Research on the Strategy of Holding Olympic Games based on AHP and FCE

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Abstract. In view of the various negative impacts brought by hosting, fewer and fewer countries have shown their willingness to host in recent years The influence model of the index is established, and the influence of each index is calculated by the method of hierarchy process (AHP) and fuzzy comprehensive evaluation model (FCE), thus the feasibility evaluation model is constructed.Two strategies are put forward: the first strategy is to organize a fixed place and find that China is the most suitable country to implement the first strategy by using entropy weight method; The second strategy is to divide the seasons into different ones, and calculate that Greece is the host country of summer by TOPSIS method, and Japan is the most suitable country to host the Winter Olympics.

Keywords: Olympic Games; AHP; FCE; Entropy Weight Method; TOPSIS.

1. Introduction

The Olympic Games are a globally renowned comprehensive sports event held every four years, attracting participants and viewers from across the globe. However, as the costs, risks, and post-event utilization of the Olympic Games have become increasingly evident, more and more countries and cities are becoming hesitant or even negative toward bidding to host the Games. The recent outbreak of the COVID- 19 pandemic has exacerbated international tensions, exposing significant vulnerabilities and risks for major sporting events, including the Olympic Games.[1]

Therefore, the International Olympic Committee (IOC) must confront the declining appeal of bidding for the Olympic Games and explore innovative solutions and strategies to preserve its influence and attractiveness.

2. Olympic Games Indicator Impact Model

Numerous scholars have conducted research from various angles to investigate the effects of hosting the Olympic Games on host countries and cities, as well as to propose potential solutions and strategies.

Table 1. Views of other scholars

Scholar	Method	Result
Baade [2]	Analyze the performance of countries that have hosted the Olympics in terms of GDP growth over the period 1950-2014	The Olympic Games may lead to resource misallocation, demand crowding out, and opportunity costs
Preuss [3]	Conducted a systematic review and comparative analysis of the social impacts of the Olympic Games	The social impact of the Olympic Games depends on a variety of factors, such as planning, implementation, communication, and participation, and proposes some methods for evaluation and optimization
Fourie and Santana-Gallego[4]	Used a gravity model to analyze the effects of the Olympic Games on tourism in host countries and cities in terms of tourism demand, tourism revenue, and tourism competitiveness.	The Olympic Games can significantly increase tourism demand and income, but this effect varies across regions and time periods and is influenced by other factors

Collins et al.[5]	Assessed the impact of the Olympic Games on environmental quality, including carbon emissions, water consumption, and solid waste, based on a life cycle assessment approach.	They compared the environmental performance of cities that have hosted the Olympic Games between 2000 and 2016 and analyzed the influencing factors and improvement measures

Construct the influencing factor map based on the above.

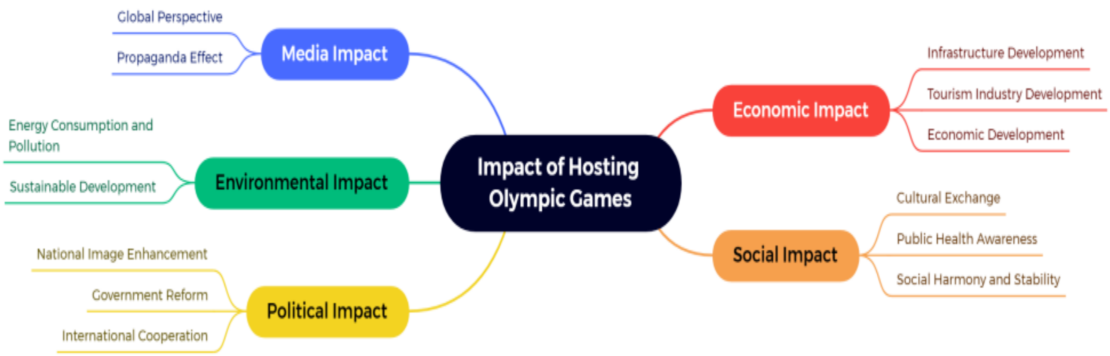

Fig. 1 Factors affecting the hosting of the Olympic Games

2.1. Analytic Hierarchy Process (AHP)

In order to better evaluate the feasibility of the Olympic Games hosting strategy, we need to build an impact model to select the relatively important indicators. According to the relevant literature, we selected six initial indicators: economic development level, budget , national popularity, infrastructure investment, environment, and human satisfaction , and calculated their weights by hierarchical analysis.The weight vectors of the seven normalized indexes are $(0.4390, 0.1815, 0.0976, 0.1971, 0.0325, 0.0523)^T$.

2.2. Fuzzy integrated evaluation model

In order to be able to obtain indicators with greater influence, we used a fuzzy integrated evaluation method.

(1) Set the Factor Sets

The impact of hosting the Olympics needs to be considered from a number of perspectives. Based on the indicators selected in the previous section, we established a collection of evaluation indicators system, i.e., the set of factors, denoted as $U = u1 , u2 , \cdots , un$.

(2) Set the Comment Sets

Due to the difference in the degree of influence of each indicator on the Olympics, different grades are often formed. The set consisting of various different decisions is called the set of rubrics and is noted as $V = v1 , v2 , \cdots , vm$.

(3) Set the Weight of Each Factor

In general, the roles of various factors in a set of factors are different in the overall evaluation.

Determine the Fuzzy Integrated Judgment Matrix and Evaluate Each Element ui

The evaluation matrix is formed with Ri as the i-th row:

$$\begin{aligned} R2 &= [0.45, 0.25, 0.1, 0.2, 0, 0] \\ R3 &= [0.35, 0.3, 0.2, 0.1, 0.05, 0] \\ R4 &= [0.5, 0.3, 0.05, 0.15, 0, 0] \\ R5 &= [0.3, 0.2, 0.2, 0.1, 0.1, 0.1] \\ R6 &= [0.3, 0.35, 0.15, 0.1, 0.1, 0] \end{aligned} \tag{1}$$

The size of this evaluation matrix is n×m, where n is the number of impact factor indicators and m is the number of rubrics.

（5）Fuzzy Integrated Judgment

The final result of performing matrix synthesis operation is B= [0.4374, 0.2464, 0.1058, 0.1939, 0.0134, 0.0033], so the influence degree of each index is as shown in Figure 2.

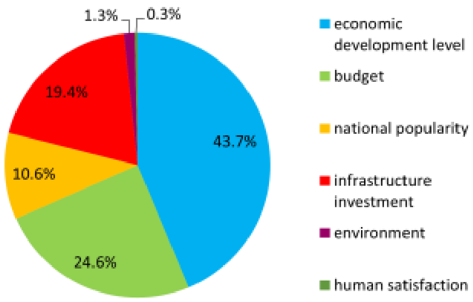

Fig. 2 Impact indicator weights for the Olympic Games

3. Olympic Games Feasibility Evaluation Model

References are cited in the text just by square brackets [1]. (If square brackets are not available, slashes may be used instead, e.g. /2/.) Two or more references at a time may be put in one set of brackets [3, 4]. The references are to be numbered in the order in which they are cited in the text and are to be listed at the end of the contribution under a heading *References*, see our example below.

3.1. The first strategy: organizing the Olympic Games in a fixed location

This strategy can effectively reduce the cost of hosting the Games and reduce the impact on the city.But how to choose a suitable area as the location of the Olympic Games is a question worth thinking about. To solve this problem, we use the entropy method to determine a suitable country to host the Olympic Games.

3.1.1 Entropy method

According to the results obtained from indicator impact model for the Olympic Games,we selected the four most influential indicators as the indicator variables in the entropy weighting method.To be able to better measure the feasibility of the strategy, we selected gross domestic product, budget , revenue from tourism and transportation infrastructure investment as evaluation indicators.

Calculate the entropy value of the jth indicator

$$e_j = -\frac{1}{\ln n}\sum_{i=1}^{n} p_{ij}\ln p_{ij}, j = 1, 2, \cdots, m. \tag{2}$$

The calculation results are ej = [0.8096, 0.4852, 0.6370, 0.7535].

Calculate the coefficient of variation of the jth indicator

$$g_j = 1 - e_j, j = 1, 2, \cdots, m. \tag{3}$$

The calculation results are gj = [0. 1904, 0.5148, 0.3630, 0.2465].

Calculate the weight of the jth indicator

$$w_j = \frac{g_j}{\sum_{j=1}^{m} g_j}, j = 1, 2, \cdots, m. \tag{4}$$

The calculation results are wj = [0. 1448, 0.3916, 0.2761, 0. 1875].

Calculate the comprehensive evaluation value of the ith evaluation object

$$s_i = \sum_{j=1}^{m} w_j p_{ij} \tag{5}$$

The final composite evaluation value obtained for each country is si = [20.2221, 100.0000, 54.9564, 10.0890, 55.2985].

Feasibility evaluation

We use the change of GDP before and after the Olympic Games in Beijing as anexample to verify the feasibility of the first strategy through a gray prediction model.

The commonly used gray prediction models are GM(1,1) model and GM(2,1) model.Since there is only one independent variable, we use a first-order differential equation model,i.e. GM(1,1).

Construct gray models and make predictions.The research results show that China's GDP shows an upward trend after hosting the Olympics, which indicates that the first strategy can bring positive benefits to the host country to some extent.

3.2. The second strategy: dividing the Olympic Games into different seasons

Splitting the Olympics into different seasons would allow more countries to hold the games and add some unique events.

3.2.1 Spring Olympic Games

We use hierarchical analysis to select the countries that are suitable for hosting the Spring Olympics.

(1) Construction of hierarchy

In order to make the results more general, we select the United States, Britain, Japan, Brazil, Egypt and Australia as comparative objects, and select economic level, national popularity, infrastructure investment and human satisfaction as layers

(2) Construction of judgment matrix

Based on the information reviewed, we created four judgment matrices by comparing the six countries two-by-two using the four indicators mentioned above as guidelines.

(3) Calculate weight by eigenvalue method

After calculation, the weight vectors for the six countries in these four indicator species are:

C1 = [0. 1025, 0.2084, 0.0463, 0.0463, 0.5503, 0.0463]

C2 = [0.4406, 0.2470, 0.0535, 0.0796, 0. 1572, 0.0221]

C3 = [0.3308, 0. 1127, 0.0602, 0.2231, 0.2231, 0.0500]

C3 = [0.3998, 0.0962, 0.0922, 0. 1780, 0. 1780, 0.0557]

(4) Consistency inspection

Consistency tests were performed on each of the four index indicators.According to the consistency test results, it can be seen that all judgment matrices are valid.

(5) Determine the weight of indicators

Using the outcomes derived from the Olympic Games' indicators impact model, we constructed a discernment matrix among distinct indicators.

After calculating to get the weights:$(0.5538, 0.2419, 0.1324, 0.0719)^T$.

The results of the consistency test are CI = 0.0153, CR = 0170.

Calculate the score and get the result

Using Egypt as an example, the final score is calculated as 0.5538 * 0. 1025 + 0.2419 * 0.4406 + 0. 1324 * 0.3308 + 0.0719 * 0.3998 = 0.23588918.

Accordingly, the scores of other countries in order are 0. 1969948, 0.05318225, 0.08723282, 0.38511946, 0.04161176.

According to the calculation, the United States is most suitable for hosting the Spring Olympics.

3.2.2 Summer Olympic Games

In order to select the most suitable country for holding the Summer Olympics, we used the data used previously as the initial data for the technique for order preference by similarity to ideal solution (TOPSIS) , which allowed the results to be more representative.

Find the positive ideal solution and negative ideal solution, and calculate the positive ideal distance and negative ideal distance

The positive ideal solution and negative ideal solution are found from the normalized matrix, and then the distances from each indicator to the positive ideal solution and negative ideal solution are calculated separately.

The positive ideal distances s obtained after calculation are 0.1686,1.0326,0.7807,0.2530,0.6928. The negative ideal distances s obtained after calculation are 1. 1354,0.5085,0.7574,1,1377,0.7644.

Calculate the composite evaluation index for each country

The value of the ranking indicator for each country is calculated according to the following equation.

$$f_i^* = s_i^0 / \left(s_i^0 + s_i^* \right), i = 1, 2, \cdots, m. \tag{6}$$

The final relative proximity obtained for each country are 0.8707,0.3300,0.4924,0.8181,0.5246.

From the above results, it is clear that Greece is the most suitable country to hold the Summer Olympics.

3.2.3 Winter Olympic Games

Taking into account the unique features of the Winter Olympics, we gathered pertinent data from four countries, specifically the United States, China, Japan, and Russia, encompassing factors such as economic status, climatic conditions, and security measures. We subsequently partitioned the data into two sets, namely a training set and a test set, implemented a support vector machine model with the former set, and assessed the model performance by leveraging the latter set.[6]

Data training and evaluation

We use a support vector machine model to train and evaluate the data. Support vector machine is a commonly used classification model that separates different classes of data by finding an optimal hyperplane. The classification function of a support vector machine is:

$$f(x) = \operatorname{sign}\left(\sum_{i=1}^{n} \alpha_i y_i K(x, x_i) + b \right) \tag{7}$$

where n is the number of samples in the training set, ai is the parameter of the support vector machine, yi is the class of the samples, K (x, xi) is the kernel function, and b is the bias term.

So train and evaluate the support vector machine model using data from the four countries mentioned above. The ratio of training and test sets is 7:3, and the kernel function used is a radial basis function kernel with a regularization factor of 0. 1, and default values are used for other hyperparameters. The results of training and evaluation are as follows Table 2:

Table 2. Results after training and evaluation

Country	Accuracy	F1-score
USA	0 75	0 6
China	0.65	0.47
Japan	0 8	0 67
Russia	0.7	0.58

Model optimization and tuning parameters

Use Cross Validation (CV) method to perform five-fold cross validation on the training dataset. Then, under each set of hyperparameters, the average accuracy and the average F1-score of the five-fold cross-validation are calculated as the evaluation metrics for that set of hyperparameters.

Through several optimizations and parameter adjustments, we obtained the best support vector machine model.The hyperparameters of this model are: regularization coefficient E=1.0, kernel function type is RBF kernel, and kernel function parameter gamma=0.1.

Projections

According to the data of Japan’s economic level, climate conditions, security level and other characteristics, they are input into the trained support vector machine model for prediction.The formula used in this step is as follows:

$$f(x) = \mathrm{sgn}(\sum_{i=1}^{n} \alpha_i y_i K(x_i, x) + b) \tag{8}$$

After calculation, the probability of Japan hosting the Winter Olympics is obtained as 0.89, so we can judge that Japan is a suitable country to host the Winter Olympics.

4. Summary

When constructing the influence model, the weight of each index is determined by combining hierarchical method with fuzzy comprehensive evaluation method This enables us to evaluate the relative importance of each index in the model more objectively and accurately At the initial stage, the candidate countries for hosting the Olympic Games were determined according to predetermined conditions Subsequently, in order to assess the feasibility of these countries as potential host sites, a grey prediction model was used, which helped to strengthen the effectiveness of the strategy.

In the second strategy, it is treated differently to determine which countries are most suitable for hosting in different seasons This includes the use of different unique requirements and specifications for each season to lead to a more concentrated and refined result.

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