0.355), indicating that transport infrastructure not only significantly promotes the coordination between urban tourism comfort and sustainable development within a city, but also generates strong positive spillovers to neighboring cities through intercity connectivity. It therefore represents a key policy lever for promoting coordinated regional development.

The total effects of overall industrial upgrading and healthcare level are both significantly positive, suggesting that the optimization of the industrial base and the provision of public services constitute robust supports for coordinated development and generate positive spatial spillovers. The total effect of economic density is also significantly positive, reflecting the supportive role of economic agglomeration in enhancing coupling coordination.

Tourism-related variables exhibit differentiated effects. The total effect of tourism intensity is significantly positive but relatively small in elasticity, indicating that tourist agglomeration exerts a positive yet limited influence on coordination. By contrast, the total effect of the economic contribution of tourism is significantly negative (−0.136), and its negative spillover effect on neighboring cities (−0.095) is greater than its local negative effect (−0.041).

This contrast reveals a “tourism dependence paradox”: a moderate level of tourism popularity is conducive to system coordination, whereas excessive economic dependence on tourism may instead inhibit coordinated development. Moreover, such dependence can generate adverse spillover effects on neighboring cities through channels such as homogeneous competition. The total effect of the degree of government intervention is negative but statistically insignificant, and the total effect of the financial development level is also insignificant, suggesting that both factors exert only limited overall influence on the coupling coordination degree.

Robustness checks

To assess the reliability of the findings, this study conducts robustness checks from three perspectives. First, the model is re-estimated using two-way fixed effects, controlling simultaneously for city and year effects. Second, the spatial weight matrix is replaced by an inverse geographic distance matrix instead of the K-nearest-neighbor matrix. Third, a likelihood ratio (LR) test is conducted to examine whether the Spatial Durbin Model can be reduced to a spatial autoregressive model (SAR). The spatial autoregressive coefficient ρ remains positive across all specifications—0.225 ($p < 0.001$) in the baseline model, 0.073 ($p = 0.141$) in the two-way fixed-effects model, and 0.360 ($p < 0.001$) under the inverse-distance spatial weight matrix—indicating that the direction of spatial spillover effects remains consistent, although ρ is not statistically significant in the two-way fixed-effects model, where year fixed effects absorb temporal shocks common to all cities.

Table 5 reports the total effects of the driving factors under the baseline model and the two alternative specifications. The core conclusions remain stable across different model settings. Transport accessibility consistently emerges as the strongest positive driver, with total effects ranging from 0.786 to 1.413. Overall industrial upgrading and healthcare level remain robustly positive, whereas the

economic contribution of tourism and the degree of government intervention are consistently negative. Only economic density and financial development level exhibit slight sign fluctuations in some specifications, mainly because their effect sizes are relatively small; however, these fluctuations do not affect the main conclusions. These results indicate that the core findings of this study are robust to alternative model specifications and choices of spatial weight matrices.

Table 5. Robustness checks: total effects of driving factors under alternative specifications

Driving factor	Baseline model: K-nearest-neighbor matrix	Two-way fixed effects	Inverse-distance spatial weight matrix	Conclusion
Transport accessibility	1.044	0.786	1.413	Robustly positive
Overall industrial upgrading	0.154	0.073	0.082	Robustly positive
Healthcare level	0.116	0.152	0.205	Robustly positive
Tourism intensity	0.002	0.002	0.005	Robustly positive
Economic density	0.015	-0.020	-0.001	Small magnitude; sign fluctuates
Financial development level	-0.001	0.003	-0.012	Small magnitude; close to zero
Degree of government intervention	-0.039	-0.254	-0.115	Robustly negative
Economic contribution of tourism	-0.136	-0.095	-0.240	Robustly negative
Spatial autoregressive coefficient ρ	0.225	0.073	0.360	Positive in all specifications; significant in the baseline and inverse-distance models

In addition, the likelihood ratio test yields an LR statistic of 116.13 with 8 degrees of freedom ($p < 0.001$), strongly rejecting at the 1% significance level the null hypothesis that the Spatial Durbin Model can be reduced to a spatial autoregressive model. This result indicates that the spatially lagged explanatory variables ($W \cdot X$) cannot be omitted and confirms the appropriateness of adopting the Spatial Durbin Model. Taken together, the robustness checks demonstrate that the empirical findings of this study are robust and reliable.

Discussion

Tourism Comfort, Urban Governance, and the Transition in Tourist-City Development

The findings indicate that tourism comfort is not merely a tourism-sector attribute, but an expression of a city's broader governance and service capacity. Its sustained improvement from 2000 to 2023, together with the persistent advantage of eastern and coastal cities, suggests that tourism comfort is closely associated with the ability of urban systems to provide accessible infrastructure, public services, environmental quality, and social order. Cities with stronger economic foundations, larger service markets, and more concentrated public resources generally achieved higher levels, whereas many

western and inland cities remained constrained by weaker infrastructure, industrial foundations, and external connectivity. These spatial patterns should be interpreted as structural associations rather than definitive causal relationships.

Population agglomeration provides one possible explanation for these differences. Larger urban markets can support more extensive transport networks, healthcare services, cultural facilities, commercial activities, and tourism reception systems. Agglomeration itself, however, does not necessarily produce greater tourism comfort. Its benefits depend on whether population and market growth are accompanied by adequate public-service provision, infrastructure investment, and effective governance. Where service capacity fails to keep pace with demand, agglomeration may instead intensify congestion and pressure on shared urban resources.

This interpretation is consistent with research showing that sustainable urban development depends not only on economic and environmental performance, but also on governance capacity, stakeholder coordination, public-service provision, and the quality of everyday urban environments (Rasoolimanesh et al. 2019; Ivars-Baidal et al. 2023). In popular tourist cities, visitors and residents use the same transport systems, public spaces, cultural facilities, commercial services, and ecological environment (Ashworth and Page 2011; Gretzel and Koo 2021; Page and Duignan 2023). Tourism comfort therefore reflects whether urban development capacity can be translated into accessible, inclusive, and high-quality conditions for both groups (Romão et al. 2018; Dwyer 2024). The positive roles of transport accessibility, industrial upgrading, and healthcare provision further demonstrate that comfortable tourism experiences are produced by the whole urban system rather than by scenic resources alone (Ivars-Baidal et al. 2023; Rasoolimanesh et al. 2019; Romão et al. 2018). The results consequently point to a transition from resource- and visitor-growth-oriented development towards a comfort- and governance-driven model. As urban tourism shifts from sightseeing towards service-, leisure-, and lifestyle-oriented activities, destination competitiveness increasingly depends on integrated public services, connectivity, environmental quality, and institutional coordination (Gretzel and Koo 2021; Page and Duignan 2023; Song and Xu 2024; Zhao et al. 2024). Resource-rich cities with weak transport systems, service provision, or industrial support may therefore struggle to translate tourism advantages into coordinated development (R. Chen et al. 2025; Pan et al. 2024). Cities at an earlier stage of development need to strengthen basic infrastructure, public services, and industrial capacity, whereas more developed destinations should place greater emphasis on service inclusiveness, congestion management, and the quality of shared urban spaces.

Host–guest sharing and the tourism dependence paradox

The steady increase in coupling coordination indicates that many tourist cities have strengthened the interaction between tourism-facing amenities and sustainable urban development. This supports the host–guest sharing perspective, which views tourist cities as shared environments rather than separate spaces for visitors and residents (Ashworth and Page 2011; Gretzel and Koo 2021; Romão et al. 2018). Tourism-facing facilities can contribute to resident wellbeing when transport, public spaces, healthcare, cultural

services, and environmental amenities are designed for inclusive use. Tourism sustainability should therefore be assessed not only through visitor numbers or destination competitiveness, but also through residents' quality of life and long-term wellbeing (Dwyer 2022a, 2022b, 2024). The effects of tourism-related variables nevertheless show that sharing does not automatically produce balanced development. Tourism intensity has a positive but limited influence, suggesting that moderate visitor flows can stimulate service demand, urban vitality, and destination attractiveness (Romão and Bi 2021; Song and Xu 2024; Zhao et al. 2024). By contrast, greater economic dependence on tourism weakens coupling coordination and generates negative spillovers to neighbouring cities. This tourism dependence paradox indicates that tourism popularity and tourism dependence operate through different mechanisms. Visitor activity can activate urban services and consumption, whereas excessive dependence may narrow the local economic base, distort resource allocation, and increase vulnerability to tourism-specific disruptions.

This finding is consistent with research on overtourism, resident wellbeing, and urban tourism governance. When tourism becomes dominant in the local economy, public resources may be disproportionately directed towards visitor consumption, while residents face congestion, higher living costs, pressure on public services, and the commodification of everyday spaces (Andereck et al. 2005; Russo 2002; Vu et al. 2020). Tourism-dependent cities may also pursue similar products, development models, and branding strategies, resulting in duplicated investment and homogeneous intercity competition. Under these conditions, host–guest sharing can shift from a mechanism of mutual benefit to a source of spatial and social tension (Vu et al. 2020). Sustainable tourist-city governance should therefore balance visitors' short-term use of urban amenities with residents' long-term needs. Tourism development needs to be integrated with industrial diversification, public-service planning, community wellbeing, and destination carrying capacity. Tourism-dependent cities should also develop differentiated functions and complementary products rather than compete primarily through visitor volume and similar forms of attraction development. Such an approach would preserve the vitality generated by tourism while reducing the social and economic risks associated with excessive dependence (Dwyer 2022a, 2022b, 2023, 2024).

Spatial spillovers and regional governance

The significant spatial autocorrelation and positive spatial autoregressive coefficient show that coupling coordination is not determined solely by local conditions. Development outcomes are also transmitted through intercity transport, factor mobility, industrial linkages, policy diffusion, demonstration effects, and spatial competition (G. Chen et al. 2024; JinweiWANG et al. 2025; Zhou et al. 2018). Transport accessibility is particularly important because its indirect effect exceeds its direct effect, while industrial upgrading and healthcare provision also generate positive spillovers. Improvements in connectivity, productive capacity, and public services can therefore benefit not only the city in which they occur, but also neighbouring cities connected through regional networks.

The timing of the observed improvement provides additional context for these spatial processes.

The acceleration after 2006 may partly reflect the expansion of transport infrastructure and urban services associated with major events such as the Beijing Olympic Games and the Shanghai World Expo. The stronger improvement and convergence observed during 2013–2019 also coincided with a greater national emphasis on high-quality development, supply-side reform, ecological governance, and regional coordination. Strategies involving the Beijing–Tianjin–Hebei region and the Yangtze River Economic Belt may have strengthened intercity connections and facilitated the diffusion of infrastructure, industrial, and institutional benefits. These relationships provide plausible contextual explanations rather than causal evidence and should be interpreted in light of the limitations of the spatial econometric design.

The comparatively stable coordination level during 2020–2023 further suggests that cities with diversified economies, stronger public services, and denser regional networks were better positioned to absorb external shocks. Differences in recovery across cities also indicate that resilience depends on more than the size of the tourism economy. Industrial structure, fiscal capacity, healthcare provision, transport connectivity, and regional integration jointly shape whether a city can maintain tourism comfort and sustainable development during periods of disruption.

These findings support governance at both local and regional scales. Local governments need to improve service accessibility, industrial diversification, ecological quality, and urban comfort provision, but isolated city-level interventions may not capture the full benefits of spatial spillovers. Regional governance should coordinate intercity transport networks, complementary destination functions, public-service cooperation, ecological protection, and mechanisms for reducing homogeneous tourism competition (J. Liu et al. 2017; Romão and Bi 2021; Vu et al. 2020). This is particularly important for western and inland cities, where tourism resources have not always been translated into stronger coordination because of weaker connectivity, service capacity, and industrial foundations. Managing tourism comfort and sustainable urban development through regional networks can help shift tourist-city development from fragmented competition towards complementary and mutually reinforcing growth (G. Chen et al. 2024; JinweiWANG et al. 2025; Zhou et al. 2018).

Conclusions, implications and limitations

Conclusions

This study develops an integrated framework for evaluating tourism comfort and sustainable urban development in 38 popular tourist cities in China from 2000 to 2023. By combining composite indices, the coupling coordination degree model, kernel density estimation, spatial autocorrelation analysis, and the Spatial Durbin Model, it examines the temporal evolution, spatial differentiation, spillover effects, and driving mechanisms of the two systems.

Tourism comfort and sustainable urban development both improved substantially during the study period, while their coupling coordination shifted from mild dysfunction towards barely coordinated development. The distribution of coordination levels moved steadily to the right, although a clear east–west and coastal–inland gradient persisted. Eastern and coastal cities generally maintained higher levels

than western and inland cities, indicating broad-based improvement alongside continuing regional disparities.

Coupling coordination also became increasingly spatially clustered and interdependent. Transport accessibility was the strongest positive driver, and its indirect effect exceeded its direct effect, showing that intercity connectivity generates benefits beyond local administrative boundaries. Industrial upgrading and healthcare provision also supported coordination and produced positive spillovers, confirming the importance of economic structure, infrastructure, and public-service capacity.

Tourism-related factors displayed contrasting effects. Moderate tourism intensity contributed positively, although its influence was limited, whereas greater economic dependence on tourism weakened local coordination and generated negative spillovers. This tourism dependence paradox suggests that visitor activity can enhance urban vitality, but excessive reliance on tourism may narrow the economic base, intensify homogeneous competition, and undermine sustainable coordination.

Theoretical and practical implications

This study makes two main theoretical contributions. It integrates tourism comfort into the framework of sustainable urban development and conceptualises it as an expression of a city's broader capacity to provide accessible, inclusive, and high-quality environments for visitors and residents. This perspective connects tourism comfort with host–guest sharing, resident wellbeing, public-service provision, and urban governance, moving beyond approaches that treat tourism comfort mainly as an outcome of scenic resources or tourism facilities (Ashworth and Page 2011; Dwyer 2024; Gretzel and Koo 2021; Page and Duignan 2023; Romão et al. 2018). The study also provides a spatially explicit explanation of how tourism comfort and sustainable urban development co-evolve. By distinguishing local effects, neighbouring-city effects, and spatial spillovers, it extends conventional analyses of factor importance and demonstrates that coordinated development is shaped by regional interaction as well as local conditions (G. Chen et al. 2024; X. Chen and Ling 2024; Ji et al. 2024; JinweiWANG et al. 2025; Zhou et al. 2018). The tourism dependence paradox further contributes to debates on tourism-led development and overtourism by distinguishing the benefits of moderate tourism activity from the risks associated with excessive economic reliance on tourism (Andereck et al. 2005; Russo 2002; Vu et al. 2020).

The practical implications centre on three areas. Tourist cities should shift from resource- and visitor-growth-oriented development towards a comfort- and governance-oriented model. Destination competitiveness increasingly depends on transport accessibility, inclusive public services, cultural facilities, ecological quality, social order, and well-managed shared spaces rather than on scenic resources and visitor numbers alone (Gretzel and Koo 2021; Page and Duignan 2023; Song and Xu 2024; Zhao et al. 2024). Transport and public-service investment should be coordinated at the regional scale. Because transport accessibility generates substantial cross-city spillovers, intercity networks, transport-service integration, and shared public-service systems should be planned across urban agglomerations rather than within isolated administrative boundaries (G. Chen et al. 2024; JinweiWANG et al. 2025; J. Liu et al. 2017; Romão and Bi 2021; Zhou et al. 2018). Industrial upgrading and healthcare provision are also

important for converting tourism resources into broader development advantages, particularly in western and inland cities with weaker service and industrial foundations (Dwyer 2024; Ivars-Baidal et al. 2023; Rasoolimanesh et al. 2019).

Tourism-dependent cities should reduce vulnerability through industrial diversification and differentiated regional positioning. Local governments need to avoid over-reliance on visitor growth, duplicated tourism products, and homogeneous destination branding. Cross-city coordination can support the management of visitor flows, the development of complementary destination functions, and cooperation in transport, public services, ecological protection, and tourism governance.

Limitations

This study is subject to several limitations. The sample consists of 38 popular tourist cities in China, so the applicability of the findings to other institutional settings and destination types remains to be examined. Comparative research involving heritage cities, coastal resorts, mountain destinations, and metropolitan tourism regions could clarify the conditions under which the observed relationships hold.

The indicator system relies mainly on city-level statistical data. This approach supports long-term and cross-city comparison but cannot fully capture the perceptions, behaviours, and emotional experiences of visitors and residents. Combining official statistics with questionnaire surveys, online reviews, mobile signalling data, social media, or spatial behaviour data would provide a more complete account of host–guest sharing.

The Spatial Durbin Model identifies spatial associations and spillover mechanisms rather than definitive causal effects (G. Chen et al. 2024; JinweiWANG et al. 2025; Zhou et al. 2018). Quasi-natural experiments, instrumental-variable approaches, or policy-shock designs could be used to assess causality and examine the policy mechanisms suggested by the present findings (L. Wang and Jia 2023).

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Figure legends

Figure 1. Conceptual coupling between tourism comfort and sustainable urban development. The framework represents element-level embeddedness, structural synergy and functional feedback linking natural conditions, production inputs, demand attraction, supply support, information and energy flows, and the reciprocal relationship between tourism comfort and sustainable urban development.

Figure 2. Study area and spatial distribution of the 38 popular tourist cities in China. The map shows sampled cities in eastern, central and western China. Base-map approval no. GS(2023)2767.

Figure 3. Evolution of tourism comfort across the 38 tourist cities, 2000–2023. The left panel compares city-level tourism-comfort values for selected years, with marker size indicating population; the right panel shows annual regional means for eastern, central and western China and the full-sample average.

Figure 4. Evolution of sustainable urban development across the 38 tourist cities, 2000–2023. The left panel compares city-level index values for selected years, with marker size indicating population; the right panel shows annual regional means for eastern, central and western China and the full-sample average.

Figure 5. Coupling coordination across the 38 tourist cities, 2000–2023. The heatmap shows annual city-level coupling coordination values, with the scale running from lower values (blue) to higher

values (red).

Figure 6. Spatial evolution of coupling coordination in 2000, 2010, 2015 and 2023. Panels a–d show the coordination categories of the sampled cities at four time points, illustrating the expansion of barely coordinated and primary coordination categories over time. Base-map approval no. GS(2024)0650.

Figure 7. Kernel-density evolution of coupling coordination. Panels a–d show the estimated distribution of coupling coordination over time for the full sample, eastern China, central China and western China, respectively.

Data availability

The datasets and supporting materials underlying the findings of this study, including the panel dataset for the 38 Chinese tourist cities from 2000 to 2023, variable definitions and transformations, and the statistical code used for data processing and empirical analysis, are available in the Supplementary Information accompanying this article.

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Author Contributions

X. W.: Conceptualization, Writing—Original Draft. B. H.: Software, Resources. H. L.: Writing—Review & Editing, Visualization, funding acquisition,. C. Z.: Methodology, Supervision, Software. All authors have read and agreed to the published version of the manuscript.

Competing interests

The authors declare no competing interests.

Ethical Approval

This article does not contain any studies with human participants performed by any of the authors.

Informed Consent

Informed consent was not required because this article does not contain any studies with human participants performed by any of the authors.

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