Dynamic Assessment and Optimization Strategy for Brand Tourism Competitiveness in the Yangtze River Delta City Cluster Based on Entropy Weight-TOPSIS

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***Abstract*—In the context of the integrated, high-quality development of the Yangtze River Delta City Cluster (YRDCC), brand tourism competitiveness is a key indicator of cities' attractiveness and regional synergy. However, most existing studies focus on static comparisons and fail to dynamically assess competitiveness trends among cities. This study uses 27 cities in the YRDCC from 2019 to 2023 as a sample and applies the entropy weight-TOPSIS method for dynamic analysis of brand tourism competitiveness. This method integrates objective weights and relative performance across multiple indicators, enabling a comprehensive identification of city differences in resource allocation, brand communication, and service capacity. The findings reveal that Shanghai and Hangzhou lead in brand tourism competitiveness due to their strong economic foundations, rich tourism resources, and continuous brand development, playing a regional demonstration role. Suzhou and Nanjing have solid foundations but require improvements in brand internationalization and tourism experience. In contrast, Chuzhou and Chizhou lag behind due to insufficient industrial support, weak infrastructure, and low brand recognition. The study recommends enhancing brand tourism competitiveness by strengthening regional cooperation, promoting differentiated development, cultivating local brand identities, and advocating for green tourism, thereby providing a sustainable development model and empirical support for tourism development in China's city clusters.**

Keywords*—Yangtze River Delta City Cluster; brand tourism competitiveness; entropy weight-TOPSIS; dynamic assessment

I. Introduction

Amid the rapid growth of global tourism, brand tourism competitiveness has become a key indicator of a city's attractiveness and development potential [1]. It is also a critical factor for cities seeking to secure a favorable position on the global tourism map [2]. International urban clusters, such as the Paris Region, the California Metropolitan Area, and the Tokyo Bay Area, have enhanced both economic growth and cultural soft power by creating highly recognizable tourism brands [3]. In contrast, China's urban agglomerations are still in the early stages of brand integration and international communication in the global tourism competition [4]. Particularly, challenges remain in regional collaboration, differentiated development [5], and the implementation of sustainable tourism concepts [6].

As one of China's most dynamic economic regions with the most well-developed urban systems, the YRDCC plays a significant role in leading the national tourism industry's transformation [7]. According to the strategic plans outlined in the "Outline of the Integrated Development of the YRDCC" and the "Three-Year Action Plan for Integrated Development of the YRDCC (2024-2026)" [8], building internationally influential cultural tourism brands has been explicitly identified as a core regional development goal [9]. However, tourism branding in the YRDCC shows clear differentiation: Shanghai, as the core city [10], has leveraged its global metropolitan image to create internationally recognized tourism brands such as Disney Resort and The Bund [11], Hangzhou, centered on "Song Dynasty Culture", has achieved high brand recognition and communication power through the integration of digital technologies [12]. In contrast, cities like Chuzhou and Chizhou, despite having favorable resource endowments, have failed to gain a competitive edge in regional tourism branding due to a lack of effective brand integration and communication strategies [13]. Overall, the imbalance in tourism branding within the YRDCC requires systematic optimization through regional collaboration and differentiated strategies under the framework of integrated development [14].

The YRDCC region still faces several challenges in tourism brand collaboration [15]. Specifically, there is a lack of efficient coordination mechanisms between cities, a prominent issue of product homogenization, and insufficient regional marketing cooperation, making it difficult to create a unified brand image [16]. In the global tourism governance system, sustainable development has increasingly become a key criterion for assessing urban tourism competitiveness [17]. Factors such as ecological protection, environmental capacity, and green travel are gradually being integrated into the brand evaluation system [18]. However, some cities, in their pursuit of rapid tourism development, have paid insufficient attention to the sustainability of resources and the environment, resulting in increased ecological pressure that hinders long-term brand development and steady improvement in international competitiveness. Therefore, strengthening regional coordination, promoting differentiated development, and integrating sustainability concepts have become key strategies for the high-quality development of tourism brands in the YRDCC.

Existing studies on urban tourism competitiveness evaluation mechanisms mostly focus on static analysis [19]. Few track the dynamic evolution of the competitive landscape within regions, and there is a lack of systematic integration between brand tourism competitiveness and the development trends of global city clusters [20]. This study, focusing on

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brand tourism, examines 27 cities in the YRDCC [21]. Using panel data from 2019 to 2023, the entropy weight-TOPSIS method is employed for dynamic assessment [22]. This method is highly objective and adaptable. It can identify the heterogeneity of competition indicators among cities and track competitiveness trends over time [23]. It is particularly suitable for analyzing multi-city, multi-year data [24].

This study uses quantitative evaluation and trend analysis to identify the strengths and weaknesses of cities at different levels in brand development [25]. It further explores underlying factors such as resource allocation [26], communication mechanisms, and governance models, and proposes targeted optimization strategies [27]. The research responds to global demands for brand system development and green transformation in tourism [28], and offers theoretical and practical insights for enhancing tourism competitiveness and promoting sustainable development in other Chinese city clusters [29].

II. Study Area and Methodological Process

A. Methodological Process

This study employs a combined approach of the Entropy Weight Method and the TOPSIS model to systematically evaluate the brand tourism competitiveness of cities within the YRDCC [30]. Additionally, ArcGIS 10.8.1 was used for spatial analysis and classification, enabling the visualization of the computed values through spatial mapping [31].

The Entropy Weight Method is an objective weighting technique based on information entropy theory [32]. It determines indicator weights by measuring the degree of information dispersion, effectively reducing bias from subjective judgment and enhancing the replicability and scientific validity of the evaluation system [34]. The TOPSIS model (Technique for Order Preference by Similarity to Ideal Solution) constructs both a positive ideal solution and a negative ideal solution to assess the relative closeness of each city to the optimal scenario, thereby capturing the comprehensive performance of competitiveness [35].

By integrating these two methods, the study leverages the objectivity of entropy-based weighting and the decision-ranking robustness of TOPSIS, making it well-suited for multi-dimensional and complex indicator analysis. Theoretically, this approach addresses common limitations in existing tourism competitiveness assessments, such as the insufficient integration of objective and subjective factors and the overly static nature of evaluation dimensions. It also extends the analytical framework of the World Economic Forum's Travel and Tourism Competitiveness Index Report, particularly the dimensions of "basic resources – service environment – perceived output".

For spatial analysis and classification, the calculated c_i values were visualized using ArcGIS 10.8.1 and classified into three levels of competitiveness: high ($c_i \geq 0.6$), medium ($0.3 \leqslant c_i < 0.6$), and low ($c_i < 0.3$). The resulting spatial distribution maps reveal the structural characteristics across the region and highlight a distinct core – periphery pattern and its spatial evolution over time [36].

Entropy weight is an objective assignment method, which is mainly based on the concept of information entropy to determine each indicator [37]. In the comprehensive evaluation of the weight, the advantage of the entropy weight method is that it can take into account the interrelationship between the evaluation indicators and avoid problems such as subjective assignment and inconsistency [38]. The specific process is as follows:

1) The matrix of the factors influencing the competitiveness of brand tourism in the YRDCC is evaluated based on five guideline layers: comprehensive strength of the city, scale of brand tourism development, brand tourism resources, brand tourism service level, and environmental quality. By constructing the original matrix Y_{ij} , where, m represents the number of evaluated cities and n represents the number of indicators, the calculation formula is as follows:

$$X_{ij} = [X_{ij}]_{m \times n} \tag{1}$$

2) The data of 20 indicators across five criterion layers, representing the branded tourism competitiveness and its influencing factors in the YRDCC, undergoes standardization to ensure the values fall within the range of [0-1]. In the formula, the original value of the *j*-th indicator for the *i*-th unit is denoted as X_{ij} , and its standardized value is denoted as X'_{ij} .

For the positive indicators of brand tourism competitiveness and influencing factors of the YRDCC, the standardization formula is as follows:

$$X'_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})} \tag{2}$$

For the negative indicators of brand tourism competitiveness and influencing factors of the YRDCC, the standardized treatment formula is as follows:

$$X'_{ij} = \frac{\max(x_{ij}) - x_{ij}}{\max(x_{ij}) - \min(x_{ij})} \tag{3}$$

3) Calculate the data entropy value $1\,e_j$ and data utility value of the branded tourism competitiveness and influencing factor indicators of the YRDCC d_j .

$$\mathrm{e_j} = -k\left[\sum_{i=1}^{n} p_{ij} \ln\left(p_{ij}\right)\right] \tag{4}$$

$$d_j = 1 - e_j \tag{5}$$

Formula:

$$P_{ij} = \mathrm{X}'_{ij} / \sum_{i=1}^{n} x'_{ij}, K = 1/\ln(n) e_j$$

4) According to the information entropy value e_j of the *j*-th indicator of brand tourism competitiveness and influencing factors of the YRDCC, As can be seen, the larger the entropy value of the brand tourism competitiveness and influencing factors indicators of the YRDCC, the smaller its role in the comprehensive evaluation of competition and the smaller the weight; conversely, the larger the weight. Under the *j*-th indicator, the weight of year *i* in this indicator is set to p_{ij}. (4) Determine the weights of evaluation indicators based on the 20 indicators identified for brand tourism competitiveness in the YRDCC.

$$w_{ij} = (1 - e_j) / \sum_{j=1}^{m} (1 - e_j) \tag{6}$$

Formula:

$$0 \le w_i \le 1$$

Through the TOPSIS model, a certain number of brand tourism competitiveness evaluation indexes and influencing factors are selected for different evaluation areas of individual cities in the YRDCC. The proximity distance of each selected region is calculated by the model. The model is used to calculate the proximity distance of each region. Therefore, the optimal solution is determined based on the comprehensive consideration of the advantages and disadvantages of each evaluation object. The results of the TOPSIS model are intuitive, and the closer the distance indicates the better the solution. The specific calculation steps are as follows:

1) Determining the Positive Ideal Solution x^+ and Negative Ideal Solution x^- of the brand tourism competitiveness of the YRDCC and its Influencing Factors:

$$\begin{aligned} x^+ &= (\max\{x_{11}, x_{21}, \cdots, x_{m1}\}, \\ &\max\{x_{12}, x_{22}, \cdots, x_{m2}\}, \cdots, \\ &\max\{x_{1n}, x_{2n}, \cdots, x_{mn}\}) \\ &= (x_1^+, x_2^+, \cdots, x_n^+) \end{aligned} \tag{7}$$

$$\begin{aligned} x^- &= (\min\{x_{11}, x_{21}, \cdots, x_{m1}\}, \\ &\min\{x_{12}, x_{22}, \cdots, x_{m2}\}, \cdots, \\ &\min\{x_{1n}, x_{2n}, \cdots, x_{mn}\}) \\ &= (x_1^-, x_2^-, \cdots, x_n^-) \end{aligned} \tag{8}$$

2) Calculate the distance between the values of the indicators of the brand tourism competitiveness of the YRDCC and its influencing factors and the positive and negative ideal solutions:

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (x_j^+ - x_{ij})^2} \tag{9}$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} (x_j^- - x_{ij})^2} \tag{10}$$

3) Calculating the proximity between the evaluation object and the ideal solution of the brand tourism competitiveness of the YRDCC and its influencing factors c_i:

$$c_i = \frac{D^-}{D^+ + D^-}, 0 < C_i < 1 \tag{11}$$

The larger the price of c_i, the better the factors are in terms of their influence on the brand tourism competitiveness of the YRDCC. On the contrary, it indicates that these factors have less influence on the brand tourism competitiveness of the YRDCC.

B. Study Area

The YRDCC, comprising 27 cities across Shanghai, Jiangsu, Zhejiang, and Anhui, is one of China's most economically dynamic and urbanized regions (Fig. 1) [39]. Although it occupies less than 2.5% of the national land area, it contributes over one-quarter of China's GDP and industrial output, making it a core engine of national economic development [40]. In recent years, the YRDCC has also emerged as a pioneer in culture-tourism integration, with rapid growth in creative industries [41], digital tourism, and high-end tourism services — laying a solid foundation for the development of high-quality tourism brands [42].

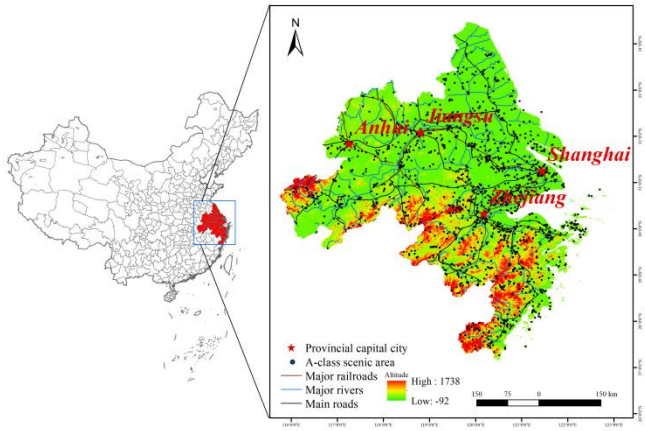

Fig. 1. YRDCC study area.

The YRDCC boasts both rich cultural heritage and modern urban attractions. It is home to nationally significant cultural sites such as Song Dynasty heritage, West Lake, the Grand Canal, and Huizhou ancient villages, alongside globally recognized destinations like Shanghai Disneyland, the Bund, Yellow Mountain, and Wuzhen [43]. Compared to other urban clusters such as the Beijing-Tianjin-Hebei region or the Guangdong-Hong Kong-Macao Greater Bay Area, the YRDCC polycentric structure and dense inter-city networks offer stronger potential for regional coordination and market integration [44]. However, disparities in tourism brand development persist across cities [45].

Core cities such as Shanghai and Hangzhou have successfully established internationally recognized tourism brands—Shanghai leveraging its global metropolitan image, and Hangzhou enhancing its "Song Dynasty culture" through digital innovation [46]. However, cities like Ningbo and Hefei, despite having abundant tourism resources, remain less competitive in brand development due to limited marketing capacity, weak regional coordination, and inconsistent policy support [47]. Moreover, as sustainability becomes a central benchmark in global tourism governance, many cities in the YRDCC have yet to fully integrate considerations such as environmental carrying capacity, ecological protection, and cultural preservation into their tourism strategies [48], These gaps not only impede the long-term development of tourism brands but also weaken their global competitiveness. Understanding the internal disparities and underlying drivers of brand tourism performance within the region is therefore essential for promoting coordinated, high-quality tourism growth and offering valuable insights for other urban clusters in China.

C. Establishment of an Indicator System

To scientifically evaluate the brand tourism competitiveness of cities in the YRDCC Agglomeration (YRDCC), this study constructs a three-tier comprehensive evaluation index system, encompassing a target layer, five criteria categories (B1 – B5), and 20 measurable and traceable secondary indicators (C1 – C20) (Table I). The system is designed to capture five essential dimensions: resource endowment, market scale, service capacity, ecological support, and digital communication effectiveness.

The indicator framework was developed in accordance with the principles of scientific rigor, quantifiability, and systematic logic. It is grounded in internationally recognized evaluation systems, including the UN World Tourism Organization (UNWTO) performance domains and the World Economic Forum (WEF) Travel & Tourism Competitiveness Index (TTCI), as well as policy documents and evaluation norms issued by China's Ministry of Culture and Tourism (MCT). The indicators have been refined to reflect the local context of the YRDCC, aligning global benchmarking with region-specific development practices. Each of the 20 indicators was selected based on three criteria: 1) Theoretical relevance to brand tourism competitiveness, 2) Empirical accessibility based on reliable multi-year statistical records (2019 – 2023), and 3) Data comparability and public transparency across all 27 cities in the YRDCC.

TABLE I. INDICATORS OF EVALUATION FACTORS OF BRAND TOURISM COMPETITIVENESS

Target Level	Criteria	Indicator Level	Unit	Indicator Direction
A Dynamic Assessment of Branded Tourism Competitiveness in the Yangtze River Delta City Cluster Agglomerations	B1 Comprehensive strength of the city	C1 GDP per capita	billion	+
		C2 Regional GDP	billion	+
		C3 Share of tertiary GDP	percent	+
		C4 Proportion of employment in the tertiary sector	percent	+
		C5 Total retail sales of consumer goods	billion	+
	B2 Brand Tourism Development Scale	C6 Domestic Tourism	million	+
		C7 Number of international tourists	million	+
		C8 Domestic branded tourism revenue	billion	+
		C9 Foreign exchange earnings from branded tourism	billion	+
	B3 Brand tourism resources	C10 Natural landscape resources	one	+
		C11 Number of historical and cultural sites	one	+
		C12 Branded Event Resources	one	+
		C13 Word-of-mouth evaluation of city tourism brands by tourists and the public	Point scale	+
	B4 Brand tourism service level	C14 Number of star-rated hotels	one	+
		C15 Number of tourist agencies	one	+
		C16 Number of public restrooms	one	+
		C17 Number of museums	one	+
		C18 Cultural and brand communication organizations	one	+
	B5 Urban environmental quality	C19 Green space coverage rate of built-up areas	pieces	+
		C20 Green space per capita	m^2/person	+

The majority of the data were obtained from government-authorized sources, primarily national and provincial statistical yearbooks. Statistical Yearbooks: China City Statistical Yearbook, China Urban Construction Statistical Yearbook, Provincial and municipal yearbooks (e.g. Shanghai Statistical Yearbook, Anhui Statistical Yearbook). Official Bulletins and Thematic Reports, China Culture and Tourism Development Statistical Bulletin (Ministry of Culture and Tourism, 2019 – 2023) Annual Work Reports from local Bureaus of Culture and Tourism across Jiangsu, Zhejiang, and Anhui. Public

Databases and API Platforms: National Data Platform (data.stats.gov.cn), Online travel platforms (Ctrip, Dianping, Mafengwo) for indicators such as C13 Visitor Reviews, using NLP-based sentiment analysis and expert-weighted scoring. Mapping and POI services (Gaode Map, Baidu Map API) for facility density and infrastructure coverage indicators.

Based on the multidimensional structure of urban brand tourism competitiveness, this study establishes an evaluation framework comprising five key criteria: urban comprehensive strength, scale of brand tourism development, brand tourism resources, quality of brand tourism services, and urban environmental quality, thereby forming a systematic indicator system.B1 Urban Comprehensive Strength reflects a city's economic foundation and development potential, serving as a fundamental support for building its tourism brand. This criterion includes five indicators (C1 – C5): per capita GDP, total regional GDP, the proportion of the tertiary industry, employment in the tertiary sector, and total retail sales of consumer goods. These indicators evaluate the city's overall development level in terms of economic output, industrial structure, and consumer vitality. B2 Scale of Brand Tourism Development represents the degree of tourism development and market attractiveness. Indicators C6 to C9 measure the number of domestic and international tourists received and related tourism revenues, providing a direct reflection of the size of the tourism market and its economic contribution. B3 Brand Tourism Resources focus on assessing the city's natural endowments and cultural characteristics. Indicators C10 to C13 include natural landscapes, historical and cultural heritage sites, branded event resources, and visitor reviews — collectively capturing the city's tourism appeal and brand perception. B4 Quality of Brand Tourism Services emphasizes the supply capacity and experiential quality of tourism services. Indicators C14 to C18 include the number of star-rated hotels, travel agencies, public restrooms, museums, and cultural or brand communication institutions, reflecting the city's capabilities in service provision and cultural promotion. B5 Urban Environmental Quality is assessed using indicators C19 and C20: the green coverage rate in built-up areas and per capita green space. These indicators evaluate the city's ecological livability and capacity for sustainable development.

This study further proposes a five-dimensional interactive model—Economy – Resources – Services – Communication – Environment — highlighting the systematic coupling and dynamic synergy among various indicators. Urban economic strength supports the development of infrastructure and service systems, providing the material foundation for the expansion of brand tourism. Rich tourism resources are the core attraction for visitors, but their value realization depends on the service system's carrying capacity and management efficiency. The quality of tourism services and the effectiveness of digital communication directly influence visitor satisfaction and brand reputation, fostering brand loyalty and enhancing urban competitiveness. A high-quality ecological environment not only improves the visitor experience but also ensures the sustainability of brand tourism. Meanwhile, digital content dissemination and feedback mechanisms based on tourist behavior further promote the visibility and communication efficiency of the city brand.

III. Results

A. Analysis of Factors of City Brand Tourism Competitiveness

B1 — Urban Comprehensive Strength: This dimension reflects a city's economic foundation and its capacity to support tourism infrastructure, service provision, and brand promotion — factors that are critical to enhancing tourism competitiveness. According to the data, Shanghai ranks first with an overwhelming score of 0.705, significantly ahead of other cities. Wenzhou (0.511) and Suzhou (0.503) follow in second and third place, respectively, indicating that robust economic development provides a strong foundation for tourism competitiveness. Although Nanjing (0.463) and Hangzhou (0.483) score slightly lower, their relatively balanced performance suggests solid economic bases and well-developed service sectors. In contrast, cities such as Chuzhou (0.046) and Tongling (0.051) remain at the bottom, reflecting limitations in resource allocation and industrial structure (Fig. 2). Overall, the distribution of scores in this dimension reveals a distinct pattern: strong concentration at the top, moderate clustering in the middle, and dispersion at the lower end.

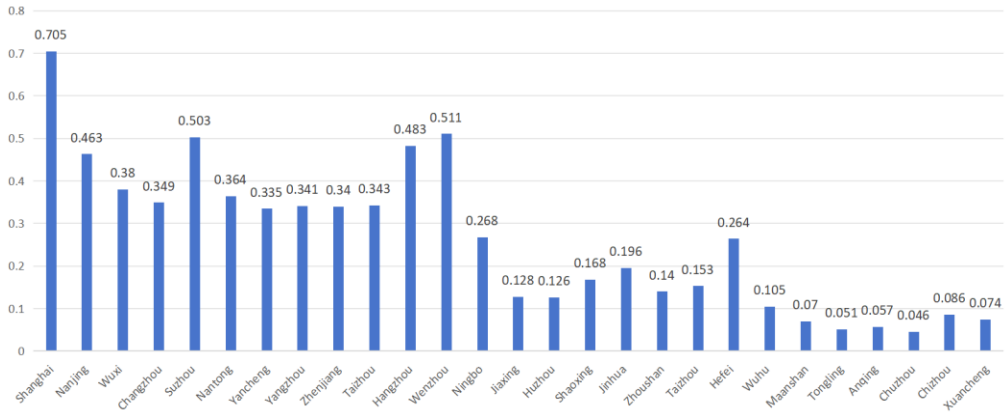

Fig. 2. B1 score distribution.

B2 — Scale of Branded Tourism Development: This dimension evaluates the external expansion capacity of the tourism market. Shanghai (1.000) significantly outperforms all other cities, demonstrating a dominant market scale and a strong brand-driven "magnetic effect" that attracts tourists across the region. Suzhou (0.578) ranks second, reflecting robust tourism reception capacity and efficient conversion of tourism flows into economic returns. Cities in the mid-range, such as Nanjing (0.226) and Wuxi (0.168), exhibit steady growth in both visitor numbers and tourism revenue, indicating solid development potential. In contrast, cities like Yancheng (0.015) and Taizhou (0.019) show limited tourism activity and weak foundational support. Overall, the distribution of scores in this dimension reveals a pronounced polarization: top-tier cities benefit from well-developed tourism ecosystems, while lower-tier cities remain in the early stages of development (Fig. 3). These cities must draw lessons from leading counterparts, particularly in enhancing the quality of tourism offerings and improving service capabilities.

B3—Branded Tourism Resources: This dimension reflects a city's tourism appeal and its cultural communication foundation. Notably, Yancheng (0.560), Hefei (0.445), and Wuhu (0.404) rank among the top three, indicating that certain cities in Anhui Province have demonstrated strong performance in integrating natural and cultural resources. For instance, Hefei benefits from the promotion of Binhu cultural assets and branded events, while Wuhu effectively leverages its rich historical heritage. Conversely, cities such as Zhoushan (0.072) and Jiaxing (0.080), despite possessing considerable resource endowments, exhibit underdeveloped capabilities in brand development and public communication. The overall distribution of scores in this dimension is relatively balanced (primarily within the 0.1 – 0.4 range), suggesting that while most cities hold comparable levels of tourism resources, their ability to transform these assets into recognizable and marketable tourism brands varies significantly (Fig. 4).

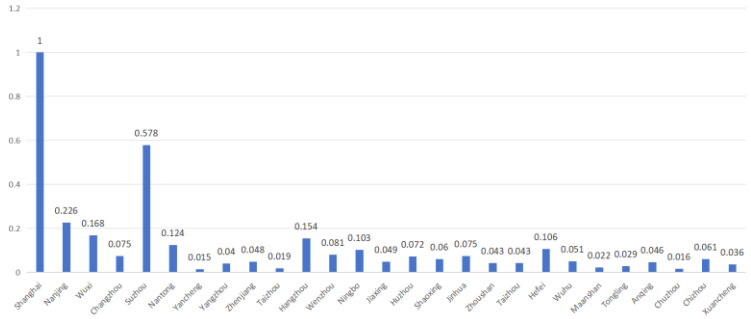

Fig. 3. B2 score distribution.

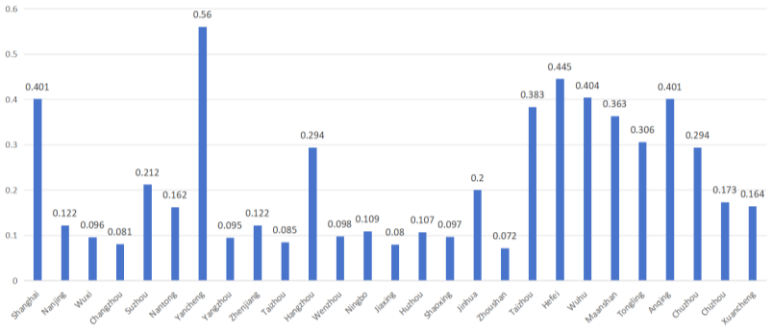

Fig. 4. B3 score distribution.

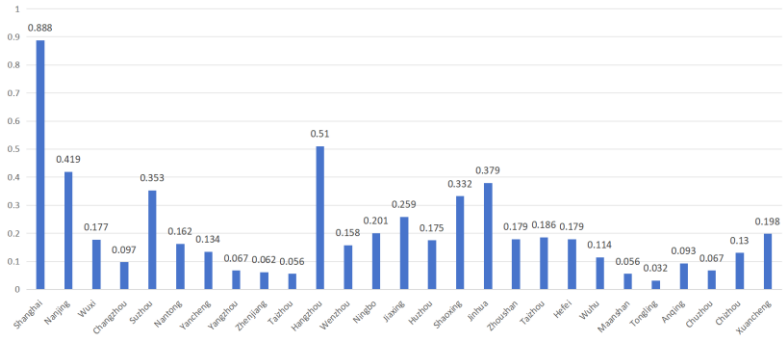

Fig. 5. B4 score distribution.

B4—Branded Tourism Service Level: Service capacity constitutes the perceptual foundation of a city's tourism competitiveness. The data show that Shanghai (0.888) ranks first, with significant advantages in high-end hotel availability, cultural and tourism facilities, and brand communication institutions. Hangzhou (0.510) and Nanjing (0.419) follow closely, indicating relatively well-developed service systems. In contrast, cities such as Tongling (0.032), Chuzhou (0.067), and Zhenjiang (0.062) exhibit notably lower scores, reflecting outdated infrastructure and limited tourism reception capacity (Fig. 5). The wide score range in this dimension highlights pronounced disparities among cities and demonstrates that investment in tourism services directly influences public perception and word-of-mouth dissemination of the city's brand.

B5—Urban Environmental Quality: Ecological livability has become increasingly intertwined with the sustainable development of tourism. Cities, such as Chizhou (0.819), Huzhou (0.764), and Yangzhou (0.752) lead in this dimension, reflecting outstanding performance in green space coverage and ecological preservation. In contrast, major urban centers like Shanghai (0.000) and Wenzhou (0.191) score significantly lower, largely due to high urbanization levels that constrain ecological space (Fig. 6). Scores in this dimension are broadly distributed between 0.2 and 0.8, indicating a relatively balanced performance overall. This suggests that in several cities, ecological civilization efforts have effectively translated into tourism advantages.

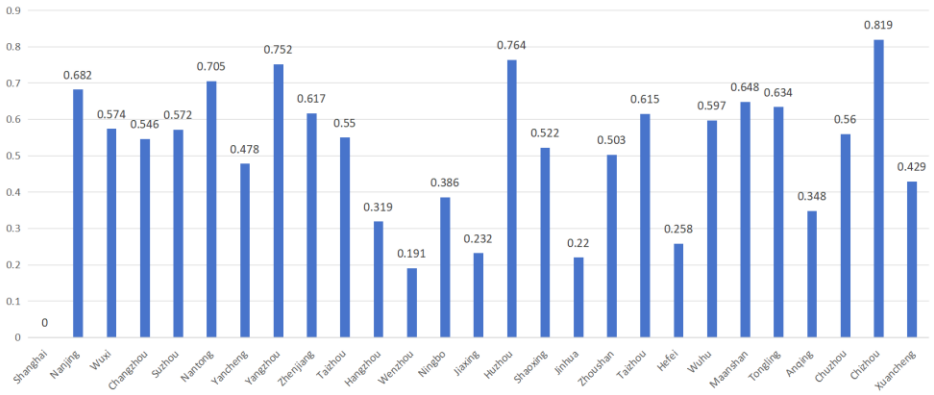

Fig. 6. B5 score distribution.

This study develops a five-dimensional interactive model—Economy – Resources – Services – Communication – Environment—to highlight the systemic synergy among the core components of brand tourism competitiveness. Specifically, urban comprehensive strength (B1) provides the financial and policy foundation for tourism development; resource endowment (B3) constitutes the fundamental appeal to tourists; service quality (B4) shapes visitor experience and word-of-mouth dissemination; development scale (B2) reflects the market transformation capacity of tourism; and environmental quality (B5) underpins the long-term sustainability of tourism systems. In practical application, high-performing cities such as Shanghai and Hangzhou can leverage their institutional resources and brand advantages to establish regional "flagship demonstration zones"—offering replicable models in areas such as infrastructure development, brand communication, and green tourism governance. In contrast, lower-performing cities like Chuzhou and Tongling may benefit from adopting mechanisms such as cross-regional tourism passes, shared resource platforms, and joint marketing strategies, thereby enhancing brand visibility and improving tourism service capacity through collaborative growth. To improve the comparability and validity of soft indicators, particularly the tourist sentiment index (C13), this study integrates social media data crawling techniques with expert scoring mechanisms, enabling data standardization and objectivity Supporting Information (S1 Table). Additionally, Gaode Map and Baidu Map APIs are employed to enhance the spatial granularity in the measurement of tourism service infrastructure, thus improving the analytical precision of the service dimension. Overall, the brand tourism competitiveness of the YRDCC exhibits pronounced characteristics of multidimensionality, imbalance, and regional differentiation. The proposed indicator system not only uncovers structural disparities across cities in terms of competitiveness factors but also offers a practical framework for future policy optimization and regional coordination. Subsequent research may further integrate visitor movement patterns, smart tourism platform data, and other real-time dynamic indicators to construct a more adaptive and time-sensitive evaluation system for urban tourism competitiveness.

B. Synthesize and Analyze

This study employs the entropy-weighted TOPSIS method to dynamically evaluate the overall performance of brand tourism competitiveness across 27 cities in the YRDCC from 2019 to 2023. The relative closeness to the ideal solution is used as a metric to assess how closely each city's tourism performance aligns with the optimal scenario-the closer the value is to 1, the stronger the competitiveness. Calculate the relative proximity of each city through the formula $c_i = \frac{D_i^-}{D_i^+ + D_i^-}$, where, D_i^+ is the distance of the city from the ideal solution and D_i^- is the distance of the city from the negative ideal solution. The evaluation process involves the following steps: First, the optimal (maximum) and anti-optimal (minimum)

values for each indicator are identified. Second, the Euclidean distances between each city and both the ideal and anti-ideal solutions are calculated. Finally, each city's comprehensive score is derived based on the relative closeness formula. Furthermore, ArcGIS 10.8.1 is employed to visualize the spatial distribution of competitiveness levels (Fig. 7), thereby revealing the spatiotemporal evolution [33] of brand tourism competitiveness over the study period.

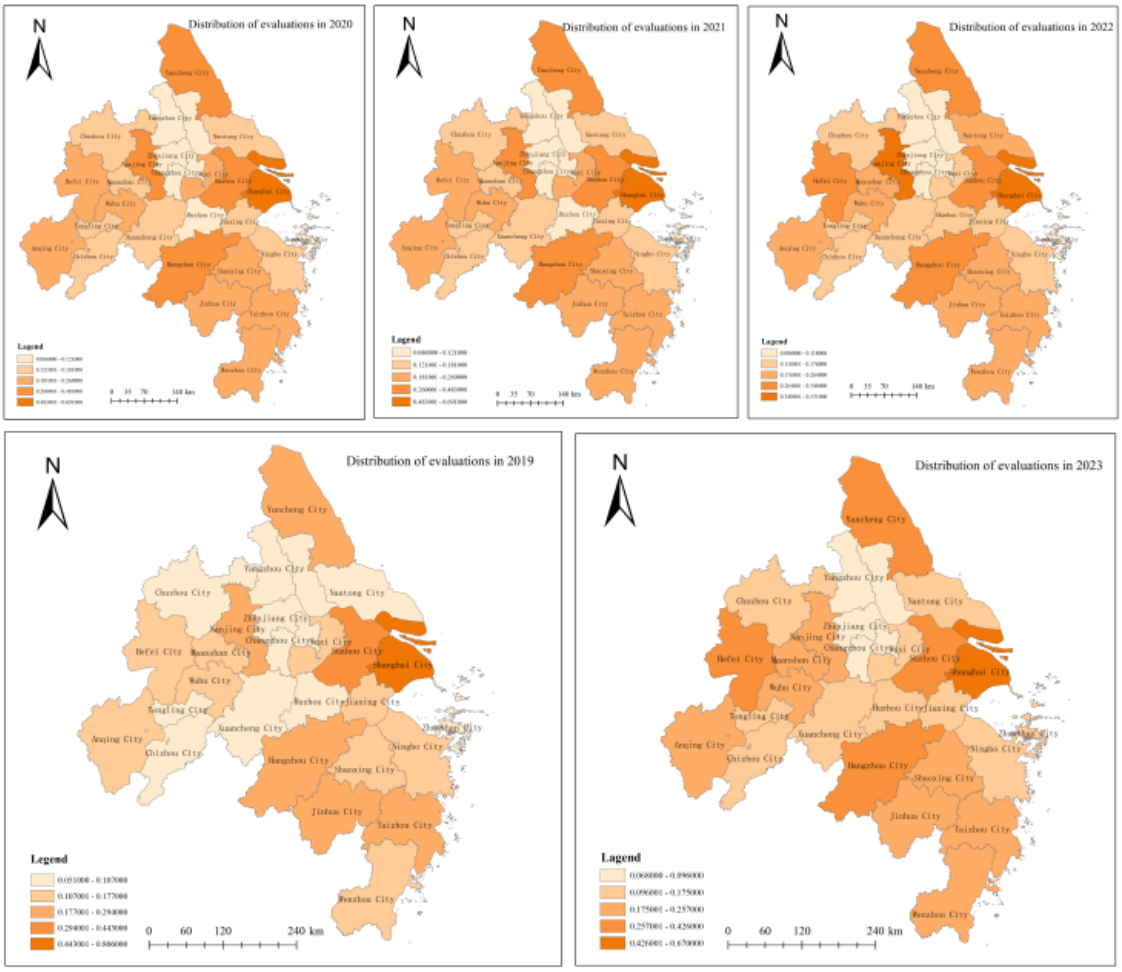

Fig. 7. Evaluation Distribution of the YRDCC.

High-performing and stable cities such as Shanghai, Suzhou, and Hangzhou have consistently maintained strong brand tourism competitiveness (Table II). From 2019 to 2023, Shanghai remained in the top position, with its relative closeness score ranging from 0.892 to 0.901. This reflects its comprehensive advantages in economic strength, international brand development, well-developed service infrastructure, and the effective integration of cultural resources, positioning it as a leading driver in regional brand tourism. Suzhou (0.601 – 0.624) and Hangzhou (rising from 0.538 to 0.689) demonstrated steady and coordinated development between brand cultivation and resource utilization, with continued efforts particularly in digital tourism, cultural and creative industries, and the provision of high-end tourism services. Cities with steadily rising performance, such as Hefei, Nantong, and Ningbo, also show promising momentum. Hefei advanced from 8th place in 2019 to 6th in 2023, with a 30.3% increase in its relative closeness score, indicating continuous progress in tourism infrastructure, investment in cultural tourism projects, and integrated brand communication. Nantong and Ningbo have achieved slow but steady gains by optimizing resource allocation and enhancing service quality. In contrast, cities showing significant decline, such as Zhenjiang and Yangzhou, have seen their rankings drop notably. Zhenjiang fell from 7th in 2019 to 12th in 2023 (a decline of 11.4%), while Yangzhou dropped from 6th to 11th (a decline of 13.1%). These setbacks are primarily attributed to lagging brand marketing, low resource utilization, and insufficient transportation connectivity. This suggests that small and medium-sized cities face the risk of marginalization if tourism strategies are not timely adjusted. The data reveal a clear trend of polarization and structural imbalance. The distribution of relative closeness scores exhibits a "top-heavy, sparse middle, scattered tail" pattern. For instance, in 2023, the gap between Shanghai (0.901) and Hefei (0.615) was considerable, while most mid- and lower-ranking cities clustered between 0.3 and 0.45. This indicates persistent disparities in critical factors such as infrastructure, brand maturity, and ecological support across the region.

TABLE II. BRANDED TOURISM RESPONSE FOR THE YRDCC, 2019-2023.

Items	D_i^+	D_i^-	c_i	Ranking
R1	0.72	0.77	0.79	1
R2	1.51	1.77	2.15	5
R3	3.87	4.8	5.96	15
R4	6.08	7.57	9.44	24
R5	0.8	0.92	1.04	2
R6	3.65	4.49	5.58	14
R7	1.24	1.47	1.76	4
R8	6.56	8.18	10.21	26
R9	6.32	7.87	9.82	25
R10	6.81	8.49	10.59	27
R11	1	1.17	1.37	3
R12	3.15	3.89	4.81	12
R13	4.11	5.1	6.34	16
R14	4.36	5.42	6.73	17
R15	5.61	6.97	8.68	22
R16	2.9	3.57	4.42	11
R17	1.93	2.36	2.88	7
R18	5.84	7.27	9.06	23
R19	2.17	2.65	3.26	8
R20	1.71	2.07	2.51	6
R21	2.42	2.97	3.65	9
R22	3.39	4.19	5.19	13
R23	4.62	5.74	7.13	18
R24	2.66	3.28	4.03	10
R25	4.87	6.04	7.51	19
R26	5.35	6.66	8.28	21
R27	5.11	6.35	7.9	20

High-performing cities should further extend the reach of their brand communication by developing high-end international tourism products and globally influential cultural IPs. They are also encouraged to continue serving as hubs of innovation and leadership, radiating positive effects to surrounding cities and driving regional integration. Mid-tier cities should focus on deeply exploring their unique cultural characteristics and establishing differentiated market positioning. Strengthening mechanisms for inter-city cooperation and regional coordination is essential to enhance the overall brand value chain and achieve synergistic development. Lower-performing cities need to adopt targeted improvement strategies. These include enhancing transportation connectivity, diversifying tourism product offerings, and encouraging the entry of private capital into the cultural and tourism sectors. Additionally, they can learn from the best practices of high-performing cities through "contextualized transplantation" and joint promotional efforts, thereby accelerating their competitiveness in a more customized and collaborative manner.

IV. DISCUSSION

A. Theoretical and Practical Significance

Theoretical significance: First, this study expands the multidimensional measurement framework of urban brand development. While traditional research on city branding has primarily focused on subjective dimensions such as perceived identity and image construction, this study introduces objective indicators — including resources, services, environment, and economy — into a systematic model. By filling the theoretical gap in the quantifiable assessment of city brands, the research contributes to shifting the focus of brand tourism from impression-based narratives to comprehensive competitiveness evaluation. Second, the study enriches the methodological foundation for assessing regional tourism synergy and competitiveness. By employing the TOPSIS model in combination with the entropy weight method, this research is among the first to systematically evaluate inter-city differences and structural characteristics of brand tourism competitiveness at the scale of Chinese urban agglomerations. It reveals the weighting mechanisms of key success factors — such as resource transformation, service provision, and ecological capacity — in the process of brand development, thereby enhancing the explanatory power and practical applicability of the theoretical model. Third, the study responds to the theoretical proposition of "structural disparities and collaborative governance" in urban tourism competitiveness. By empirically analyzing the performance of cities across five dimensions (B1 – B5) and their complementary relationships, this research concretizes the concepts of "coordinated development" and "complementary advantages". For instance, core cities such as Shanghai can foster brand enhancement in peripheral cities through infrastructure spillovers and institutional connectivity. Conversely, lower-tier cities may reduce market entry barriers via collaborative resource allocation and coordinated marketing, jointly advancing the formation of a multi-layered and interactive regional brand competitiveness framework.

Relevance: First, the study supports China's national strategy for promoting coordinated regional development. As brand tourism is one of the core pillars of YRDCC integration, the findings help accurately identify the relative position and weaknesses of each city within the brand competitiveness system. This provides a valuable data foundation for the coordinated allocation of cultural and tourism resources, cross-regional integration, and targeted policy implementation. Second, it contributes to enhancing the international communication capacity and cultural influence of urban agglomerations. In the context of globalization, brand tourism serves as a key vehicle for cities to participate in international discourse and cultural exchange [50]. The study highlights how cities such as Hangzhou and Hefei have elevated their brand levels through smart tourism platforms and international events, illustrating the critical role of branding in embedding cities into global tourism networks. Third, the research facilitates regional complementarity and structural optimization. By uncovering structural disparities among cities across dimensions such as resources, services, and the environment, it proposes replicable branding strategiesz, such

as “flagship-driven development”, “differentiated positioning”, and “ecological synergy”, offering theoretical support for constructing a tourism development model based on “differentiated positioning + coordinated integration”.

B. Competitiveness Analysis and Policy Recommendations

This study employs the entropy-weighted TOPSIS model to construct a comprehensive evaluation system comprising five criterion layers and 20 core indicators, enabling an effective assessment of the hierarchical characteristics of brand tourism competitiveness across the YRDCC. The findings reveal significant disparities among cities in terms of economic foundations, resource endowments, service infrastructure, and ecological environment—factors that fundamentally drive the differentiation in tourism competitiveness.

Cities such as Shanghai and Hangzhou have consistently ranked among the top in tourism competitiveness, owing to their strong economic foundations, high tourism reception capacity, and significant international influence. However, they also face challenges such as sluggish brand renewal and mounting ecological pressures. It is recommended that these cities further enhance their leadership by developing "regional tourism flagship demonstration zones" and strengthening resource sharing and brand collaboration with neighboring cities — through initiatives such as the YRDCC Cultural Tourism Expo and joint city marketing platforms. Additionally, adopting green tourism policies, including low-carbon transportation and carbon-neutral scenic areas, can help alleviate ecological constraints and sustain their global competitiveness.

Cities such as Suzhou and Ningbo possess rich cultural resources and robust manufacturing bases, but their levels of brand recognition remain moderate. However, they still face limitations in the provision of high-end services and international outreach. To bridge these gaps, targeted efforts should be made to develop distinctive cultural IPs (intellectual properties) that highlight local heritage and creativity. For example, Suzhou could deepen the digital presentation of its classical garden culture, while Ningbo might highlight its “Maritime Silk Road” heritage and expand port-related tourism development. Furthermore, enhancing cooperation with international tourism organizations, such as introducing multilingual guided services and launching overseas advertising campaigns, can significantly improve both the appeal and service quality for international visitors [51].

Cities such as Yangzhou, Zhenjiang, and Taizhou face multiple challenges, including low brand visibility, underdeveloped infrastructure, and weak digital services. To enhance their competitiveness, priority should be given to improving transportation accessibility and tourism reception capacity through the development of high-grade hotels and visitor centers. Drawing on the successful experiences of nearby high-performing cities, these cities could adopt regional travel passes and integrated transportation systems to promote tourist mobility and resource complementarity. Additionally, efforts should be made to strengthen local festival brands, for example, Yangzhou could leverage the Slender West Lake Cultural Festival as a stable platform to attract visitors and enhance brand recognition.

It is recommended that the entire region implement an integrated green tourism development strategy. Small and medium-sized cities can enhance their ecological brand value by jointly developing ecological corridors and launching collaborative low-carbon tourism routes. The promotion of green transportation option, such as electric vehicles and public bicycles, alongside the establishment of smart management systems will enable real-time monitoring of tourism resources and environmental carrying capacity. These measures will collectively strengthen the region’s capacity for sustainable tourism competitiveness.

C. Domestic and International Case Studies and Lessons

Enhancing tourism competitiveness requires more than abundant resource endowments; it hinges on the synergistic interaction of institutional innovation, cultural identity, and environmental sustainability [49]. The following representative cases offer valuable lessons for the YRDCC in its pursuit of high-quality and differentiated tourism development.

Kyoto, Japan-Cultural Continuity through Festival Branding, Kyoto exemplifies how traditional cultural assets can be embedded into everyday urban life and tourism practice. Through the preservation of historical architecture and the regular hosting of festivals such as the Gion Matsuri, Kyoto has institutionalized cultural rituals that enhance visitor loyalty and deepen place-based identity. For cities in the YRDCC, this suggests the value of a “cultural embedding” strategy — transforming intangible cultural heritage, such as Jiangnan water-town traditions, into dynamic experiences via immersive tourism formats like themed performances, cultural fairs, and participatory heritage events.

Florence, Italy-Balancing Heritage Conservation with Tourism Development, Florence demonstrates how cultural heritage and tourism can coexist through well-designed institutional frameworks. Mechanisms such as “cultural usage rights” and designated “historic architecture control zones” enable the city to maintain cultural authenticity while promoting adaptive reuse. These practices offer policy implications for YRDCC cities, particularly Suzhou and Anhui’s Huizhou villages, which face similar pressures to reconcile heritage conservation with increasing tourism demands. Drawing on Florence’s approach could support the development of sustainable, heritage-based tourism strategies across the YRDCC.

Freiburg, Germany – Advancing Green Transformation in Urban Tourism, Freiburg’s reputation as a “green city” stems from its successful integration of environmental goals into tourism planning. Through the development of low-carbon scenic zones, comprehensive public transit networks, and environmentally certified accommodations, Freiburg exemplifies ecologically responsible tourism. Given the environmental constraints faced by the densely populated urban cores of the YRDCC, this case underscores the need to formulate regional “low-carbon tourism development guidelines,” implement ecological carrying capacity assessments in popular destinations, and encourage responsible visitor behavior through policy incentives and public education.

Pearl River Delta (PRD) vs. YRDCC: Divergent Pathways of Tourism Competitiveness. A domestic comparative analysis between the PRD and YRDCC highlights their divergent strategic orientations in tourism development. The PRD, encompassing cities such as Guangzhou, Shenzhen, and Zhuhai, has pursued a market-oriented, globally integrated model, leveraging mechanisms such as free trade zones, port infrastructure, and large-scale commercial events (e.g. Canton Fair, Shenzhen Tech Expo) to drive tourism growth. This model prioritizes volume, innovation, and modern leisure consumption.

By contrast, the YRDCC adopts a development logic centered on cultural preservation, ecological balance, and regional coordination. Cities like Hangzhou and Suzhou have cultivated tourism brands rooted in Jiangnan cultural identity, integrating heritage conservation with high-quality visitor experiences. While the PRD excels in infrastructure openness and digital marketing, it faces challenges in fostering cohesive cultural narratives and safeguarding intangible heritage. The YRDCC, though more conservative in its pace of innovation, offers a more sustainable and culturally enriched model through its emphasis on regional synergy and ecological tourism. This comparison suggests that the YRDCC could benefit from selectively adopting the PRD's strengths in digitalization and international outreach, while offering in return a replicable model of integrated, heritage-centered, and ecologically sustainable tourism development. Such a synthesis would allow both regions to enhance their competitiveness while aligning with global trends toward responsible and differentiated tourism branding.

D. Research Limitations and Future

This study has carried out in-depth exploration in the construction of the indicator system and assessment methods, but the following limitations still exist. First, data acquisition limitations, part of the city tourism-related data is not detailed enough, the future should be introduced to improve data collection by means of big data monitoring, tourist satisfaction surveys and other means. Second, dynamic monitoring is insufficient, failing to fully reveal the long-term impact of policy changes and other external factors on tourism, it is recommended to combine with the panel data model to dynamically monitor the evolution mechanism of competitiveness in the future. Third, the integration of multi-source data, the current assessment mainly relies on macro statistics, in the future, social media data, tourists' word-of-mouth evaluation and other information sources can be introduced to enrich the research dimension. Fourth, smart tourism and digital development, in the future, attention should be paid to the empowerment of smart tourism platforms and digital management tools on the competitiveness of city brands, and explore the role of digital technology in promoting the upgrading of the cultural and tourism industry.

V. CONCLUSIONS

This study focuses on the YRDCC and investigates the structural measurement and dynamic comparison of regional brand tourism competitiveness. A comprehensive indicator system was constructed, encompassing five dimensions: overall urban strength, scale of brand tourism development, tourism resources, service quality, and environmental conditions. The framework includes 20 secondary indicators, with clearly defined data sources and a scientifically grounded structure. It aligns closely with the World Economic Forum's framework for tourism competitiveness while incorporating region-specific factors such as digital communication and sustainable development. Using the entropy-weighted TOPSIS method, the study applies objective weighting to calculate the relative closeness of each city to an ideal solution. This enables a comprehensive evaluation of the overall performance, structural characteristics, and spatial evolution of brand tourism competitiveness among YRDCC during the period from 2019 to 2023.

The competitive landscape of brand tourism in the YRDCC region exhibits a spatial pattern characterized by "dominant leadership and distinct gradients." Cities like Shanghai and Hangzhou have consistently ranked at the top in terms of competitiveness, demonstrating strong capacities in resource integration, economic support, and brand diffusion. These cities are typical examples of "lagship cities". Meanwhile, cities such as Suzhou, Nanjing, and Ningbo maintain relatively stable performance in terms of cultural resources and tourist reception, yet still have room for improvement in global brand development and cultural IP export. At the lower end of the spectrum, cities like Chuzhou, Tongling, and Zhoushan struggle with underdeveloped infrastructure, weak digital services, and limited brand communication capacity, highlighting the ongoing issue of regional development imbalance. The indicators used in this study exhibit interrelated and synergistic effects. The proposed "Five-Dimensional Synergy" model reveals that: B1 (Overall Urban Strength) provides essential capital and policy support for tourism development; B2 (Development Scale) reflects market conversion and external expansion capacity; B3 (Resource Base) determines core attractiveness; B4 (Service Quality) influences tourist experience and word-of-mouth dissemination; B5 (Environmental Quality) serves as the foundation for building green tourism brands. These dimensions are highly interlinked across different cities, collectively shaping their brand tourism competitiveness structures. In terms of temporal evolution, cities such as Hefei and Hangzhou have shown notable upward momentum, each climbing two ranks, indicating that investments in smart tourism, infrastructure, and brand-related events have yielded significant results. In contrast, cities like Zhenjiang and Yangzhou have experienced a marked decline in competitiveness, reflecting delays in cultural-tourism integration, market responsiveness, and product innovation. Cities such as Shanghai and Suzhou continue to demonstrate stable and long-term competitive advantages, highlighting their strong resilience within the regional brand tourism system. From a spatial perspective, GIS-based visualization results reveal a "core – periphery" distribution pattern. High-competitiveness cities are mainly concentrated in the Shanghai – Jiangsu – Zhejiang corridor, whereas most cities in Anhui remain in developmental lowlands. Although cities like Chizhou and Wuhu possess ecological advantages, these have not yet been effectively transformed into brand strengths, underscoring the urgent need to enhance regional resource coordination mechanisms.

This study makes three key contributions at both theoretical and practical levels: First, it expands the theoretical framework for evaluating urban brand competitiveness, particularly by integrating heterogeneous indicators from multiple sources and combining objective and subjective data analysis. This approach addresses the existing gap in comprehensive understanding of city brand tourism in the current literature. Second, by constructing a five-dimensional interactive framework encompassing economy, resources, services, communication, and environment, the study strengthens the causal relationships and synergetic logic among indicators. This provides a more structured and coherent approach to modeling brand tourism competitiveness. Third, methodologically, the integration of the entropy-weighting method and the TOPSIS ranking model overcomes the limitations of traditional subjective weighting approaches. It enhances both the scientific rigor and operational feasibility of cross-city comparative analysis.

High-ranking cities such as Shanghai and Hangzhou should play a leading role by establishing regional "flagship demonstration zones". These cities can spearhead collaborative brand-building initiatives, including co-hosted festivals, inter-city tourism alliances, and shared platform mechanisms, to drive coordinated upgrades among mid- and low-ranking cities. Mid-level cities like Suzhou, Ningbo, and Hefei should focus on leveraging their unique resources and cultural symbols to strengthen differentiated brand positioning. Efforts should also be made to enhance international visibility and brand recognition. Lower-tier cities, including Chuzhou, Tongling, and Zhenjiang, should prioritize addressing infrastructure gaps and improving digital service capabilities. Through targeted policy support, strategic market partnerships, and in-depth cultural resource development, these cities can "scale up by leveraging external strengths". At the regional level, a green and low-carbon transformation should be actively pursued. By integrating ecological preservation with brand development, the YRDCC region can establish a model that combines "ecological space + smart management + green communication", thereby enhancing long-term sustainable competitiveness.

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INFORMED CONSENT STATEMENT

All participants in this study provided their informed consent.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors on request.

CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

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