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Research on Tourism Strategies in China Based on Planning Models

Ruiqi Zhou[1,†,*], Yiqiao Zhang[2,†], Shi Zhou[3,†]

[1]*School of Finance, Southwestern University of Finance and Economics, Chengdu, China*
[2]*School of Insurance, Central University of Finance and Economics, Beijing, China*
[3]*School of Engineering, Beijing Forestry University, Beijing, China*
[†]*These authors also contributed equally to this work*
[*]*Corresponding author: 13379941615@sohu.com*

Abstract: *With the implementation of the 144-hour visa-free transit policy in China, more and more tourists from different countries are willing to try to travel to China. The goal of this paper is to plan the best excursion routes within 144 hours by combining time, money, and other resources to provide tourists with the optimal travel experience. First, this paper uses the TOPSIS method and gray correlation analysis to calculate the weights and rankings of each city. The results of these analyses will help determine which cities have higher priority in tourists' travel plans. Subsequently, in the planning model, different travel routes are calculated based on the constraints such as the best overall travel experience and the lowest cost for tourists, respectively, to meet the needs of different tourists. Through this approach, this study provides scientific tools and methods for foreign tourists' travel planning and provides valuable references for other path planning problems.*

Keywords: *entropy weight-TOPSIS-GRA grouping, traveling salesman problem, optimization model*

1. Introduction

In recent years, China's tourism industry has been growing rapidly, especially with the implementation of the 144-hour visa-free transit policy by the Chinese government, and more and more foreign tourists are choosing to come to China to explore its rich cultural and natural landscapes. Against this background, designing an optimal travel route for tourists within a limited period has become a challenging problem. Traditional travel route planning usually considers only a single factor, such as time, cost, or travel experience. To enhance the quality of tourists' travel within a limited time, this paper proposes a planning model that integrates the TOPSIS method and gray correlation analysis, aiming to balance multiple factors, such as time, cost, and travel experience, to provide tourists with a scientifically sound optimal tour route within 144 hours. This research not only provides tourists with personalized travel planning solutions, but also provides new solution ideas and methods for complex path optimization problems.

2. Data collection and pre-processing

2.1 Data collection

This article collects 35,200 scenic spots in a total of 352 cities through the official website of China Tourism, including basic information such as name, website, address, attraction introduction, attraction opening hours, picture URL, attraction rating, recommended visit time, suggested visit season, ticket price and so on. The basic information of tourist attractions in 352 cities in China is compiled into a complete data set.

2.2 Data preprocessing

In the process of data processing, this paper finds that there are problems such as score gaps, duplicate statistics of scenic spots, and invalid score values [1]. For the completeness of the master data and the accuracy of the subsequent analysis, the blank and invalid scores were filled with 0, and the Python program was used to filter and remove duplicate statistical points.

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3. Entropy weight -TOPSIS-GRA group method

To explore the tourism scores of different cities to determine specific route planning, this paper uses Entropy weight -TOPSIS-GRA group method. Entropy weight -TOPSIS-GRA group method is a brand-new method. The combination method of entropy weight -TOPSIS-GRA has obvious advantages in multi-index decision analysis. First, the entropy weight method automatically allocates weights by calculating the information entropy of each index, which makes the weight distribution more objective and avoids the deviation caused by human subjectivity. Secondly, TOPSIS method can comprehensively measure the advantages and disadvantages of a scheme by calculating the distance between the scheme situation and the ideal solution and the negative ideal solution, which is convenient to find the optimal solution. Finally, the grey correlation degree (GRA) method can effectively deal with the nonlinearity of sample data by measuring the correlation degree between each scheme and the ideal scheme.

3.1 Entropy weight method measurement

To determine the weight of factors such as city size, cultural heritage, and climate in the comprehensive score of the city, this paper selects the entropy weight method for measurement [2]. The specific steps of the Entropy Weight Method are as follows：

(1) Normalization:

$$P_{ij} = \frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}} \tag{1}$$

Where P_{ij} is the normalized value of the ith sample under the jth indicator, X_{ij} is the element of the original matrix.

(2) Calculate the entropy value:

$$E_j = -k \sum_{i=1}^{n} P_{ij} \ln P_{ij} \tag{2}$$

Where $k = \frac{1}{\ln n}$ and n is the sample size.

(3) Calculate the coefficient of difference:

$$d_j = 1 - E_j \tag{3}$$

(4) Calculate the weights:

$$w_j = \frac{d_j}{\sum_{j=1}^{m} d_j} \tag{4}$$

Where m is the number of indicators.

As shown in Figure 1 and Table 1, according to the entropy weight method, the heat map of the neutral distribution of the entropy weight method for each index is plotted, and the weights of each factor are determined.

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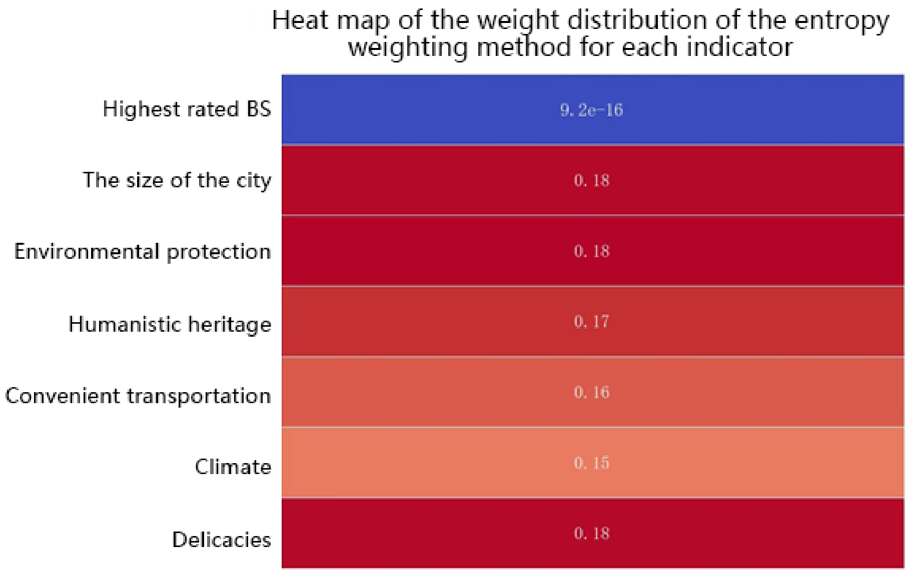

Figure 1: Heat map of the neutral distribution of the entropy weight method for each indicator

Table 1: Weights calculated by the entropy weight method

Index	Weight
Highest rated BS	0.0000
The size of the city	0.1757
Environmental protection	0.1770
Humanistic heritage	0.1693
Convenient transportation	0.1563
Climate	0.1454
Delicacies	0.1763

3.2 TOPSIS measurement

The TOPSIS method is a commonly used comprehensive evaluation method, which makes full use of the information of the raw data, and its results can accurately reflect the gaps between the evaluation options [3]. This method is used to score the ideal degree of different cities, and the specific calculation steps are as follows:

(1) Normalization matrix:

$$R_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{n} X_{ij}^2}} \quad (5)$$

(2) Weighted normalization matrix:

$$V_{ij} = w_j * R_{ij} \quad (6)$$

(3) Determine the ideal solution and the negative ideal solution:

$$V_j^+ = max(V_{ij}), V_j^- = min\ (V_{ij}) \quad (7)$$

(4) Calculate the distance between the ideal and negative ideal solutions:

$$S_i^+ = \sqrt{\sum_{j=1}^{m} (V_{ij} - V_j^+)^2}$$
$$S_i^- = \sqrt{\sum_{j=1}^{m} (V_{ij} - V_j^-)^2} \quad (8)$$

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(5) Calculate the relative proximity:

$$C_i^{+} = \frac{S_i^{-}}{S_i^{+} + C_i^{-}} \tag{9}$$

3.3 Grey correlation analysis (GRA) association measurement

Grey correlation analysis (GRA) can effectively handle the nonlinearity of sample data by measuring the correlation between each scheme and the ideal scheme [4], and it is calculated as follows:

(1) Normalization matrix:

$$Z_{ij} = \frac{X_{ij} - min\,(X_j)}{max(X_j) - min\,(X_j)} \tag{10}$$

(2) Find the ideal solution:

$$Z_j^{-} = max\,(Z_{ij}) \tag{11}$$

(3) Calculate the grey correlation coefficient:

$$\varepsilon_{ij} = \frac{\min_i \min_j \left|Z_{ij} - Z_j^{*}\right| + \rho \max_i \max_j \left|Z_{ij} - Z_j^{*}\right|}{\left|Z_{ij} - Z_j^{*}\right| + \rho \max_i \max_j \left|Z_{ij} - Z_j^{*}\right|} \tag{12}$$

Where ρ is taken as 0.5.

(4) Calculate grey correlation:

$$\gamma_i = \frac{1}{m}\sum_{j=1}^{m} \varepsilon_{ij} \tag{13}$$

3.4 Overall score

The combination of these three methods can complement each other in weight allocation, scheme evaluation and nonlinear processing, and improve the scientific and reliability of decision making. By averaging TOPSIS and GRA scores, the final ranking is more robust and can more accurately reflect the combined strengths of each program. Based on this method, we can find the top 50 cities with the highest overall score, as shown in Figure 2.

$$S_i = \frac{C_i^{+} + \gamma_i}{2} \tag{14}$$

Where S_i is the overall score of the ith city.

4. Variant of the traveling salesman problem

The Traveling Salesman Problem (TSP) is a classic problem in combinatorial optimization that aims to find the shortest path to visit a series of cities and return to the point of origin [5-7]. There are mainly the following constraints:

(1) Only select the highest-rated attractions in each city.

(2) Only travel in the top 50 cities in the overall ranking.

(3) Follow the time limit of up to 144 hours.

(4) Entry from Guangzhou.

Then the following definition can be given: Node is the best attraction in each city and cost includes the cost of travel from one city to another and the cost of tickets.

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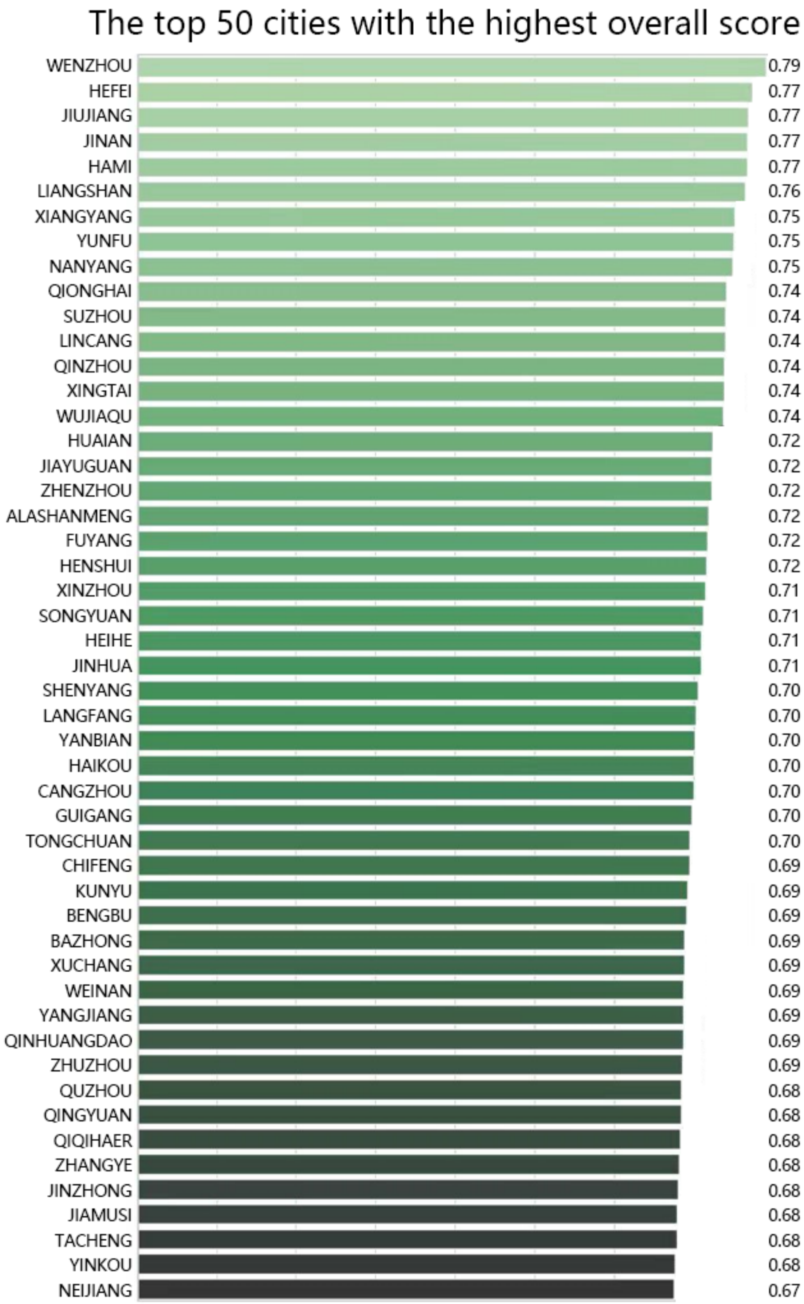

Figure 2: Overall score

This can then be modeled into a weighted graph, where the large nodes represent the cities, and the small nodes represent the best spots in each city. The edges of the nodes represent the high-speed rail connection between cities, and the weights of the edges are the travel cost (including ticket costs) and the time spent on the high-speed rail. Then the three decision variables can be given: X_{ij} is binary decision variables, if the path from city i through city j is 1, otherwise it is 0; S_i is score attractions in City i; t_{ij} is the travel time from city i to city j. So, the problem can be solved by the following steps:

(1) Determine the initial values of N_{min} and S_{min} step by step.

(2) Adjust N_{min} and S_{min} gradually to solve the optimization problem after each adjustment.

(3) Collect all generated solutions that show trade-offs at different thresholds.

(4) Analyze the solution set and determine the optimal Pareto solution. In detail, the minimum threshold of the number of cities visited N_{min} and the minimum threshold of play experience (scenic

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spot score) S_{min} should be set, which are:

$$\sum_i x_{ii} \geq N_{\min}, \sum_i s_i x_{ii} \geq S_{\min} \tag{15}$$

Where x_{ii} indicates staying in city i to select scenic spots. At the same time, a city can only be accessed once:

$$\sum_j \neq_i X_{ij} = 1, \forall i, \sum_i \neq_j X_{ij} = 1, \forall j \tag{16}$$

Secondly, the subloops need to be set to avoid:

(1) Prevent subloops from appearing in the solution.

(2) Use Miller-Tuck-Zemlin (MTZ) constraints or other techniques. Finally, the time constraint needs to be set:

$$\sum t_{ij} x_{ij} \leq 144 hours \tag{17}$$

Then, the objective functions can be set under these constraints:

$$Maximiz\,e\, Z_1 = \sum_i x_{ii}, \quad MaximizeZ_2 = \sum_i s_i x_{ii} \tag{18}$$

The data set is a previously derived composite score ranking of 352 cities. Secondly, for the case of tourists who want to spend the least and visit as many cities as possible. Specifically, all relevant decision variables and constraints in the former case are still valid, but the objective function is changed. The objective function can be set in this case to:

$$MinimizeZ = \sum_i \sum_{\neq j} c_{ij} x_{ij} \tag{19}$$

Where c_{ij} is the cost of traveling from city i to city j (including time and expenses). Next, a new set of variables should be created: C_{min}, C_{max}, S_{min}, S_{max}, N_{min}, N_{max}, are the minimum and maximum values of cost, score, and number of cities, respectively, for normalization.

Weight setting: The selection of weights α, β, γ should be based on the specific needs and strategic priorities of the project. For example, if the quality of the attraction is the most important thing, then β can be set larger than α and γ.

Sensitivity Analysis: Sensitivity analysis is performed to understand the impact of different weight configurations on the final solution and whether they meet the decision maker's expectations.

Based on this, the objective function can be further improved: Suppose C is the cost of the trip, S is the sum of the attraction ratings, and N is the number of cities visited. The objective function can be refined:

$$Minimize\ Z = \alpha \frac{C - C_{min}}{C_{max} - C_{min}} - \beta \frac{S - S_{min}}{S_{max} - S_{min}} + \gamma \frac{N - N_{min}}{N_{max} - N_{min}} \tag{20}$$

The weights α, β, γ are user-defined weight parameters that reflect the relative importance of cost, attraction rating, and number of cities visited in the objective function.

5. Conclusions

In this paper, an optimization model is proposed by combining the TOPSIS method and grey correlation analysis, aiming to develop the best tour route for tourists within 144 hours. The results show that the proposed method can effectively calculate the weight and ranking of each city and provide a variety of travel route choices for different types of tourists under the constraints of satisfying tourists' comprehensive tourism experience and minimum cost. This optimization model provides scientific decision-making support for foreign tourists' tourism planning in China and provides a new reference for other path planning problems. With the continuous expansion of China's tourism market and the diversification of tourists' needs, future research can further consider more complex factors and diverse constraints to optimize the tourism experience and promote the sustainable development of the tourism industry.

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By combining the TOPSIS method and gray correlation analysis, this paper proposes an optimization model aimed at developing the best tour route for tourists within 144 hours. The results show that the method can effectively calculate the weights and rankings of each city and provide diversified travel route choices for different types of tourists while satisfying the constraints of comprehensive tourist experience and minimum cost. This optimization model provides scientific decision support for foreign tourists' travel planning problems in China and provides new references and lessons for other route planning problems. With the continuous expansion of China's tourism market and the diversified development of tourists' demands, future research can further consider more complex factors and diversified constraints to optimize the tourism experience and promote the sustainable development of tourism.

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