Feasibility Study of Fixed Olympic Cities Based on TOPSIS Evaluation Model

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Abstract. Olympic Games have been facing a steady decline in the number of bids, with countries experiencing varying degrees of negative impact, making the cost of hosting the Games unaffordble for most countries. Therefore, the paper tends to find a strategy for hosting the Olympic Games that suits the current state of the world and address the issue of choosing a host country for the Games. This paper developed an Olympic Games host city assessment model to identify two permanent hosts for the Games and make recommendations to the International Olympic Committee. Then the paper analyzed the feasibility of the two countries chosen as hosts for the Olympic Games and carried out a predictive analysis of Beijing, China and Salt Lake City, USA for putting each sub-indicator in the predictive analysis. Sensitivity analysis is used to verify the impact of potential strategies on our metrics. The paper discusses the implications of the policy and the pros and cons of it.

Keywords: Olympic Games Host City Assessment Model, Entropy Weight Method, Feasibility, ARMA.

1. Introduction

The Olympic Games are now one of the most prestigious sporting events in the world, providing a platform for countries and regions to showcase their sporting abilities, with each event attracting the attention of the entire community. However, the high cost of hosting the Games has placed a huge financial burden on the host countries and cities. In the future, the fundamental question we need to consider and face is how to establish a system for hosting the Olympic Games that is relevant to the times and how to make our Games more healthy and sustainable.

We firstly collected and processed the required data. A comprehensive evaluation model using hierarchical analysis is combined with the entropy method to calculate the weights of our indicators. We chose the TOPSIS evaluation method to obtain country rankings and select the most suitable country to host the Games and position it as a permanent host country. Then we selected China and the USA as the hosts of the Spring/Summer Olympic Games, giving sound reasons for the choice and evaluating all aspects of the two countries. In addition, we quantified the effectiveness of the policy, taking into account the characteristics of the historical data, and chose the ARMA model to predict and compare the indicators and composite scores. Finally we analyse the impact of the policy period on the various aspects of hosting the Olympic Games and point out the advantages of choosing a permanent host country.

2. Preliminary

2.1. Assumptions

1.We assume that the reason for choosing the host country of the Olympic Games is its political stability and security.

2.We assume that the economic conditions of the host countries of the Olympic Games are the same items.

3.We assume that any traveler is equally likely to visit any country.

4.We assume that the host country of the Olympic Games is capable of receiving tourists at the same level as the host city.

5.We assume that the choice of the host country of the Olympic Games is reflected comprehensively and scientifically through limited and reasonably selected indicators.

2.2. Entropy weight method

We assume that *i* (Value range[1,*m*]) is the object of evaluation, and *j* (Value range[1,*n*]) is the indicators of evaluation[1]. Standardized treatment of indicators: homogenization of heterogeneous indicators. Since the units of measurement of various indicators are not uniform, before using them to calculate composite indicators, we must first standardize them, that is, convert the absolute value of the indicator into a relative value, and we let:

$$x_{ij} = |x_{ij}| \tag{1}$$

Then we solve the homogenization problem of different quality index values. For the high and low indicators, we use different algorithms for the data[2].

$$x'_{ij} = \left[\frac{x_{ij} - min(x_{1j}, x_{2j}, \cdots, x_{nj})}{max(x_{1j}, \cdots, x_{nj}) - min(x_{1j}, \cdots, x_{nj})}\right] \tag{2}$$

$$x'_{ij} = \left[\frac{max(x_{1j}, x_{2j}, \cdots, x_{nj}) - x_{ij}}{max(x_{1j}, \cdots, x_{nj}) - min(x_{1j}, \cdots, x_{nj})}\right] \tag{3}$$

2.3. Notations

The important notations are shown in Table 1.

Table 1. Symbols notation

Symbols	Description
e_j	The entropy of the indicators
g_j	The variance of the indicators
CI	Feature vector
CR	Consistence test
Z_{ij}	Data is processed dimensionless

3. Experiments

3.1. Problem analysis

After establishing the impact indicators of hosting the Olympic Games (economy, land use and tourism, etc.) through different perspectives and obtaining relevant data, we developed an impact evaluation model of hosting the Olympic Games using the quantitative method of Integrated weighting-TOPSIS to evaluate the impact of hosting the Olympic Games on various aspects of the host country.

The model was applied to a total of 24 countries hosting the Winter and Summer Olympic Games from 1976-2020, and the proximity of each Olympics to the best solution was calculated and ranked. The results are presented as a bar chart showing the comparison between each Olympic Games.

3.2. Model establishment

Integrated weighting-TOPSIS[3] is an Olympic impact evaluation model that we combine the existing hierarchical analysis method and entropy weighting method to determine weights and analyze based on TOPSIS method. Entropy weighting method was proposed by Professor Chen Jingrun in 1989, which is a method to calculate weights based on information entropy theory. In the entropy method, the degree of influence of each factor on the decision result is regarded as the information

entropy, and the weight of each factor is inversely proportional to the information entropy, i.e., the lower the information entropy, the higher the weight. AHP (Analytic Hierarchy Process) is a subjective empowerment method, which is a multi-level hierarchy proposed by American operations researcher Thomas Saati in 1970s. AHP helps decision makers to quickly and accurately determine the importance and weights among different factors by hierarchizing the decision problem, constructing a hierarchical model, making comparative judgments, and calculating weights. The calculation of index weights in this paper uses a combination of entropy weight method and hierarchical analysis, which helps to eliminate the subjective influence brought by AHP weight calculation and makes the weight determination more accurate. The technique of ranking preference for ideal solution similarity (TOPSIS) is a traditional comprehensive evaluation method for solving multi-objective decision analysis of limited solutions. It can make full use of information from raw data to reflect the gaps between evaluation programs. In this paper, the combined Integrated weighting-TOPSIS method is used to ensure the objectivity of evaluation results based on data, which is better than other methods and is an improvement of the generality of other methods. Figure 1 shows the specific model.

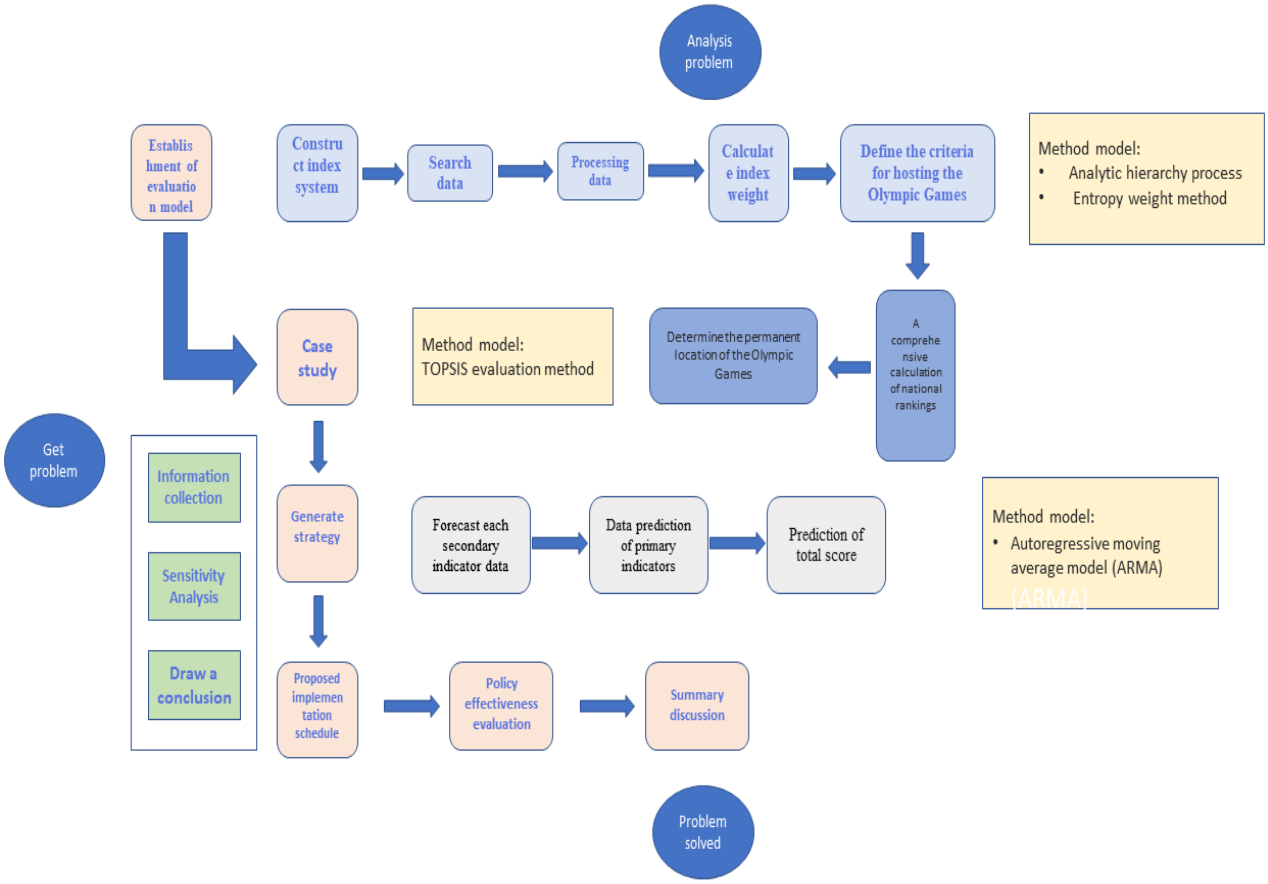

Figure 1. The flow chat of model

3.3. Combination EWM and AHP

We set the weight obtained by the entropy weighting method as W_{i1} and the weight obtained by the hierarchical analysis method as W_{i2}. We obtain the combined weight of the two combined W_i[4].

$$W_i = \frac{W_{i1}+W_{i2}}{2} \quad (4)$$

The results of combined weights and the weights of secondary indexes are shown in Figure 2.

Figure 2. For Primary and secondary indicators

3.4. Result

According to the steps of PLS regression[5], by extracting potential factors, it is found that when there are 5 potential factors, it can explain 80% of the information of the independent variables, and based on this, the maximum number of principal components of the parameters is determined. VIP (Cumulative Projection Importance) means that when the number of components is different[6], the interpretation importance of X to Y can also be used to refer to the maximum number of principal components. Among them, for in- dependent variables with a large VIP (greater than 1), it plays a relatively greater role in explaining potential factors (and thus explaining dependent variables).

Table 2 shows the factor variance explanation.

Table 2. The rank of each countries

Countries	Close to the optimal solutions	Rank
2008 Beijing, China	0.640860044	1
2002 Salt Lake City, USA	0.627205087	2
1980 Lake Placid, USA	0.620642118	3
2000 Sydney, Australia	0.6051183	4
1996 Atlanta, USA	0.602752142	5
1984 Los Angeles, USA	0.599324989	6
1998 Nagano, Japan	0.536136364	7
1984 Sarajevo, Yugoslavia	0.523249412	8
2014 Sochi, Russia	0.509322781	9
1992 Albertville, France	0.494265253	10
2006 Dublin, Italy	0.486723312	11
2010 Vancouver, Canada	0.484196816	12
2020 Tokyo, Japan	0.479342375	13
2018 Pyeongchang, South Korea	0.477266621	14
1980 USSR	0.445702472	15
2012 London, UK	0.401689783	16
2016 Rio, Brazil	0.362335292	17
2004 Athens, Greece	0.352951235	18
1988 Seoul, South Korea	0.344682982	19
1992 Barcelona, Spain	0.335444046	20
1976 Montreal, Canada	0.331734673	21
1994 Lillehammer, Norway	0.329547612	22
1976 Innsbruck, Austria	0.290909383	23
1988 Calgary, Canada	0.22688178	24

By designing the TOPSIS algorithm[7], we obtained the proximity of a total of 24 Olympic Games to the optimal solution in the current state of the model and ranked them. The specific results are shown in the table above. The closest Olympic Games to the optimal solution is the 2008 Beijing Summer Olympic Games with the value of 0.640860044. The closest Olympic Games to the optimal solution is the 1988 Calgary Winter Olympic Games with the value of 0.22688178. The value is 0.22688178[8].

4. Discussion

We propose a permanent location for both the summer and winter Olympic Games. The advantages of having a permanent location for both the summer and winter Olympic Games are mainly economic, political and cultural.

We believe that dividing the Olympic Games into four spring, summer, autumn and winter would increase the inequality in the number of competitive events, with an imbalance in the number of competitions in each season, such as more events in summer and fewer in winter leading to unequal opportunities for participating countries and regions. At the same time athletes would face shorter training periods, affecting their health and performance.

4.1. Selection of city

As for the final choice of permanent host sites for the Summer and Winter Olympic Games, I believe that the choice should be made from countries that have already hosted the games. We used the established evaluation model to obtain the scores of previous summer and Winter Olympics by TOPSIS method.

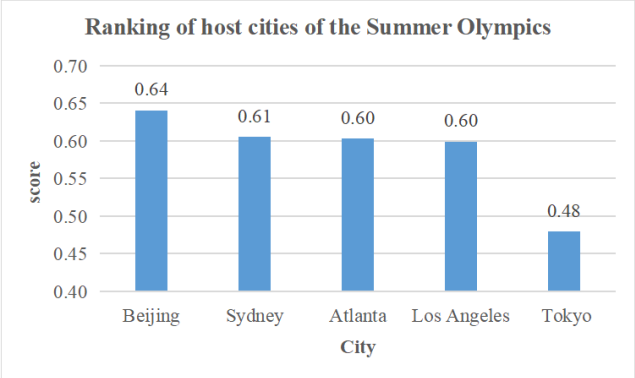

Figure 3. Ranking of host cities of the Summer Olympics

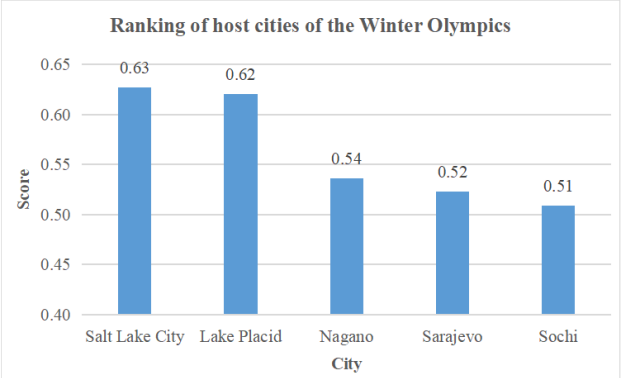

Figure 4. Ranking of host cities of the Winter Olympics

Figure 3 and figure 4 shows the countries that have hosted the Summer Olympics and the Winter Olympics since the modern Games began. We use our evaluation model to score each Summer and Winter Olympic Games. We've got a ranking of all the host cities. The top five host cities for the Summer and Winter Olympics are shown above. We can thus get the best countries and cities to host the Summer and Winter Olympics. Beijing**,** China, is the permanent host city of the Summer Olympic Games in the future with the highest score of 0.64. Salt Lake City in the United States has the highest score among the national cities that have hosted the Winter Olympics, and will be the permanent host of the future Winter Games.

4.2. The strength and weakness of the model

Our model contains 7 primary indicators and 18 secondary indicators that are well representative of most of the main factors in selecting a country to host the Olympic Games, making our model highly inclusive and the data obtained more reliable.

All of the data used in our model is obtained from official websites, such as the World Bank. This makes our data sources official and authoritative and ensures the accuracy of the data.

We use a combination of hierarchical analysis and entropy weighting in our data analysis so that the weighted results are as close as possible to the actual results. The first step is to use the hierarchical analysis method (AHP)[9] to score the selected indicators subjectively and to calculate the weight of each indicator. After that we use the entropy method to calculate the weights objectively[10]. Finally the final results of the two models are combined to give a relatively high degree of accuracy to our calculations.

When we identified the two countries to host the Olympic Games, we did not consider the contingencies that could arise in that country that would make it impossible to host the Games. When unforeseen circumstances occur, our model will no longer be applicable.

5. Conclusion

We have successfully established the model for predicting the best selection of Olympic host cities by Entropy weight method.etc. The results shows that Beijing and Salt Lake City of the USA are the chosen cities in the angle of economics,politics,cultures and sports influence, etc. However, there are still some problem to be solved. We did not consider the contingencies that could arise in that country that would make it impossible to host the Games. When unforeseen circumstances occur, our model will no longer be applicable.

References

[1] He Z , Guo Z , Lin P ,et al.A method for interval-valued intuitionistic fuzzy multiple attribute decision making based on fuzzy entropy[J].Journal of intelligent & fuzzy systems: Applications in Engineering and Technology, 2020(6):38.

[2] Wang H , Yue P .Short-Term Traffic Flow Prediction of Coastal Cities based on Entropy Weight Method[J]. Journal of Coastal Research, 2020, 103(sp1):739.

[3] Xu T T , Qin J D .A New Representation Method for Type-2 Fuzzy Sets and Its Application to Multiple Criteria Decision Making[J]. International Journal of Fuzzy Systems, 2023.

[4] Abouelrous A , Bliek L , Zhang Y .Digital Twin Applications in Urban Logistics: An Overview[J]. 2023.

[5] Vaidya O S , Kumar S .Analytic hierarchy process: An overview of applications[J].European Journal of Operational Research, 2006, 169(1):1-29.

[6] Islam R .Evaluation of suggestions by the analytic hierarchy process: A case study on a public university in malaysia[J]. 2022.

[7] Ferranti J S , Chaves A P , Cruz M ,et al.Applying arima model in the context of agriculture and industries[J]. 2022.

[8] Olson D L .Comparison of weights in TOPSIS models[J].Mathematical & Computer Modelling, 2004, 40(7-8):721-727.

[9] Vuattoux J L , Carpentier E L .The bicepstral distance between random signals: a new tool for comparison of arma models identification methods based on higher-order statistics[J]. 2022.

[10] Kalita H , Kumar K .Virtual prediction and estimation of the tensile properties of engineering materials[J]. IJIDeM: International Journal on Interactive Design and Manufacturing, 2023.