

Exploring the Spatial Distribution of B&B in Ningbo and Its Influencing Factors

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Abstract: The introduction of recent policies and standard guidelines in China has propelled the B&B industry towards transformation and advancement, making B&B tourism a pivotal force in fostering regional tourism growth. Utilizing POI data from B&B in Ningbo, Zhejiang Province, this study employs methodologies including standard deviation ellipses, average nearest neighbor index, kernel density estimation, cold spot analysis, and MGWR to quantitatively analyze the spatial distribution characteristics of B&B and their key determinants. Findings reveal: (1) B&B in Ningbo exhibit a spatial pattern of central clustering surrounded by peripheral dispersion. Ningbo has two high-density core areas for B&B; (2) Ningbo city districts and counties B&B distribution differences, was "northwest - southeast" extended distribution; (3) the location of B&B strongly correlates with tourist attractions; (4) Primary factors influencing B&B distribution in Ningbo, ranked by explanatory power, include attraction density, per capita GDP, urban residents' disposable income, highway density, elevation, and railway density.

Keywords: B&B, POI data, spatial agglomeration, influence mechanism, Ningbo city.

1. Introduction

Minsu refers to Bed & Breakfast, commonly abbreviated as B&B, governed by China's B&B policies. In June 2023, the "China B&B Development Report" (2023~2024), also known as the B & B Blue Book, launched in June 2023 to analyze current status, trends, opportunities, and challenges of China's B&B industry.

Provinces and cities optimize B&B spatial distribution by establishing B&B-centered industrial spaces for integration and improved traffic flow to tourist spots. Anshun City and Tonglu County introduced action plans for tourism lodging development, while Songyang County has a long-term plan for its lodging industry. The rise of B&Bs as a new type of residence has gradually become a hot spot in the accommodation industry[1].

B&B are popular in the accommodation industry. B&B drive tourism growth, facilitate cultural exchange and heritage preservation, generate employment, and foster community engagement.

Currently available literature, mostly focuses on tourists' value perception[1-3], space design[4, 5], and the current development status of the B&B industry[6-8]. For the spatial distribution of B&B, Hu Yu and Linlin Xu explored the development characteristics and patterns of B&B clusters in Zhejiang Province, and analyzed them from the macro level down to the micro scale to understand the mechanisms affecting the development of B&B clusters[9]; Yishu Qiu, Zhenmin Zhu focused on the

spatial distribution characteristics of B&B in 26 cities in the Yangtze River Delta region and their evolutionary trajectories, and concluded that B&B industry in the Yangtze River Delta presents a pattern of high concentration in the eastern cities and low concentration in the western cities[1];LI Yan focused on the spatial distribution of B&B in the Beijing-Tianjin-Hebei region and its influencing factors, and propose developing boutique rural and community B&B for innovative shared B&B development[10].

Comprehensive research methods in the literature, at present, the data related to lodgings are mostly obtained from government and industry reports at all levels, lodgings online platform data, surveys and field visits; In regard to technologies for analyzing the distribution characteristic of B&B, Arc GIS spatial analysis method, spatial econometric model[11], and spatial re-gression[12, 13]are widely applied. The research on influencing factors mostly uses multiple regression, GWR, and less MGWR[14] However, the number of researches on the distribution characteristics of lodging in the discipline of geography is still relatively small[15-17].

2. Research area, data sources and research methodology

2.1. Research area

This study focuses on Ningbo City, located in Zhejiang Province, as its research area, encompassing 10 districts and counties. The current and historic prosperity of Ningbo is in no small way related to its geographical position, just 20 km inland from the Hangzhou estuary and the gateway to the East China Sea[18]. Positioned in the Yangtze River Delta region, Ningbo boasts a favorable natural environment, advanced socio-economic status, and robust capacity for international engagement.

In 2023, Ningbo's tourism revenue hit 87.74 billion yuan, attracting 65.795 million domestic and 155,000 inbound tourists. The city has nearly 1,400 registered B&Bs with over 32,000 beds, including 110 high-quality B&Bs, ranking among the forefront of the province and the nation.

Yinzhou District has boosted Ningbo's lodging development since 2020 with the "Ningbo Fenghua District to Promote Lodging Development Implementation Measures".

2.2. Data source

The spatial data of B&Bs in this study consist of POI data. Prior to May 3, 2024, data were gathered using a web crawler tool from Ctrip (<https://www.ctrip.com/>), a prominent domestic travel website. After filtering, a total of 1378 POI representing B&B were obtained. Administrative vector boundaries of Ningbo were sourced from the Geo-spatial Data Cloud and Resource Environment Science and Data Platform (<https://www.gscloud.cn/>). This study examines factors influencing accommodation choice, including socio-economic and cultural backgrounds, technological development, and tourists' preferences. The relationship between B&B density and these factors is analyzed using six indicators for economic status, transportation, natural environment, and tourism resources.

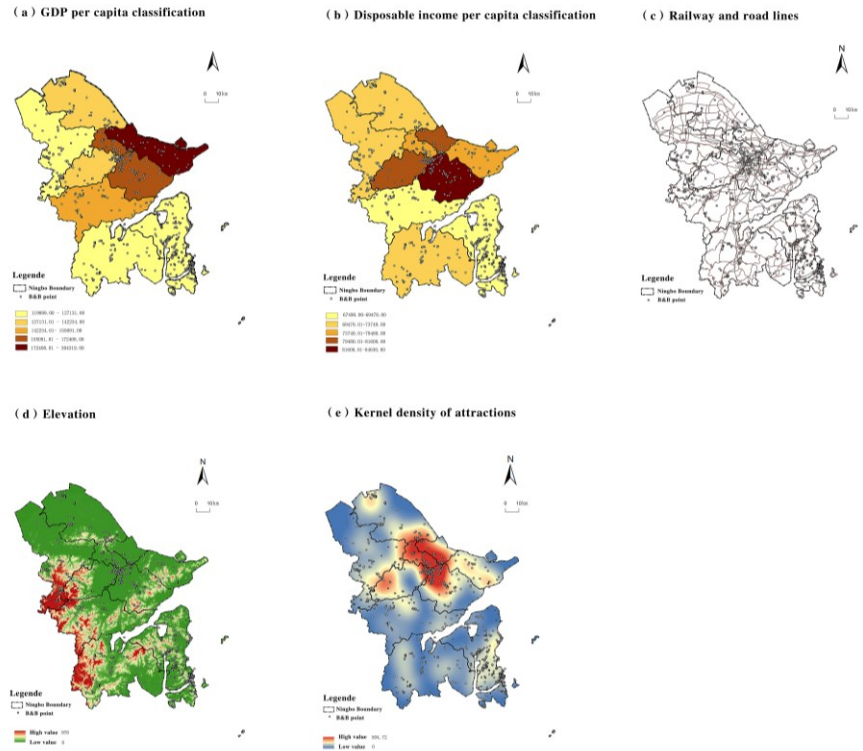


Figure 1: Influencing factors

Data sources include Ningbo's Digital Elevation Model (DEM) data from the Planning Cloud Platform (<https://www.guihuayun.com/>), per capita GDP and disposable income figures from the 2023 Ningbo Statistical Yearbook within the China Economic and Social Big Data Platform (<https://data.cnki.net/>), tourism attraction data from the official website of Ningbo Culture, Radio, Film and Television Tourism Bureau (<https://wglyj.ningbo.gov.cn/>), with coordinates manually extracted using the Baidu map coordinate system. Vector data representing Ningbo's road network in the transportation dimension are sourced from the Geo-spatial Data Cloud and Resource Environment Science and Data Platform (<https://www.gscloud.cn/>).

Table 1: Selection of Impact Factors

Dimension	Code	Indicator	Unit
Economic	X1	GDP per capita	RMB
	X2	Disposable income per capita	RMB
Traffic conditions	X3	Density of railway network	km/km ²
	X4	Road network density	km/km ²
Natural environment	X5	Elevation	m
Tourism resources	X6	Density of 3A(Third-class spots) and above attractions	pcs/km ²

2.3. Research Methodology Plus References

2.3.1. Standard deviation ellipse

The directional distribution[19],proposed by Lefever[20], which can reveal the spatial distribution of various economic phenomena using the spatial statistical method and the spatial distribution characteristics of geographical elements, is widely used in geography[19].

This method analyzes the spatial distribution of lodgings in Ningbo to identify their aggregation posture and direction, thus determining whether there is a significant directional distribution or aggregation of lodgings in specific areas.

$$\begin{cases} \bar{X} = \sum_{i=1}^n W_i X_i / \sum_{i=1}^n W_i \\ \bar{Y} = \sum_{i=1}^n W_i Y_i / \sum_{i=1}^n W_i \end{cases}$$

Where: \bar{X}, \bar{Y} are the latitude and longitude of the coordinates of the centre of gravity of the standardized ellipse of Ningbo B&B; X_i, Y_i are the latitude and longitude of the coordinates of the center of the i th region; W_i is the spatial weight of an attribute value of the i th region.

2.3.2. Average nearest neighbor index

In this paper, the nearest neighbor index is used to characterize the spatial distribution of the elements of B&B points. The principle is to measure the distance between each point and the nearest neighbor in the geographic space, and take its average value to get the average nearest neighbor distance, which is calculated as follows[21].

$$R = \frac{r}{r'} = 2\sqrt{D}$$

Where: r is the actual nearest neighbor distance ; $R=1$ implies random surface distribution; $R>1$ indicates uniform distribution; $R<1$ indicates aggregated distribution.

2.3.3. Kernel density analysis

Kernel density estimation (KDE), also known as the Parzen's window[22], is one of the most well-known approaches to estimate the underlying probability density function of a dataset[23].

This paper studies the equilibrium of B&B spatial distribution by exploring its POI data's agglomeration/dispersion pattern. It determines the unit density of Ningbo's B&B POI within a given range. Its calculation formula is:

$$F(x) = \frac{1}{T_h} \sum_{i=1}^T k\left(\frac{x-X_i}{h}\right)$$

Where: $f(x)$ is the estimated value of the kernel density of Ningbo B&B, $k(\frac{x-X_i}{h})$ is the kernel function, T is the number of Ningbo POIs, $x - X_i$ refers to the distance from the POIs to X_i .

2.3.4. Cold hot spot analysis

Getis-Ord G_i^* hot and cold spot analysis is used to analyze hot and cold spot. This method has been widely used in the study of hotels and Airbnb distribution[24]. Its calculation formula is:

$$G(d) = \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij}(d) x_i x_j}{\sum_{i=1}^n \sum_{j=1}^n x_i x_j}$$

If $G(d) > 0$, the higher the value, the greater the distribution density of B&B, belonging to the B&B hotspot area; if $G(d) < 0$, the lower the value, the smaller the distribution density of B&B, belonging to the B&B cold spot area.

2.3.5. MGWR (Multi-scale Geographically Weighted Regression)

In the paper, the multi-scale geographically weighted regression (MGWR) model analyzes factors impacting Ningbo's lodging spatial distribution pattern. By relaxing the identical spatial scale

assumption, we can develop a more powerful spatial model. This is the essence of multiscale geographically weighted regression[25]. Its calculation formula is:

$$y_i = \sum_{j=1}^k \beta_{bwj}(u_i v_i) x_{ij} + \varepsilon_i$$

Where: MGWR analyzes Ningbo lodging spatial distribution factors, relaxing the identical spatial scale assumption for a more powerful model.

3. Results and Analyses

3.1. Spatial Distribution Types of B&B in Ningbo

The spatial coordinates of B&B in Ningbo were analyzed using the Arc GIS average nearest neighbor analysis tool. The results indicate that Ningbo's B&B exhibit an agglomeration distribution pattern. Results indicate an agglomeration distribution pattern. The nearest-neighbor index $R = 0.29$ ($z = -50.51$, $p < 0.01$) suggests a pronounced agglomeration tendency among B&Bs, indicating strong spatial clustering.

Ningbo's B&B industry agglomeration pattern may result from market demand, resource efficiency, regional economic growth, and spatial management.

3.2. Characteristic analysis of spatial distribution of Ningbo B&B

Ningbo lodging industry exhibits a "central core with peripheral clusters" structure. This phenomenon aligns with Friedman's core-periphery development theory within the growth pole framework [26].

Lodging in Ningbo is concentrated in Jiangbei, Haishu, Yinzhou, their intersection, and extend outwards towards Xiangshan County. Peripheral areas have multiple clusters. The 5A-rated Tianyi Pavilion-Moon Lake is at the core intersection of these districts, while Ningbo's largest commercial complex, that the city center has more influence and there are more concentrated scenic spots and B&B[27]. Additionally, the 4A-rated China Fisherman's Village in Xiangshan County serves as another core density point.

Ningbo B&B's azimuth is 39.216° with ellipse center at (121.66, 29.55) in Fenghua District, curved significantly in a "northwest-southeast" direction.

B&B in Ningbo was spatially analyzed. Xiangshan is a hot spot with 500 B&B, while Yinzhou, Cixi, Yuyao and Ninghai are sub-hot spots. Haishu, Fenghua, and Jiangbei are sub-cold spots with 31-68 B&B, while Zhenhai and Beilun are cold-spots with fewer than 30 B&B.

Ningbo's B&B distribution is imbalanced across districts and counties due to location, planning, development, culture, and infrastructure.

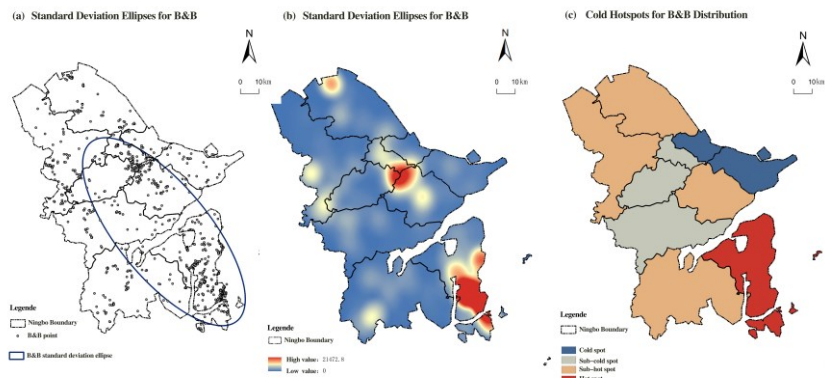


Figure 2: Spatial Distribution Characteristics of Ningbo B&B

4. Analysis of influencing factors of spatial distribution of lodging in Ningbo

4.1. Analysis of model regression results

MGWR model R² is 0.99, with corrected R² at 0.98, indicating good fitting. AICc for grid area 3000*3000 is -1747.07. High R² value supports MGWR's fitting of Ningbo B&B spatial data and influencing factors.

Table 2: Regression coefficients of influencing factors

Explanatory variables (adjusted)	Mean	Standard deviation	Minimum	Median	Maximum
Density of attractions	0.47	0.39	-0.38	-0.41	4.74
GDP per capita	-0.16	0.19	-1.65	-0.18	0.91
Disposable income per capita	0.08	0.22	-2.07	0.07	1.43
Road density	-0.06	0.08	-0.85	-0.06	0.79
Railway density	-0.02	0.07	-0.60	-0.01	0.54
elevation	-0.05	0.01	-0.06	-0.05	-0.04

4.2. Analysis of spatial heterogeneity of influencing factors

Tourism resource density affects B&B spatial distribution in Ningbo. Positive regression coefficient indicates attraction density promotes B&B distribution. Xiangshan County's eastern region has the highest regression coefficient at over 1.0364 and shows a strong positive relationship between attractions and B&B. B&B clustering around attractions leads to higher occupancy rates and economic benefits, creating a positive distributional pattern.

Economically, Ningbo economy as a whole is more developed, and there are significant differences among regional economy. Positive GDP per capita coefs in Xiangshan, Haishu, Fenghua, and Cixi County's eastern parts; negative coefs elsewhere due to high land prices, intense industrial competition, and strict urban planning, discouraging lodging development.

Ningbo's B&Bs positively correlated with per capita disposable income. Wealthy areas are more likely to have B&Bs. In Ninghai County the southeast, higher coefficients indicate that leisure activities at upscale B&Bs encourage establishment. Consumers' demands and consumption capacity will support Chinese B&B development[28].

Transportation conditions indicate road density challenges in areas of high density including congestion, land price inflation, and residential proximity. Ninghai/Fenghua are areas of low efficiency and low equity. Positive correlations in Cixi City's north, Yuyao-Haishu border, and Xiangshan County's east.

Railway density mostly negatively correlates in most areas with sporadic positive correlations. The strongest correlation is on the southern side of Xiangshan County.

Ningbo's lodging distribution negatively influenced by uniform -0.39-0.00 elevation hindrance due to lower infrastructure.

Ningbo B&B's location shaped by tourism, economic, transport, and geographic factors.

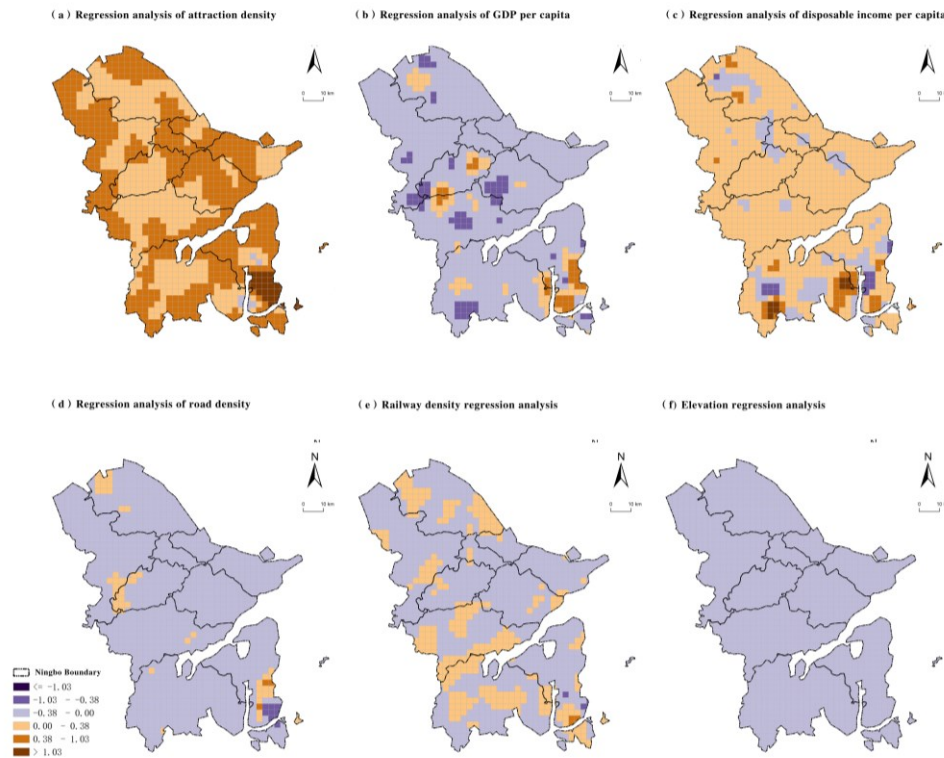


Figure 3: MGWR model

5. Conclusion and Discussion

5.1. Conclusion

(1) Ningbo's B&B landscape exhibits a central circle + peripheral group pattern, with the hub near Ningbo Railway Station and adjacent to Tianyi Pavilion. This area serves as Ningbo's commercial hub and is home to high-end B&B. Xiangshan County, known for its tourism resources and high-end B&B, underscores the correlation between natural conditions and guest appeal.

(2) B&B distribution in Ningbo varies notably. Xiangshan leads with 500, Yinzhou and Yuyao follow with 133 and 123 respectively. Zhenhai has 22 and Beilun 30. Factors include environment, economy, tourism assets, and transportation. However, impact varies across regions. Strategic measures should be implemented: policy guidance for B&B location planning, relaxed construction standards in low-density areas, and targeted support and incentives for businesses in underrepresented areas; enhanced facility and service provisions, increased investment in infrastructure, and intensified marketing efforts.

(3) Ningbo B&B distribution factors are attraction density, per capita GDP, urban resident disposable income, highway density, elevation, and railway density. All except elevation have significant sample weights above 70%. For B&B operators, the key is to assess tourism resources in their area. Areas with 3A or higher-rated scenic spots are advantageous due to visibility and attractiveness, attracting large customer bases.

Evaluate nearby residents' GDP and disposable income, as greater affluence leads to higher acceptance of B&B pricing and increased demand for leisure activities. Check transportation infrastructure to ensure accessibility via both road and rail networks for convenience and shorter travel times. Avoid areas prone to traffic congestion.

These considerations underscore the comprehensive approach necessary for successful B&B location planning and operational strategy in Ningbo.

(4) To achieve balanced spatial distribution and reduce disparities in B&B development in Ningbo, the following are suggested: Foster inter-regional coordination and cooperation in B&B development, focusing on both central areas and peripheral regions; use policy incentives to attract investors to remote yet promising areas.

These strategies aim to enhance the overall development and distribution of B&B across Ningbo, ensuring broader economic benefits and tourism opportunities throughout the region.

5.2. Discussion

(1) Data for this paper came from Ctrip.com and was batch-crawled by Baidu. Despite screening, some issues such as coordinate deviation and incomplete B&B data persist. Future efforts may engage with scholars for joint crawling, using multiple lodging software to collect data and select the most accurate B&B data for spatial research.

(2) This paper uses an MGWR model that only considers spatial heterogeneity and not time. Future research will consider time by using advanced models and incorporating the evolution of Ningbo's lodgings over the past five years.

(3) Subjective factors will be added to future analysis of influencing factors. This can be done via questionnaires or interviews.

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