International Journal for Housing Science and Its Applications
Publish August 10, 2025. Volume 46, Issue 4 Pages 6888-6898

https://doi.org/10.70517/ijhsa464594

Dynamic Evaluation Model and Application of Brand Effect of Architectural Culture and Tourism Industry under the Perspective of Spatio-Temporal Big Data--Taking the Brand of Historical Neighborhood as an Example

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Abstract In the context of globalized economic development, the architectural culture and tourism industry has become an important engine to promote regional economic growth. As the core element of enterprise competitive advantage, the scientific assessment of brand effect is of great significance to enhance the competitiveness of the industry. Traditional assessment methods often rely on static data, making it difficult to accurately reflect the dynamic change characteristics of brand value. The rapid development of spatio-temporal big data technology provides a new technical path for brand effect assessment, which can realize real-time monitoring and accurate analysis of brand value. This study constructs a dynamic assessment model of brand effect of architectural culture and tourism industry based on spatio-temporal big data, and adopts the AHP-FCE method to establish an assessment system containing 3 primary indicators, 10 secondary indicators and 26 tertiary indicators. Taking Beijing Shichahai Historical Neighborhood as an example, 204 valid questionnaires were obtained by distributing 248 questionnaires, with an effective recovery rate of 82.26%. The results show that: the overall score of brand effect is 4.021 points, which is at a good level; the weight of brand strength is the highest at 0.7530, of which the weight of brand development power reaches 0.3498; the annual number of tourists increases from 15.24 million in 2016 to 21.46 million in 2024, which is an increase of 40.81%; and the degree of media coverage reaches a peak in 2019 at 0.2152. The study shows that the assessment model can effectively quantify the brand effect and provide scientific basis for the brand construction of historical neighborhoods.

Index Terms spatio-temporal big data, architectural culture and tourism industry, brand effect, dynamic evaluation model, AHP-FCE method, historic district

I. Introduction

Historic neighborhood refers to with the development of the economy, we live in the city from the spatial structure, planning layout to the built environment has undergone a great change, some of the city's traditional neighborhoods with deep origins, often preserved a rich historical and cultural heritage and unique natural and humanistic landscapes, and they can reflect the strong local characteristics and ethnic customs [1]-[4]. With the development of the architectural culture and tourism industry, the brand effect of historical neighborhoods has made a significant contribution to the tourism economy, and it plays an important role in the marketing of historical neighborhoods by assessing their brand effect [5]-[7].

Brand effect refers to the cognition, image and attitude formed by the historic district in the minds of consumers [8], [9]. The brand effect of historic districts is influenced by various factors, including brand awareness, brand image, and brand relevance [10], [11]. The purpose of assessing the brand effect of historic districts is to understand the brand's influence on the market and to provide a basis for developing marketing strategies [12], [13]. First of all, the assessment of brand effect of historic districts can help management units to understand the current situation of historic district brands and the degree of their influence on target consumers, so that they can target the development of brand building and promotion strategies based on the results of the assessment to improve the market competitiveness, brand efficiency and market position [14]-[17]. Therefore, the brand management unit of the historic district should focus on the development and research of the assessment of the brand effect of the historic district in order to realize its creation of more excellent performance and reputation in marketing [18]-[20]. In the assessment, it is necessary to analyze the market competitive environment, understand the competitors' brand strategy and market share situation, as well as consumer demand changes and other aspects, and the

commonly used brand effect assessment indexes include brand awareness, brand image, brand relevance, brand loyalty, etc. [21]-[24].

At present, the integrated development of culture and tourism industry has become an important trend of global economic transformation and upgrading, and the architecture culture and tourism industry, as a core part of it, carries the dual mission of inheriting history and culture and promoting economic development. Brand effect, as a key indicator of industrial competitiveness, not only reflects the market value of the enterprise, but also its cognitive status and emotional connection in the minds of consumers. As a typical representative of architectural culture and tourism industry, the formation and development of brand value of historic districts have unique cultural attributes and characteristics of the times. However, traditional brand evaluation methods mostly adopt static analysis frameworks, lacking in-depth insight into the dynamic evolution of brand value, and making it difficult to accurately capture the changing law of brand effect in time and space dimensions. The rise of big data technology, especially spatio-temporal big data, provides brand effect assessment with new technical means and analytical perspectives, which can realize multi-dimensional, all-round and real-time monitoring of brand value.

This study constructs a dynamic assessment model of brand effect of architectural culture and tourism industry under the perspective of spatio-temporal big data, adopts AHP-FCE method combining hierarchical analysis and fuzzy comprehensive evaluation method, establishes a comprehensive assessment index system covering three dimensions, namely, brand revenue, brand loyalty, and brand strength, and selects Shichahai Historical District in Beijing as a typical case for empirical analysis, through questionnaire survey, network Through questionnaire survey, data mining, media report analysis and other multivariate data collection methods, the brand effect is dynamically evaluated from four perspectives: brand awareness, brand loyalty, brand best-seller, and brand popularity, to verify the model's scientificity and practicability.

II. Construction of brand effect assessment model for architectural cultural tourism industry

This chapter constructs a brand effect assessment index system and utilizes the AHP-FCE method to assign weights and multi-level comprehensive judgment to the index system, with a view to applying it to the assessment of brand effect of architectural culture and tourism industry based on spatio-temporal big data.

II. A.Brand effect evaluation index system

II. A. 1) Constructing a brand effect evaluation index system

The brand effect assessment index system of architectural culture and tourism industry is mostly based on different brand effect theories. Brand equity theory holds that a strong brand can enhance the effect of marketing activities, improve brand loyalty and premium effect, and win competitive advantages for enterprises. The essence of the value evaluation based on brand equity theory is to estimate and evaluate the brand effect with reference to assessing intangible assets. It is a quantitative evaluation method to measure the brand's earnings by utilizing third-party data provided by financial analysts, chambers of commerce, and financial reports, such as return on net assets, and adjusted by considering non-financial data, such as leadership, stability, marketing, international development capability, development trends, support received, and trademark protection status. According to customer value theory, strong brands have high value because they establish multiple relational contracts with consumers, and the brand effect includes customer trust in the brand product and the contract between consumers. Based on the perspective of customer value theory, the essence of brand effect evaluation is to evaluate the brand value of the enterprise through the factors of consumers' recognition, love and loyalty to the brand. The contractual relationship between brands and consumers is mainly manifested in consumers' loyalty to the brand. Stakeholder value theory holds that brand value relies on the interrelationships of stakeholders to carry out multiple construction of complex systems, the essence of which is centered on the brand, including suppliers, the media, the government and other economic, social and natural elements. Based on the stakeholder perspective, the essence of brand effect evaluation is that different stakeholders have different value needs and value expectations for brands.

In addition to the above brand effect assessment system, there is also brand effect assessment for different industries and enterprise characteristics, which takes into account the influence of financial factors, market factors, consumer factors, social and cultural values on brand effect, and builds brand effect assessment models.

To summarize, brand effect assessment should not only consider the financial return, but also pay attention to the subjective feelings and wishes of consumers. This paper draws on the existing brand effect assessment model, takes the three dimensions of brand revenue, brand loyalty and brand strength as the first-level indicators of the system, and refines the influence factors of each dimension.

The brand effect assessment index system is constructed as shown in Table 1, and the brand effect assessment index system includes 3 first-level indicators, 10 second-level indicators and 26 third-level indicators.

Table 1: Brand effect evaluation index system

First-level indicator	Secondary indicators	Third-level indicators	Symbol
Brand revenue (A1)	Brand profitability (B1)	Return on net assets	C1
Brand loyalty (A2)	Customer stickiness (B2)	Customer churn rate	C2
		Brand complaint rate	C3
		Brand repurchase rate	C4
Brand strength (A3)	Brand leadership (B3)	Scale benefit	C5
		Market share	C6
	Brand stability (B4)	Quick ratio	C7
		Current ratio	C8
		Asset-liability ratio	C9
	Brand resource power (B5)	Total fixed assets	C10
		Total intangible assets	C11
	Brand cultural power (B6)	Corporate culture	C12
		Social contribution	C13
	Brand support degree (B7)	Financial appropriation	C14
		Tax preference	C15
		Customer recognition.	C16
		Investors continue to invest	C17
	Brand radiation power (B8)	Sales channel	C18
		Sales expenses	C19
		Customer acceptance	C20
	Brand development power (B9)	Growth rate of operating income	C21
		Net profit growth rate	C22
		Investment in research and development	C23
		Patent situation	C24
	Brand credibility (B10)	Consumer word-of-mouth	C25
		Product	C26

II. A. 2) Design implications of indicators

(1) Brand earnings

Brand earnings is to examine the brand effect of the enterprise from the perspective of financial and capital returns, and to evaluate the degree of brand contribution to the enterprise's earnings. The brand profitability is chosen as the secondary indicator under the brand revenue dimension, and is measured by the return on net assets.

(2) Brand Loyalty

Brand loyalty is mainly from the perspective of customers' subjective feelings and preferences to examine the brand effect of the enterprise, reflecting whether there is a psychological tendency for customers to buy again after using the brand products or enjoying the brand services and the degree of the possibility of re-purchase. Based on the substantive connotation of brand loyalty, customer stickiness is regarded as a secondary indicator, which consists of three tertiary indicators: customer churn rate, brand complaint rate and brand repurchase rate.

(3) Brand Strength

Brand strength is a comprehensive examination of the enterprise's brand effect from the aspects of the brand's market competitiveness, future risk-resistant ability and sustainable development ability, which is the most fundamental reason for brand differences. Brand strength includes brand leadership, brand stability, brand resources, brand culture, brand support, brand radiation and brand credibility of eight aspects.

II. B.Assessment of brand effect based on AHP-FCE

Combining the AHP hierarchical analysis method [25] and the FCE fuzzy judgment method [26], the assessment of the brand effect of the architectural culture and tourism industry is carried out by sequentially establishing the hierarchical model, the set of rubrics, the set of indicator weights, and the matrix of affiliation, and finally carrying out a multilevel comprehensive judgment.

II. B. 1) Hierarchical modeling

The evaluation index system of brand effect of architectural culture and tourism industry U is divided into primary evaluation index $U_i(i=1,2,...,m)$, second-level evaluation index set $U_{ij}=(U_{i1},U_{i2},...,U_{in})$ and the set of tertiary evaluation indicators $U_{ijk}=(U_{ij1},U_{ij2},...,U_{ijz})$.

II. B. 2) Creation of the rubric set

The set of rubrics is a collection of evaluation indexes judging the state, that is to say, it refers to the grade V_k that determines the branding effect of the architectural culture and tourism industry, i.e., $V=(V_1,V_2,...,V_n)$, which are divided into five grades: excellent, good, average, passing, and poor, respectively.

II. B. 3) Determination of the set of indicator weights

In order to determine the weights of each evaluation index, first establish the priority relationship matrix → then construct the fuzzy consistent judgment matrix → finally determine the index weight set.

(1) Priority relationship matrix

Comparative analysis of the weights of the evaluation indicators of brand effect of architectural culture and tourism industry based on the expert survey method and the establishment of priority relationship matrix according to its importance, the judgment matrix of the bottom evaluation indicator set U_i established is shown in equation (1):

$$a=\begin{pmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \cdots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{pmatrix} \tag{1}$$

where a_{ij} refers to the importance of the evaluation indicator U_{ei} to U_{ej}.

Among the commonly used methods of numerical comparison of indicators, the fuzzy consistent judgment matrix method can reduce the influence of human subjective judgment to a greater extent, so this method is used to determine a_{ij}:

$$a_{ij}=\begin{cases} 0.5 & s(i)=s(j) \\ 1.0 & s(i)>s(j)(i,j=1,2,,n) \\ 0.0 & s(i)<s(j) \end{cases} \tag{2}$$

$s(i),s(j)$ denote the relative importance of evaluation indicators U_{ei} and U_{ej}, $0\le a_{ij}\le 1$ and $a_{ij}+a_{ij}=1$, respectively, and a is a fuzzy complementary matrix.

(2) Fuzzy consistent judgment matrix

In order to reduce the influence of human subjective judgment and improve the rationality of decision-making, the paper transforms the fuzzy complementary matrix a to obtain b_i by summing the rows of $a=(a_{ij})_{n\times n}$:

$$b_i=\sum_{k=1}^{n}a_{ik}\ (i=1,2,\cdots,n) \tag{3}$$

Then transform b_i according to the following formula:

$$A_{ij}=\frac{b_i-b_j}{2n}+0.5 \tag{4}$$

(3) Evaluation index weight set

In the paper, the sum-row normalization method is used to determine the weights of each evaluation index, and the matrix transformation is $E=(e_{ij})_{n\times n}$, where e_{ij} is

$$e_{ij}=\frac{A_{ij}}{\sum_{i=1}^{n}A_{ij}} \tag{5}$$

Then sum the rows of the E matrix and transform to get the vector $F=(f_1,f_2,\cdots,f_n)$, and also normalize the processing of F, which leads to the set of weights of evaluation indicators:

$$W_i=(\omega_{i1},\omega_{i2},...,\omega_{in})^T \tag{6}$$

II. B. 4) Subsidiarity matrix

In order to determine the degree of affiliation of each indicator in the set of peer evaluation indicators relative to its rubric level, an affiliation matrix R was created as follows:

$$R=\begin{pmatrix} r_{11} & \cdots & r_{1k} \\ \vdots & \cdots & \vdots \\ r_{n1} & \cdots & r_{nk} \end{pmatrix} \tag{7}$$

r_{ij} is is the degree of affiliation of the i th evaluation indicator relative to the j th rubric level.

II. B. 5) Multi-level synthesis of judgments

Multi-level comprehensive evaluation is to evaluate the indicators at all levels in an orderly manner to derive the corresponding set of evaluation indicators and derive the target indicators.

(1) Bottom-level indicator judgment

The bottom indicator judgment set D_i is obtained by fuzzy operation $W_i^T\circ R$ through the weight set and affiliation matrix of the corresponding evaluation indicators:

$$\begin{aligned} D_i=W_i^T\circ R_i&=(\omega_{i1},\omega_{i2},...,\omega_{in})^T\circ\begin{pmatrix} r_{11} & ... & r_{1k} \\ \vdots & \cdots & \vdots \\ r_{n1} & \cdots & r_{nk} \end{pmatrix} \\ &=(d_{i1},d_{i2},...,d_{ik})(i=1,2,...,m) \end{aligned} \tag{8}$$

where "$\circ$" refers to the fuzzy operation to synthesize the first son, the operation model in the text is the primary cause to determine the operator $M(\wedge,\vee)$, ignoring the secondary cause to highlight the influence of the primary cause, that is:

$$\begin{gathered} d_{ij}=\max\{\min(\omega_{ij},r_{je})\} \\ (i=1,2,...,m;j=1,2,...,n;e=1,2,...,k) \end{gathered} \tag{9}$$

(2) First-level evaluation index judgment

Transform the second-level evaluation index judgment set D_i and the first-level evaluation index weight set W through equation (9) to derive the first-level evaluation index affiliation matrix R:

$$\begin{aligned} D=W^T\circ R&=(\omega_1,\omega_2,...,\omega_m)^T\circ\begin{bmatrix} D_1 \\ D_2 \\ ... \\ D_m \end{bmatrix} \\ &=(d_1,d_2,...,d_k) \end{aligned} \tag{10}$$

The set of weights of first-level evaluation indicators W is given by expert opinion.

(3) Comprehensive judgment of target indicators

The judgment set D is derived layer by layer through the above steps, and the estimation of brand effect assessment of target indicator U is solved by equation (11).

$$H=D\circ G^T=(d_1,d_2,...,d_k)\circ(g_1,g_2,...,g_k)^T \tag{11}$$

III. Model application using historic district branding as an example

This chapter provides a comprehensive application of the constructed model to assess the branding effect of the architectural cultural tourism industry with the example of Shichahai, a historical neighborhood brand in Beijing.

III. A. Calculation results and analysis of indicator weights of AHP method

Combined with the results of AHP method, the weights of Beijing Shichahai brand effect assessment indicators and their ordering are shown in Table 2. In the assessment system of Beijing Shichahai brand effect, in terms of the first-level indicators, the weights of the indicators are, in descending order, brand strength A3 (0.7530) > brand revenue A1 (0.2047) > brand loyalty A2 (0.423), which indicates that brand strength is the first factor to be taken into account in the assessment of the brand effect of Beijing Shichahai. In the secondary indicators, the weights of the indicators are: brand development strength B9 (0.3498)>brand profitability B1 (0.2047)>brand leadership B3 (0.1111)>brand radiance B8 (0.1035)>brand stabilization B4 (0.0826)>brand resource strength B5 (0.0762)>customer stickiness B2 (0.0423)>brand Credibility B10 (0.0158) > Brand Support B7 (0.0073) > Brand Culture Power B6 (0.0067). Among them, brand development power is the most important factor in the evaluation of the brand effect of Beijing Shichahai, which fully indicates that in the process of brand building of Beijing Shichahai, it should focus on strengthening the profitability and innovation ability of the brand. The second most important indicator is the profitability of the brand, which suggests that both operating income and asset returns should be emphasized in order to enhance the brand's anti-risk ability and promote the brand effect. The third most important indicator is brand leadership. Therefore, the brand's power of discourse in the industry can be enhanced by seizing market share and improving the scale efficiency of the enterprise, so as to improve the brand effect of Beijing Shishakai. The brand culture power has the lowest weight among the 10 secondary indicators and is at the bottom of the list, indicating that in the process of improving the brand effect of Beijing Shichahai, the main focus should be on the economic benefits of the brand. However, the cultural strength of the brand, as an indispensable part of the foundation, should also be focused on improving, and strive to realize the unity of economic, cultural and social benefits.

In terms of the total ranking of the indicator layer, the top 10 indicators in terms of weight value are return on net assets C1 (0.2047) > market share C6 (0.1097) > R & D investment C23 (0.0937) > selling expenses C19 (0.0924) > revenue growth rate C21 (0.0868) > patent situation C24 (0.0864) > net profit growth rate C22 (0.0829) > fixed profit growth rate C22 (0.0829) > Total fixed assets C10 (0.0443) > Quick ratio C7 (0.0425) > Current ratio C8 (0.0346). Accordingly, attention should be paid to optimizing the asset structure, improving the brand's economic efficiency, expanding the brand's market share, increasing the investment in R&D and improving the R&D output rate, and enhancing the brand effect of Beijing Shishakai as a whole.

Table 2: Weight of brand effect evaluation indicators

First-level indicator	Weight	Secondary indicators	Weight	Third-level indicators	Weight	C-level weight	Sort
A1	0.2047	B1	0.2047	C1	1	0.2047	1
A2	0.0423	B2	0.0423	C2	0.5627	0.0238	12
				C3	0.2293	0.0097	13
				C4	0.2080	0.0088	14
A3	0.7530	B3	0.1111	C5	0.0126	0.0014	25
				C6	0.9874	0.1097	2
		B4	0.0826	C7	0.5145	0.0425	9
				C8	0.4189	0.0346	10
				C9	0.0666	0.0055	18
		B5	0.0762	C10	0.5814	0.0443	8
				C11	0.4186	0.0319	11
		B6	0.0067	C12	0.6269	0.0042	19
				C13	0.3731	0.0025	22
		B7	0.0073	C14	0.3835	0.0028	21
				C15	0.1233	0.0009	26
				C16	0.2192	0.0016	24
				C17	0.2740	0.0020	23
		B8	0.1035	C18	0.0309	0.0032	20
				C19	0.8928	0.0924	4
				C20	0.0763	0.0079	16
		B9	0.3498	C21	0.2481	0.0868	5
				C22	0.2370	0.0829	7
				C23	0.2679	0.0937	3

				C24	0.2470	0.0864	6
		B10	0.0158	C25	0.4747	0.0075	17
				C26	0.5253	0.0083	15

III. B. FCE method evaluation results and analysis

III. B. 1) Single-factor judgments

This study takes Beijing Shichahai tourists as the object of investigation, and a total of 248 questionnaires were distributed in July 2024, and 204 valid questionnaires were returned, with an effective recovery rate of 82.26%. After finishing, the initial quantitative values of the current status of the brand effect assessment indicators of Beijing Shichahai were obtained as shown in Table 3. Collecting and organizing the raw data and data processing according to the score weight, the evaluation matrix of the indicator factors is formed as shown in Table 4.

Table 3: Statistics on the current brand effect of Shichahai, Beijing

Target layer	First-level indicator	Secondary indicators	Third-level indicators	Evaluation value				
				Excellent	Good	General	Passing	Poor
O	A1	B1	C1	95	60	43	6	0
	A2	B2	C2	91	68	39	5	1
			C3	80	67	51	6	0
			C4	83	66	47	8	0
	A3	B3	C5	84	67	45	6	2
			C6	87	68	40	9	0
		B4	C7	62	70	66	5	1
			C8	77	68	55	4	0
			C9	71	78	48	7	0
		B5	C10	74	62	61	7	0
			C11	78	77	43	6	0
		B6	C12	69	43	82	9	1
			C13	72	63	61	7	1
		B7	C14	55	68	71	8	2
			C15	46	81	70	6	1
			C16	57	84	55	8	0
			C17	48	85	62	6	3
		B8	C18	49	82	64	9	0
			C19	66	65	67	5	1
			C20	52	74	73	5	0
		B9	C21	56	81	59	7	1
			C22	47	69	78	9	1
			C23	67	78	52	7	0
			C24	64	72	61	6	1
		B10	C25	62	81	53	7	1
			C26	70	80	51	3	0

Table 4: Evaluation index results of the brand effect of Shichahai, Beijing

Target layer	First-level indicator	Secondary indicators	Third-level indicators	Evaluation value					Evaluation value
				Excellent	Good	General	Passing	Poor	
O	A1	B1	C1	0.466	0.294	0.211	0.029	0	4.197
	A2	B2	C2	0.446	0.333	0.191	0.025	0.005	4.190
			C3	0.392	0.328	0.250	0.030	0	4.082
			C4	0.407	0.324	0.230	0.039	0	4.099
	A3	B3	C5	0.412	0.328	0.221	0.029	0.010	4.103
			C6	0.427	0.333	0.196	0.044	0	4.143
		B4	C7	0.304	0.343	0.324	0.024	0.005	3.917
			C8	0.377	0.333	0.270	0.020	0	4.067
			C9	0.348	0.383	0.235	0.034	0	4.045
		B5	C10	0.363	0.304	0.299	0.034	0	3.996
			C11	0.382	0.378	0.211	0.029	0	4.113
		B6	C12	0.338	0.211	0.402	0.044	0.005	3.833
			C13	0.353	0.309	0.299	0.034	0.005	3.971
		B7	C14	0.270	0.333	0.348	0.039	0.010	3.814

			C15	0.226	0.397	0.343	0.029	0.005	3.810
			C16	0.279	0.412	0.270	0.039	0	3.931
			C17	0.235	0.417	0.304	0.029	0.015	3.828
		B8	C18	0.240	0.402	0.314	0.044	0	3.838
			C19	0.324	0.319	0.328	0.024	0.005	3.933
			C20	0.255	0.363	0.358	0.024	0	3.849
		B9	C21	0.275	0.397	0.289	0.034	0.005	3.903
			C22	0.231	0.338	0.382	0.044	0.005	3.746
			C23	0.329	0.382	0.255	0.034	0	4.006
			C24	0.314	0.353	0.299	0.029	0.005	3.942
		B10	C25	0.304	0.397	0.260	0.034	0.005	3.961
			C26	0.343	0.392	0.250	0.015	0	4.063

III. B. 2) Fuzzy synthesis of judgments

Taking the results of the evaluation indicators as the benchmark, calculate the fuzzy comprehensive evaluation value of each level in turn, and assign the value according to the evaluation set *V*={excellent, good, average, pass, poor}, multiply the fuzzy comprehensive evaluation value of each level of the indicators with 5, 4, 3, 2, and 1, respectively, and arrive at the evaluation score of the brand effect of Beijing Shichahai, as shown in Table 5.

The overall score of Beijing Shichahai brand effect is 4.021, which is at the level of “good”, reflecting that the brand of this historic district is highly praised by local tourists on the whole. In addition, from the evaluation results of the first-level indicators, it can be seen that the brand revenue has the highest score of 4.197, followed by brand loyalty of 4.146, and finally brand strength of 3.967, indicating that the brand of Beijing Shichahai performs well in terms of brand profitability and customer adhesion, but the brand strength still needs to be further improved. From the evaluation results of the secondary indicators, it can be seen that the evaluation value of the indicator of brand support is the lowest, with a score of 3.843, indicating that there is still room for improvement in the recognition of customers and investors of Beijing Shichahai, and that it is necessary to further strive for governmental financial allocations and tax incentives.

Table 5: The final results of the brand effect of Shichahai, Beijing

Target layer	Evaluation value	First-level indicator	Evaluation value	Sort	Secondary indicators	Evaluation value	Sort
O	4.021	A1	4.197	1	B1	4.197	1
		A2	4.146	2	B2	4.146	2
		A3	3.967	3	B3	4.143	3
					B4	3.988	6
					B5	4.045	4
					B6	3.884	9
					B7	3.843	10
					B8	3.924	7
					B9	3.903	8
					B10	4.015	5

IV. Dynamic assessment of the brand effect from the perspective of spatio-temporal big data

In this chapter, we continue to take Beijing Shichahai as the object, and based on spatio-temporal big data, we dynamically evaluate the brand effect of Beijing Shichahai from four dimensions: brand recognition, brand loyalty, brand best-seller and brand awareness.

IV. A. Brand Recognition

Brand awareness refers to the depth of consumers' understanding of a brand. The public's awareness of Beijing Shichahai brand mainly includes the awareness of Shichahai's development method and the awareness of Shichahai's related culture. Through the cooperation with Beijing Shichahai, a questionnaire was distributed to local residents to find out the public's understanding of the brand of Shichahai as a historic district. The results show that the public's understanding of Shichahai's development approach is higher than the public's understanding of Shichahai's related culture. Specifically, the proportion of residents who know very well and relatively well about the development approach of Shichahai is as high as 70.52%, which is much higher than the 26.74% who know about the historical and cultural awareness of Shichahai. At the same time, the proportion of those who do not understand

the development method of Shichahai in the unawareness group is also much lower than that of those who do not understand the history and culture of Shichahai. This also reflects that the current public awareness of the Shichahai historic district brand is more at the level of the development approach and less at its history and culture.

IV. B. Brand Loyalty

Brand loyalty refers to the preference for a certain brand shown in consumers' consumption decisions. In this paper, brand loyalty of Shichahai Historic District is defined as the public's active seeking of Shichahai-related information. In terms of specific numerical characterization, Baidu index data from 2012-2022 is adopted. The weekly retrieval times of Shichahai information by the general public are shown in Figure 1.

Through the Baidu retrieval data, it can be seen that the public's attention to the Shichahai Historic District has experienced obvious changes: the public's understanding of Shichahai was almost 0 before 2014, the public's attention to Shichahai began to gradually increase in 2014, and the public's attention to the Shichahai Historic District reached the highest level in 2016, 528 times, and since then it has leveled off, but the overall level of attention is higher than that in 2016 Before.

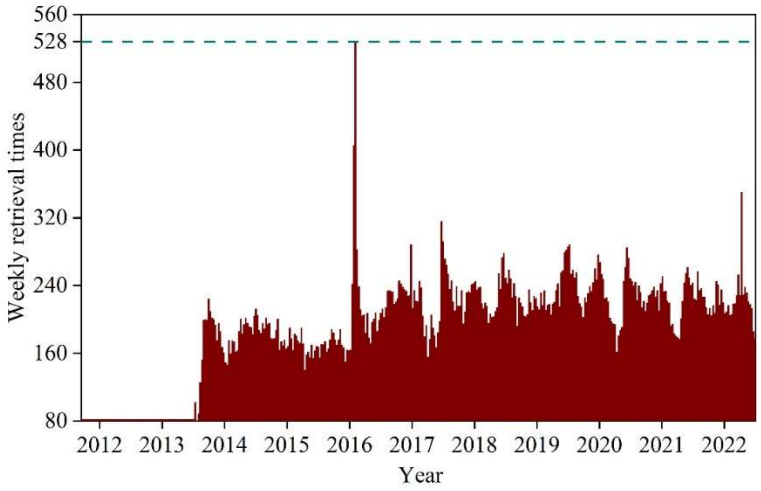

Figure 1: The number of times information is retrieved per week

IV. C. Brand sell-through

The degree of brand popularity is the degree of acceptance of brand products by consumers in reality. The main body of the best-selling degree of the historical street brand should be reflected in the degree of public acceptance of the historical street brand and related products, which is most intuitively the increase in the number of tourists in the historical street and the increase in tourism revenue. According to statistical data, since 2016, the economic income of Beijing Shichahai has increased significantly, with the annual number of tourists increasing from 15.24 million people in 2016 to 21.46 million people in 2024, an increase of 40.81%, and the annual tourism income increasing from 4.26 billion yuan in 2016 to 5.88 billion yuan in 2023, an increase of 38.03%.

IV. D. Brand awareness

The degree of coverage of historic districts by mainstream media is an important indicator of brand awareness of historic districts. The full-text database of important Chinese newspapers contains academic and informative literature published by various important newspapers in China since 2000, which can be used as the main data for evaluating the degree of media coverage of the slow city. By collecting the news of Shichahai coverage from 2010 to 2022, a total of 68 news articles were obtained after eliminating the number of invalid articles. In order to extract the information of each news article more effectively, the concept of “information entropy” is introduced to evaluate the effective information of news reports, and the calculation formula is as follows:

$$H = N \log_2 3500 \tag{12}$$

$$I_k = \left(\frac{N_k}{N_t} + \frac{H_k}{H_t} \right) / 2 \tag{13}$$

where N represents the number of news reports in Shichahai, I_k represents the degree of media coverage of Shichahai in k years, N_k represents the total number of news reports in Shichahai in k years, N_t represents the total number of all news reports in k years, H_k represents the effective amount of information in Shichahai news reports in k years, and H_t represents k The amount of effective information for all news reports per year.

The results of calculating the degree of media coverage of Shichahai are shown in Figure 2, which shows that the amount of effective information of Shichahai-related news reports shows a positive correlation with the degree of media coverage. Media coverage prior to 2016 was generally at a low level of 0.0125. After 2016, media coverage of shikshas gradually increased and reached its highest level of 0.2152 in 2019. Although the overall coverage has dropped after 2019, the overall level is still higher than before the branding of Shichahai, which shows the effectiveness of the branding of Shichahai.

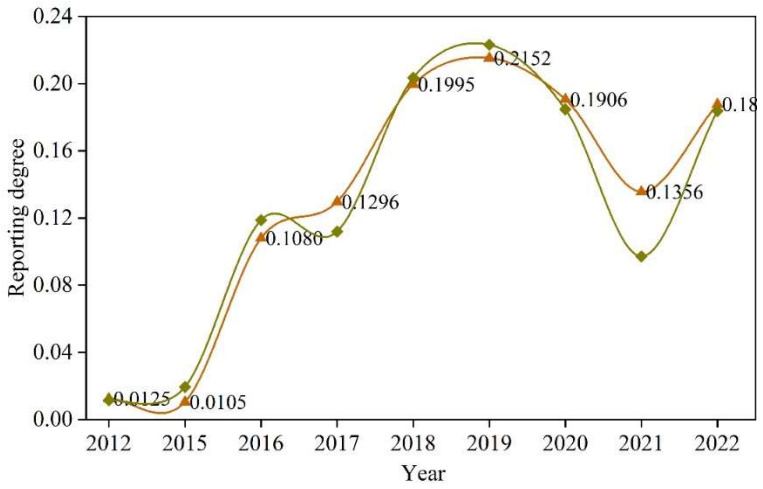

Figure 2: Media coverage of Shichahai

V. Conclusion

By constructing a dynamic assessment model of the brand effect of architectural culture and tourism industry under the perspective of spatio-temporal big data, the Shichahai Historic District in Beijing was empirically analyzed, and rich assessment results were obtained. The assessment results show that the brand effect of Shichahai performs well as a whole, with an overall score of 4.021, and performs most prominently in terms of brand revenue, with a score of 4.197, showing the advantages of this historic district in terms of economic benefits. From the weighting analysis, brand strength dominates the assessment system, with a weighting value of 0.7530, of which brand development power, as the most important secondary indicator, has a weighting of 0.3498, reflecting the decisive influence of the brand's sustainable development ability on the overall brand effect. The analysis of spatio-temporal big data reveals the dynamic change characteristics of the brand effect, and the annual tourism revenue of Shichahai grows from 4.26 billion yuan in 2016 to 5.88 billion yuan in 2023, an increase of 38.03%, reflecting the significant improvement of the brand value. The media attention data shows that the media coverage of Shichahai continued to grow after 2016, reaching an all-time high of 0.2152 in 2019, indicating that the brand awareness has been effectively improved. The assessment model can not only accurately quantify the static level of brand effect, but also dynamically track the evolutionary trajectory of brand value, providing a scientific assessment tool and data support for brand building and management decision-making of the historic district.

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