An Exploration of Route Synergy between Attractions in Xi'an's Main Urban Area Based on the Node-Place Model

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Abstract
Currently, China is in the period of high - quality and intensive urban development. Handling the relationship between the traffic value and the tourism value of the routes between scenic spots is crucial for the efficient utilization of tourism resources. This paper takes 120 public transportation connection routes among 15 scenic spots above 4A level in the main urban area of Xi'an as the research object. It establishes an index system for the traffic value and tourism value of the routes, and uses the ArcGIS platform to conduct a minimum resistance analysis of each index. Based on the node - place model, it evaluates the current development status of each route. The research results show that there is a phenomenon of non - coordinated development among the routes: the scenic spots can be divided into four states: balanced, subordinate, pressured, and imbalanced. Corresponding development strategies are proposed for each state. For example, in the balanced state, the values should be increased or decreased simultaneously; in the subordinate state, the traffic and tourism facilities need to be improved; in the pressured state, the traffic pressure should be relieved; in the imbalanced state, the value structure should be optimized. This research provides a basis for improving the public transportation facilities in scenic spots, optimizing traffic organization, and enhancing the level of intelligent transportation services.

Keywords: Node-place model; Minimum resistance model; Public transportation routes; Tourist needs; Main urban area of Xi'an

Introduction

With the acceleration of the global urbanization process, the efficient utilization of urban space and sustainable development have become the focus of attention for governments and academia around the world. Against this backdrop, the optimization of the urban transportation system and the rational allocation of tourism resources are of particular importance. As the link connecting various functional areas within the city and external regions, the public transportation system is not only the "lifeblood" of urban operation but also an important driving force for urban tourism development. However, how to balance traffic efficiency with the harmonious co - existence of tourism experience and the urban environment has become a major challenge in current urban planning and transportation management.

Luca Bertolini proposed the node - place model, which profoundly reveals the dual characteristics of station areas. That is, the dialectical relationship between its attribute as a key node in the transportation network and its attribute as a place for diverse urban life spaces. This theoretical framework points out that station areas need to efficiently integrate multiple transportation modes to ensure the smooth transfer of people and goods, meeting the rapid - flow needs of modern society. At the same time, it shoulders the heavy responsibility of urban function expansion, integrating multiple activities such as business, leisure, and entertainment, attracting and promoting people to stay and interact in specific areas. The core of the node attribute lies in promoting the efficient distribution of people, while the place attribute focuses on creating a pleasant environment to encourage people's in - depth participation and experience.

The tension and synergy between the two constitute the internal dynamic mechanism for the development of station areas. On the one hand, the improvement of node efficiency (such as the optimization of transportation facilities) can attract more people, laying the foundation for the realization of place value. On the other hand, the enrichment and quality improvement of place functions further stimulate transportation demand, forming a positive cycle. This process reflects the trend of the harmonious co - existence of node value and place value in dynamic adjustment, which is a model for urban space optimization and transportation system integration.

In terms of results, the node - place model describes three synergy states: The subordinate state means that the node value and the place value are in synergy but at a low level, indicating low - level development in the area; The balanced state is the ideal state, where the node value and the place value are in synergy and at a moderate level, representing sustainable development in the area; The pressured state means that the node value and the place value are in synergy but at a high level, indicating over - development in the area; An imbalanced node means that the node value is much higher than the place value; An imbalanced place means that the place value is much higher than the node value. The practical significance of the node - place model lies in summarizing the complex problems of station areas into the synergistic interaction relationship between the node value and the place value, and using quantitative means to evaluate the development status of station areas, guiding the key points of future construction in station areas and proposing targeted development ideas.

Based on this understanding, Luca Bertolini proposed the node - place model in 1999. This model quantifies two performance indicators of station areas - node value and place value - by establishing an index system. Scholars highly recognize Luca Bertolini's ideas and have conducted some fruitful research. There are also quite a number of studies in the context of Chinese cities. For example, Zheng Degao and others pointed out that transportation hubs should be combined with urban planning, with a focus on the value of transportation nodes and the value of urban places; Chen Lan and others summarized station areas as "multi - modal transportation nodes" and "functionally complex urban places"; Wang Chengfang and others proposed a planning and design idea for station areas based on the dual characteristics of nodes and places in combination with the conceptual design scheme of the new public transportation system in Nanhai District, Guangzhou.

In summary, scholars generally believe that the mutual coordination and promotion of node value and place value are the keys to the sustainable development of station areas. Based on this, this paper uses the traffic value of routes as the node value and the tourism value as the place value, extending it to the traffic - tourism value of public transportation routes between scenic spots, and studies the development synergy of public transportation routes between scenic spots in the central urban area of Xi'an. Studying the integration between scenic spots and the existing urban transportation also provides a basis for improving the public transportation facilities in scenic areas, optimizing traffic organization, and enhancing the level of intelligent transportation services in a targeted manner.

1 Research Design

1.1 Overview of the Research Area

The research area of this paper is the main urban area of Xi'an, which includes Yanta District, Beilin District, Lianhu District, Weiyang District, Baqiao District, and Xincheng District, with a total area of approximately 832 square kilometers. Xi'an is one of the first batch of famous historical and cultural cities. As the core development area of Xi'an, the main urban area has 15 scenic spots above 4A level, such as the Big Wild Goose Pagoda, Shaanxi History Museum, and Daming Palace National Heritage Park, attracting a large number of domestic and foreign tourists. Therefore, the number and distribution of scenic spots in the research area are appropriate, providing sufficient data samples. Meanwhile, with the acceleration of the old - city renovation and urban renewal process, how to coordinate the intensive development of urban scenic - area resources has become a major challenge for cities. In summary, selecting the main urban area of Xi'an as the research area has important demonstration value (Figure1).

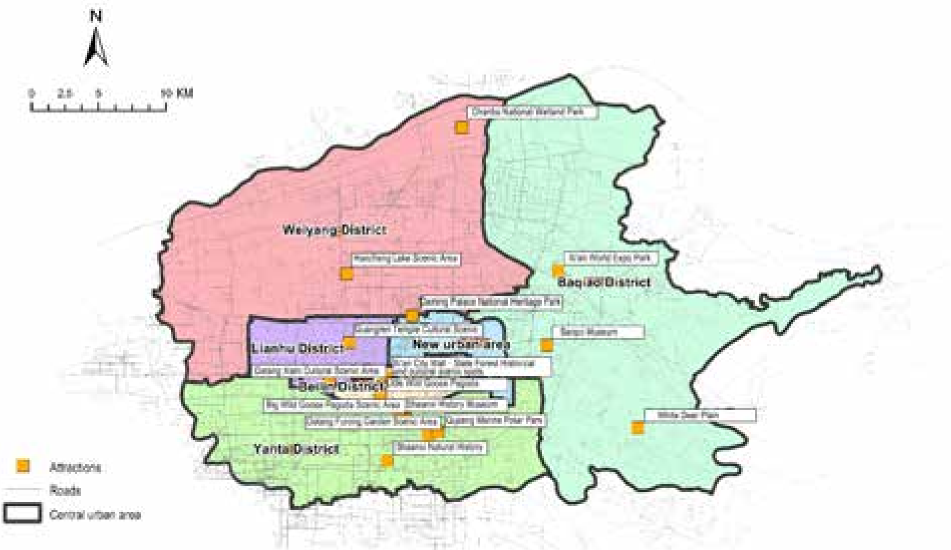


Figure 1. Scope map of main urban area of Xi'an

1.2 Research Steps

First, the optimal routes for 15 scenic spots in the main urban area of Xi'an were selected through the recommendation of Gaode Map and recorded using the ArcGIS platform (Table 1). Then, by reviewing relevant literature and considering the characteristics of tourist needs, a factor system for the traffic and tourism values of scenic - area routes in the main urban area of Xi'an was determined. The traffic value includes the density of public - transportation stations and road - network density, while the tourism value includes the density of characteristic shops and scenic - spot density. The method of constructing resistance surfaces was used to generate individual - factor resistance surfaces and classify and overlay them to obtain the traffic and tourism resistance values of each tourism route (Table 2).

The Minimum Resistance Model is an academic theoretical framework used to describe and analyze that when systems, individuals, or groups face multiple possible paths or choices, they tend to choose the paths with the least resistance, lowest cost, or highest efficiency.

Finally, the node - place model analysis was conducted using the two types of resistance values obtained for each route to get the synergy results of the development of five types of tourism routes.

To eliminate the differences in dimensions and orders of magnitude among indicators, this paper first performed max - min standardization on the data. The specific formula is as follows: In the transformation function, x is the original data value, x' is the standardized value, max is the maximum value in the original data, and min is the minimum value in the original data.

$$\chi' = \frac{\chi - min}{max - min}$$

1.3 Data Sources

In terms of scenic - spot selection, this paper referred to the data published by the Xi'an Culture and Tourism Bureau and screened 15 scenic spots at or above 4A level within the main urban area of Xi'an. The road - network data were sourced from the 2023 Chinese road data published on the Open Street Map website. The text data of bus and subway stations and lines were obtained from the official website of Xi'an Metro and the urban rail development plan of Xi'an. The route directions were selected from the optimal public - transportation routes recommended by Gaode Map, including transfer data and travel - time information. The POI data of shops were obtained from the Baidu Map API interface.

2. Research Process

Table 1. List of scenic spots in the main urban area of Xi'an

Number	Level	Name of scenic spot
1	5A	Big Wild Goose Pagoda Scenic Area
2	5A	Datang Furong Garden Scenic Area
3	5A	Xi'an City Wall · Stele Forest Historical and cultural scenic spots
4	5A	Xi'an City Wall · Stele Forest Historical and cultural scenic spots
5	5A	Shaanxi History Museum
6	4A	Qujiang Marine Polar Park
7	4A	Datang Xishi Cultural Scenic Area
8	4A	Banpo Museum
9	4A	Xi'an Museum (Little Wild Goose Pagoda)
10	4A	Xi'an World Expo Park
11	4A	Hancheng Lake Scenic Area
12	4A	Chanba National Wetland Park
13	4A	Shaanxi Natural Museum
14	4A	White Deer Plain · White Deer Warehouse Scenic Area
15	4A	Guangren Temple Cultural Scenic Area

Table 2. Resistance factor table

First order factor	Secondary factor	Grading method	Resistance coefficient	Weight
Tourist experienceSite properties	Scenic spot density	According to nuclear density or linear density analysis, it is divided into five categories by natural breakpoint method	1-9	0.35
	Characteristic store density			0.25
Road connectivityNode properties	Road network densityRoad network density			0.15
	Density of bus and subway stations			0.25

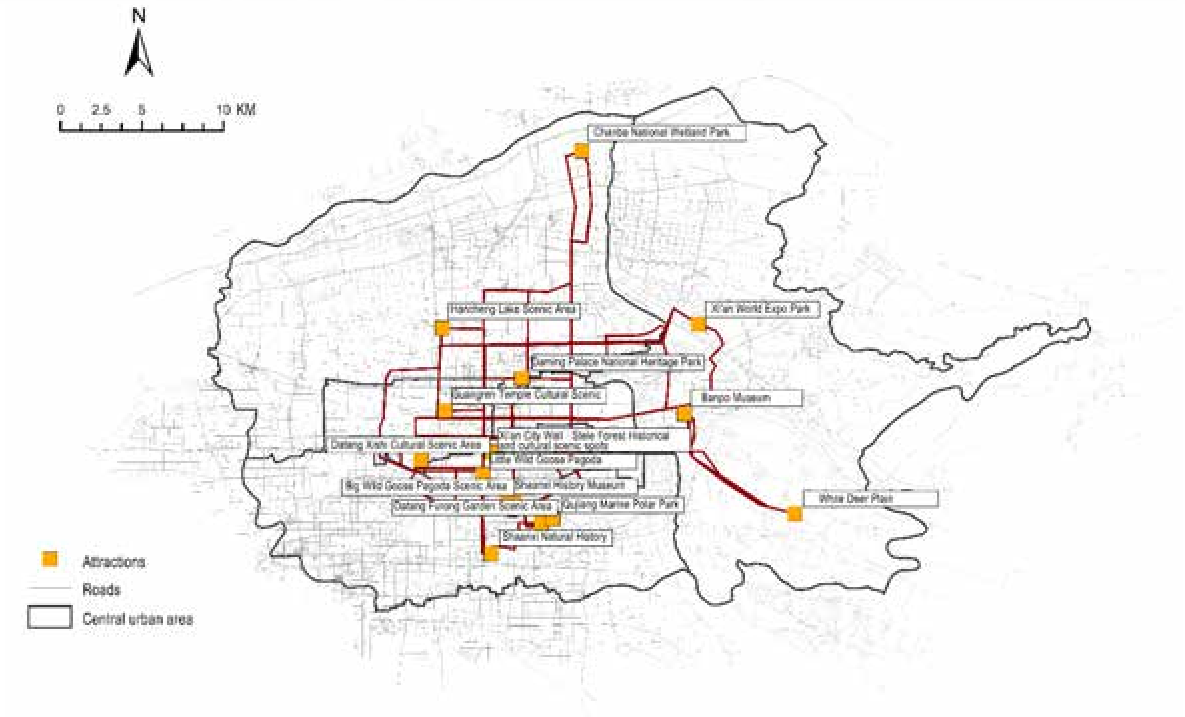


Figure 2. Traffic routes between scenic spots

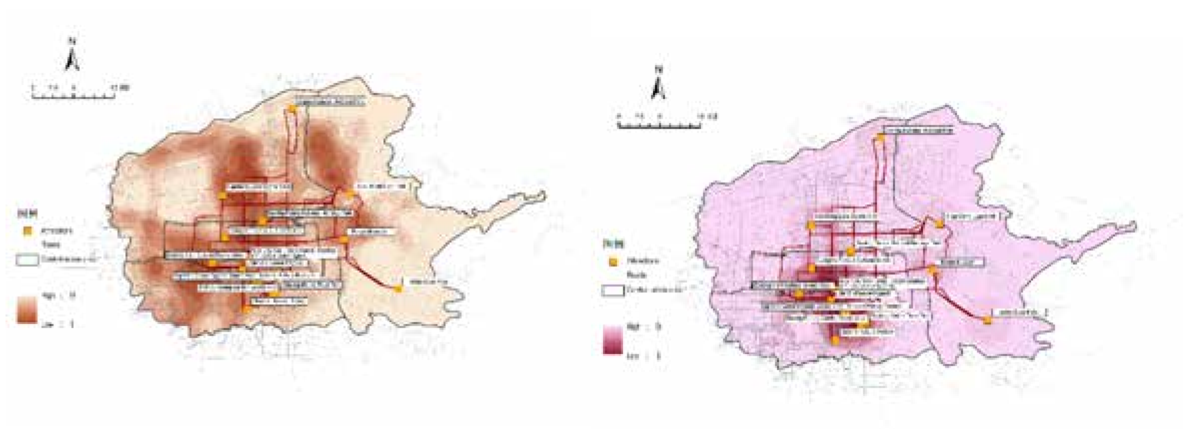


Figure 3. Traffic value (left) and tourism value (right) resistance results

This research takes public transportation as the research perspective and uses Gaode Map as the platform. The selected travel modes include a combination of subway, bus, and walking (more than 1 km) for public transportation. The ArcGIS platform is used to record the starting points, transfer times, and overall travel time data of each route. A total of 120 routes between 15 scenic spots are screened (Figure 2).

2.2 Node (Traffic) Value Measurement

2.2.1 Public Transportation Station Density

The density of public transportation stations (bus stops and subway stations) can represent their distribution and, to some extent, reflect the closeness of the connection between scenic spots and the city. This paper uses the Kernel Density tool for cluster analysis. The results show that the station distribution density around Han City Lake Scenic Area, Datang West Market, Expo Park, Banpo Museum, and the Ming City Wall area is relatively large, and the public transportation accessibility in these areas is better.

2.2.2 Road Network Density

The road network density represents the convenience of tourists' transfers to some extent. In areas with a high density, there are more transportation options and better accessibility. The analysis using the Kernel Density tool shows that the road network density around Datang West Market, the Big Wild Goose Pagoda, and the Ming City Wall area is relatively high. Scenic spots like Bailuyuan are far from the urban area, so the road network density is low.

2.2.3 Quantitative Superposition Results

By referring to relevant literature, weights are assigned to the two factors of public transportation station density and road network density, and reclassification is carried out. Then, the Weighted Sum tool is run to obtain the comprehensive resistance surface of traffic value (Figure 3).

2.3 Place (Tourism) Value Measurement

2.3.1 Characteristic Shop Density

In this paper, the POI data of characteristic shops are obtained from the Baidu Map interface. Shops such as homestays, specialty stores, and characteristic food stores that meet the six major needs of tourists, namely "eating, accommodation, transportation, sightseeing, shopping, and entertainment", are screened. Therefore, areas with a high density of characteristic shops represent, to some extent, the more developed tourism areas in the main urban area of Xi'an. The analysis using the Kernel Density tool shows that the density of characteristic shops near the Bell and Drum Towers and the Datang Ever - Bright City is relatively high, with relatively high tourism value and more attractive to tourists. The tourism industry construction near the Expo Park and the Bailuyuan Scenic Area is relatively poor.

2.3.2 Scenic Spot Density

The scenic spot density can represent the concentration of tourism resources to some extent. The analysis using the Kernel Density tool shows that the area composed of the Shaanxi History Museum, the Big Wild Goose Pagoda, the Datang Furong Garden, and the Qujiang Ocean Polar Park has a relatively high scenic spot density and is more attractive to tourists.

2.3.3 Quantitative Superposition Results

By referring to relevant literature, weights are assigned to the two factors of characteristic shop density and scenic spot density, and reclassification is carried out. Then, the Weighted Sum tool is run to obtain the comprehensive resistance surface of tourism value .

2.4 Node - Place Model Construction

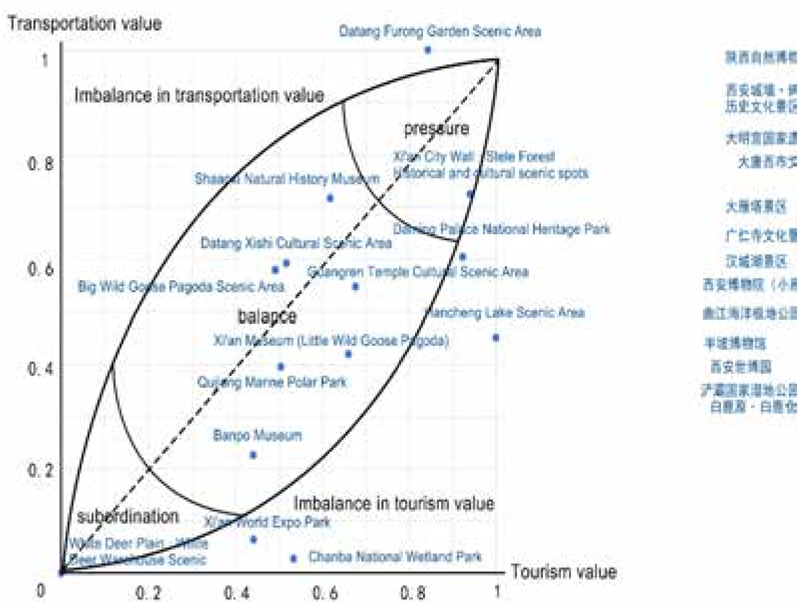
Analysis of 20m buffer area for routes between scenic spots. Using the 14 routes of each scenic spot as a mask, the raster data of traffic value and tourism value are extracted, and the average value of each scenic spot's route is recorded. The obtained data are processed by max-min standardization to get two values for each scenic spot (Table3). Taking the traffic value as the y - axis and the tourism value as the x - axis, a node (traffic) - place (tourism) model is established. Through model evaluation, it can be found that half of the scenic spots are in a balanced state, and some are in a subordinate state, a pressured state, or an imbalanced state.

3. Development Judgment and Development Strategies
3.1 Balanced State

Table 3. Table of transportation tourism value of each scenic spot

Name of scenic spot	Traffic value	Tourism value
Big Wild Goose Pagoda Scenic Area	0.51	0.42
Datang Furong Garden Scenic Area	0.16	0.00
Xi'an City Wall · Stele Forest Historical and cultural scenic spots	0.06	0.28
Xi'an City Wall · Stele Forest Historical and cultural scenic spots	0.08	0.40
Shaanxi History Museum	0.51	0.42
Qujiang Marine Polar Park	0.50	0.61
Datang Xishi Cultural Scenic Area	0.48	0.41
Banpo Museum	0.56	0.77
Xi'an Museum (Little Wild Goose Pagoda)	0.34	0.58
Xi'an World Expo Park	0.56	0.94
Hancheng Lake Scenic Area	0.00	0.55
Chanba National Wetland Park	0.47	0.97
Shaanxi Natural Museum	0.38	0.28
White Deer Plain · White Deer Warehouse Scenic Area	1.00	1.00
Guangren Temple Cultural Scenic Area	0.32	0.45

Figure 4. Traffic tourism value model of scenic spots in the main urban area of Xi'an



According to the result analysis, the Shaanxi Natural History Museum, the Qujiang Ocean Polar Park, the Xi'an Banpo Museum, the Xi'an Museum (Xiaoyanta), the Guangren Temple Cultural Scenic Area, the Xi'an Datang West Market Cultural Scenic Area, the Xi'an Big Wild Goose Pagoda Scenic Area, and the Shaanxi History Museum are all in a balanced state, but their synergy levels vary. Specifically, the Big Wild Goose Pagoda Scenic Area and the Datang West Market Scenic Area are close to the 45° line, showing a better synergy state. Therefore, in their subsequent development planning, emphasis should be placed on ensuring that the traffic value and tourism value increase or decrease simultaneously to maintain and promote the continuous evolution of the synergy state. In contrast, although the Banpo Museum and the Xi'an Museum maintain a balanced state, they deviate significantly from the 45° line. Therefore, in the subsequent strategic deployment, attention should be focused on optimizing the value structure: strengthening the relatively low - level elements of their traffic value to avoid potential imbalance risks and ensure the robustness of overall balance and coordinated development.

3.2 Subordinate State

According to the result analysis, the Bailuyuan·Bailucang Scenic Area is in a subordinate state, with the traffic and tourism values being in synergy but at a low level, and the two values are equal and both low. In the later stage, targeted optimization strategies can be proposed, such as creating tourism special lines, adding bus stops, and increasing the implantation of characteristic shops.

3.3 Pressured State

According to the result analysis, the traffic value and tourism value of the Xi'an City Wall·Beilin Historical and Cultural Scenic Area are both at a high level, belonging to the pressured state. The advantages of popular scenic spots are fully reflected, and the node value and place value are relatively high, which is also consistent with people's general perception. The future development of this scenic area should focus on relieving traffic and urban development pressure and avoiding over - tourism development and traffic congestion as much as possible.

3.4 Imbalanced State

According to the result analysis, the Xi'an Datang Furong Garden Scenic Area, the Xi'an Chanba National Wetland Park, the Xi'an Expo Park, the Daming Palace National Heritage Park, and the Xi'an Han City Lake Scenic Area are all in an imbalanced state. Among them, the Datang Furong Garden Scenic Area is in a traffic - value imbalanced state, and the others are in a tourism - value imbalanced state. Therefore, in the subsequent tourism development, the Datang Furong Garden Scenic Area should pay attention to relieving traffic pressure and appropriately balancing tourism resources; the other scenic spots have good traffic accessibility but insufficient tourism development. In the future, attention should be paid to the implantation of the tourism industry to improve the tourist experience.

4. Conclusion

In summary, based on Luca Bertolini's node - place model, this research takes 15 scenic spots at or above 4A level in the main urban area of Xi'an as the research object and deeply explores the synergy between the traffic value and tourism value of public transportation routes between scenic spots. By constructing a comprehensive resistance surface, key factors such as public transportation station density, road network density, characteristic shop density, and scenic spot density are quantitatively analyzed, and then the development states of each scenic spot in the node - place model are revealed. The research results show that the development states between scenic spots are diverse, including the balanced state, the subordinate state, the pressured state, and the imbalanced state. According to the characteristics of each state, corresponding optimization strategies are proposed: for scenic spots in the balanced state, the traffic and tourism values should be increased or decreased simultaneously to promote coordinated development; for those in the subordinate state, the overall value should be improved by adding transportation facilities and enriching the tourism industry; for scenic spots in the pressured state, attention should be paid to traffic diversion and the balance of tourism carrying capacity to avoid over - development; for those in the imbalanced state, according to the specific situation, the transportation facilities should be optimized or the tourism industry should be implanted to achieve value balance and improvement. This research not only provides a scientific basis for the optimization of public transportation routes between scenic spots in the central urban area of Xi'an but also offers valuable references for the integrated development of transportation and tourism in other cities.

Referencing style

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