Research on Olympic Site Selection Based on Evaluation Model

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Abstract. In recent years, most countries and cities have suffered certain negative effects, and the motivation to host the Olympic Games has dropped significantly, and the number of countries declaring the Olympics has decreased. This paper gives two options for holding the Olympic Games as a way to help the ICMG committee solve the Olympic Games site selection problem.determining the permanent site for the Olympic Games, considering that the permanent site requires a certain level of prestige and economic support from the country, the paper decided to start with countries that have hosted the Summer and Winter Olympic Games, because these countries tend to have a better Olympic atmosphere and the old sites of Olympic stadiums can help ease the burden of the host country. In order to select the most suitable permanent site from the former host countries, the paper considered a number of indicators to describe the success of previous Olympic Games, such as economic level, human satisfaction, the level of prestige of the host country or city, etc., and subdivided the secondary indicators on the basis of the primary indicators, thus establishing the Olympic Site Evaluation System, which was adopted by the EWM-TOPSIS model to rate each host, and the most suitable permanent site for the Summer Olympics is London, UK, while the most suitable permanent site for the Winter Olympics is Lake Placid, USA, by Matlab software solution.Holding the Four Seasons Olympics. In this paper, firstly, according to the IOC's classification criteria for the Games, the paper determined the major sports to be held in four seasons based on reasonable criteria, including 10 major sports in spring, 17 major sports in summer, 3 major sports in autumn and 7 major sports in winter.

Keywords: Olympic Site Selection Evaluation System, EWM-TOPSIS, Cluster Analysis, Euler Distance.

1. Introduction

The IOC is encountering a decline in the quantity of proposals to hold the Olympics, encompassing both the Summer and Winter Games. Previously, hosting the Olympics was viewed as a highly sought-after and esteemed opportunity. However, in more recent times, cities and countries that have hosted the Olympics have faced a range of negative impacts that affect both the short and long term. To combat these problems, creative thinkers are exploring a variety of options and strategies. One idea is to consider having a permanent location for both the Summer and Winter Games. Another possibility is to divide Olympic sports into four groups instead of two, and hold four smaller Olympic Games throughout the year Winter, Spring, Summer, and Fall. This approach could potentially lessen the burden of hosting such a large-scale event. Research has shown that sustainability is an important factor in addressing the issues facing the Olympic Games. In his systematic review, Hong (2018) found that sustainability has become one of the themes of the Olympic Games, including environmental, social, and economic aspects. the paper also suggest that governments, organizations, and other stakeholders should pay more attention to sustainability during the bidding and hosting process of the Olympic Games [1]. In conclusion, solving the problems faced in hosting the Olympic Games requires a combination of factors. Sustainability, cooperation and innovation are important aspects of the solution. Reducing the size, decentralizing the Olympic movement and using modern technology may be viable solutions to reduce the burden on cities and countries. In the future, the IOC will need to work together with cities and countries to find the best solutions to achieve sustainability and shared prosperity.

2. Options for the Permanent Site of the Winter and Summer Olympic Games

When considering hosting the Olympic Games, a host city or country faces a variety of considerations and challenges. To support ICMG's work, the paper propose to use the EWM-TOPSIS model to develop a system of evaluation indicators and to assess each potential host city or country[2].

The paper indicator system consists of five primary indicators: economic level, human satisfaction, tourism, host country prestige level, and opportunities for future improvement, with several secondary indicators under each primary indicator. For example, under the human satisfaction level, The paper consider two secondary indicators: the number of athletes participating and the audience opinion index.

The paper chose the EWM-TOPSIS model because of its ability to rank and rank effectively when dealing with multi-indicator decision problems with weights. The model uses a weighted Euclidean distance and a weighted Manhattan distance to calculate each city's score and compare it with other cities to determine the optimal host city[3]. In doing so, we consider the direction of each indicator, e.g., country GDP total is a positive indicator and audience opinion index is a negative indicator.

By using the EWM-TOPSIS model, we are able to provide a comprehensive and objective assessment that will help ICMG make informed decisions in the selection and decision to host the Olympic Games. At the same time, our indicator system provides a useful framework for ICMG to use in the selection of future Olympic Games host cities.

2.1. Construction of Olympic Site Selection Evaluation System

The relationship between input and benefit should be fully considered for the selection of permanent sites for the Summer and Winter Olympic Games. On the premise of the target layer: "Selecting the permanent Olympic site", The paper selected five first-level indicators, i.e. the criterion layer:

Each of these level 1 indicators has the following level 2 indicators, i.e. the indicator layer:

Country GDP total

Hosting the Olympic Games requires a lot of money to build stadiums, facilities, infrastructure, etc. Therefore, the level of economy is crucial to hosting the Games[4]. The higher the economic level of a country, the more qualified it is to be the permanent site of the Olympic Games.

Number of athletes participating

A successful organizer can be reflected in many aspects, among which it has a certain relationship with the number of athletes participation. The holding of the Olympic Games requires large-scale organization, coordination and execution, and the number of athletes participation can reflect the organizer's organizational ability to a certain extent. In addition, the Olympic Games need a large number of venues and facilities to hold various competitions. If the venue facilities are insufficient or of poor quality, it will affect the competition and the experience of the participants. Among other things, the Olympic Games need to do a good job of security, including protecting the safety of participants and spectators, preventing terrorist attacks and other security incidents. As a global sporting event, the Olympic Games are often affected by the international political situation. If political factors interfere with the normal conduct of the Olympic Games, it will also affect the success of the Games. And the number of athletes participating is able to side-by-side reflect whether the organizers do a good job in these aspects to do a comprehensive. In addition to the number of athletes participating, the "audience opinion index" is also one of the indicators that can reflect the "satisfaction of the audience or local residents", which reflects the level of interest in the current Olympic Games, the financial investment of the organizer in the current Olympic Games: advertising, financial investment, etc., which can reflect the level of importance of the organizer to the Olympic Games.

Number of travelers

The number of tourists can reflect the popularity and image of the city and country hosting the Olympics. If the city or country hosting the Olympics itself has a high popularity and image, it may attract more tourists to come to watch and visit the games. On the contrary, if the image is poor or

there are problems such as security, it may have a negative impact on tourism[5]. Timing and location of the Olympic Games: If the timing and location of the Olympic Games match the peak season of local tourism and popular destinations, it may attract more tourists to visit. Conversely, if the timing and location of the Olympic Games do not match the local tourism industry, it may have a negative impact on tourism.

Prestige index

The prestige level of the host country we can quantify from many aspects, here the paper choose whether the host country is currently a developed country as our main factor to quantify the prestige level of the host country, the paper take the factor named prestige index, whether a country is a developed country can be seen, whether the country's policies are solid, whether the security is stable, and its laying down the level of a country's comprehensive strength.

Host city host times

The number of times a country has successfully applied for the Olympic Games may reflect the strength and influence of that country in the field of the Olympic Movement. Generally speaking, the stronger and more influential a country is in the field of Olympic sports, the higher the success rate of its application to host the Olympic Games. In addition, the successful hosting of the Olympic Games has a great impact on a country, which can not only enhance the country's popularity and image in the world, but also promote the development of local economy, culture, society and other aspects.

Let the ith primary index be Ui(i=1..4), and the characteristics obtained in section 4.1 as the influencing factors of the primary index are the secondary indexes, and let the jth secondary index under the ith primary index be Uij(i=1..4,j=1..3) to construct the Olympic site selection evaluation index system as the following table 1:

Table 1. Olympic site selection evaluation index system

Number	Primary indicator	Number	Secondary indicator	Direction
U1	Economic level	U11	Total national GDP	positive
U2	Human satisfaction	U21 U22	Number of athletes Spectator opinion index	positive negative
U3	Tourism	U31	Number of visitors	positive
U4	Host country's prestige level	U41	Prestige index	positive
U5	Chances for future improvement	U51	Number of times held	positive

2.2. EWM-TOPSIS Model based on the Selection of the Permanent Olympic Site

Before modeling, the index data need to be normalized and standardized, the paper use min-max normalization method to transform the original series $x_1, x_2, \ldots, x_n$.

$$y_i = \frac{x_i - \min_{1\le j\le n}\{x_j\}}{\max_{1\le j\le n}\{x_j\} - \min_{1\le j\le n}\{x_j\}} \tag{1}$$

Then the new sequences $y_1, y_2, \ldots, y_n \in [0,1]$ and are dimensionless.

The data are preprocessed as shown in Fig 1 below.

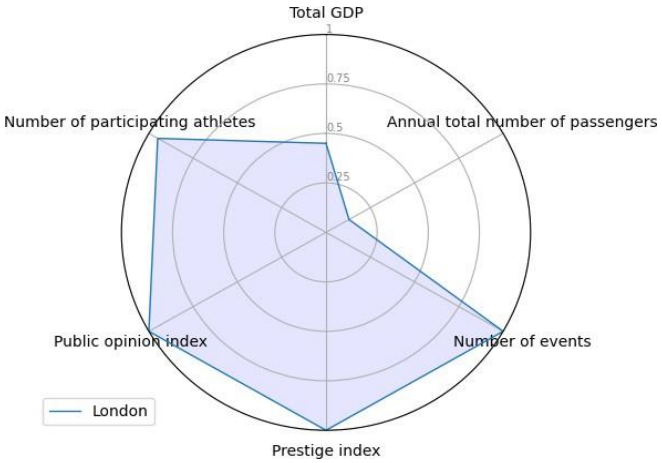


Fig 1. Standardized data display for London related indicators

2.3. EWM-TOPSIS Model Building

2.3.1 Construct the original data matrix [6]

Combining the index values obtained in 4.1, let the information sources covered by random variables X = x_1, x_2, x_3 occur with probability i = 1,2,3 among them, and $\sum^{3}_{i=1,}$ Pi = 1, construct the original data matrix L.

$$L = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{16} \\ r_{21} & r_{22} & \cdots & r_{26} \\ r_{31} & r_{32} & \cdots & r_{36} \end{bmatrix} \tag{2}$$

2.3.2.Calculation of index value weights:

$$\begin{cases} p_{ij} = \dfrac{r_{ij}}{\sum_{i=1}^{m} r_{ij}} \\ E_j = \sum_{i=1}^{m} P_i \log_2 \dfrac{1}{p} \\ W_j = \dfrac{1 - E_j}{\sum_{i=1}^{m} (1 - E_j)} \end{cases} \tag{3}$$

Where: Pi j is the characteristic weight or contribution of the ith system under the jth indicator; Ej is the entropy value of the jth indicator; Wj is the entropy weight of the jth indicator.

2.3.3.Constructing a weighted normalized decision array V

$$V = W_j r'_{ij} = \begin{bmatrix} w_1 r_{11} & w_2 r_{12} & \cdots & w_n r_{1n} \\ w_1 r_{21} & w_2 r_{22} & \cdots & w_n r_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ w_1 r_{m1} & w_2 r_{m2} & \cdots & w_n r_{mn} \end{bmatrix}_{m \times n} \tag{4}$$

2.3.4.Calculate the relative proximity of each alternative [7]

Firstly, determine the positive and negative ideal solutions under each index, and then calculate the relative proximity Di of each option relative to the ideal point, the larger Di,the better the comprehensive benefit of the evaluation object; conversely, the smaller, the worse the comprehensive benefit of the evaluation object.

2.4. Solution of EWM-TOPSIS Model

2.4.1 Selection of Countries Involved in Scoring,As shown in Tables 2 and 3

Table 2. Hosts of previous Summer Olympics

Summer Olympic Sessions	Years	Country Regions
1	1896	Athens, Greece
2	1900	Paris, France
...	...	...
31	2016	Rio de janeiro Brazil

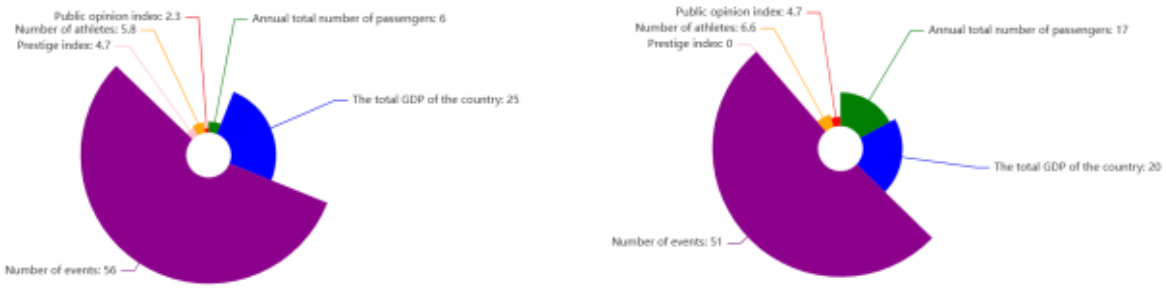
Table 3. Previous Winter Olympics organizers

Winter Olympics Sessions	Years	Country Regions
1	1924	Chamonix, France
2	1928	St. Moritz, Switzerland
...	...	...
23	2018	Pyeong chang South Korea

In order to reduce the difficulty of the question and narrow down the list of candidate countries, we selected the countries that hosted the previous Summer Olympic Games and the previous Winter Olympic Games as candidates for the permanent location of the two Games. The data are mainly from the first to the recent 2018 period. The selection of countries that have hosted the Summer Olympic Games and the Winter Olympic Games is a logical operation. These countries generally have a high level of experience in hosting the Olympic Games and the level of hosting, and are more equipped with the conditions and strength to host the Olympic Games compared to other countries. There are 31 Summer Olympic Games with 21 countries and 23 Winter Olympic Games with 13 countries.

2.4.2 Index Weights and Site Selection Scores

In this scheme, we divide the Olympic Games into Summer and Winter Games, and get the information entropy and information utility values of the six secondary indicators for Summer and Winter respectively by the entropy weighting method through Matlab software programming, and finally get the indicator weights as follows Fig 2 and Table 4:



(a)Summer Olympic Weight Map (b) Winter Olympics Weight Map

Fig 2. Summer/Winter Olympic Nightingale rose weight graph

Table 4. Summer Olympic host country composite score

Country	London, UK	Los Angeles, USA	Paris, France
Combined score	0.712	0.583	0.44
Sort	1	2	3

Analyzing the chart of the Summer Olympics, we can get the following information: through the entropy weighting method the paper solved to get the weight of each secondary index, and it is known

that the host city has the highest weight of 56%, followed by the total GDP of the country which reaches 25%, under this group of weights, the paper can calculate the "permanent location suitability" of each host country of the Summer Olympics through EWM-TOPSIS We were able to calculate the "permanent location suitability" score for each country hosting the Summer Olympics through EWM-TOPSIS [8]. The rating of the London region of the United Kingdom reached 0.712 ranking first, followed by Los Angeles of the United States, whose rating reached 0.583, and finally Paris of France, whose rating was 0.44. It can be seen that London of the United Kingdom as the host city of the Summer Olympics has some advantages: 1. Long history of the Olympics: Britain is one of the birthplaces of the Olympic movement and has successfully held the Olympic Games and other The UK is one of the birthplaces of the Olympic movement and has successfully hosted the Olympic Games and other major sports events many times. These experiences and histories can provide valuable reference and guidance for Britain to host the Summer Olympics. 2. Strong economic strength: As one of the most developed economies in the world, Britain has strong economic strength and can afford the cost of hosting the Olympic Games. At the same time, London is also a world-renowned business and financial center, which can provide strong support for the sponsorship and fundraising of the Olympic Games,as shown in Table 5.

Table 5. Winter Olympics host country composite score

Country	Lake Placid, USA	Innsbruck, Austria	St. Moritz, Switzerland
Combined score	0.693	0.576	0.544
Sort	1	2	3

Analyzing the graph of the Winter Olympics, we can get the following information: By the entropy weighting method, we solve for the weight of each secondary index, and it is known that the highest weight of the host city is 51%, followed by the total GDP of the country is 20%. Unlike the Summer Olympics, where the number of visitors is also a key weighting, the EWM-TOPSIS calculates the "permanent location suitability" score for each host country of the Winter Olympics [9]. Lake Placid, USA topped the list with a rating of 0.693, Innsbruck, Austria ranked second with a rating of 0.576, followed by St. Moritz, Switzerland with a rating of 0.544. It can be seen that the Winter Olympics pay more attention to the popularity and image of the city and country than the Summer Olympics, and it also reflects the strong strength of the United States as the number one economy.

2.5. General Analysis of the Permanent Olympic Site Proposal

In conclusion, the entropy weighting method and the EWM-TOPSIS algorithm have been used to analyze and calculate the weighting of the secondary indicators for the Summer and Winter Olympics, and both London, UK and Lake Placid, USA ranked first in the "suitability of permanent location", indicating that their advantages as host cities for the Olympic Games have been fully reflected. London, England, with its long history of Olympic Games and strong economy, and Lake Placid, USA, with its advantages in terms of visibility and image of the Winter Olympics, are the key factors for their top ratings.

3. The Site Selection and Rotation Arrangement Plan for the Four Seasons Olympic Games

3.1. Selected Four-season Olympic Representative Countries

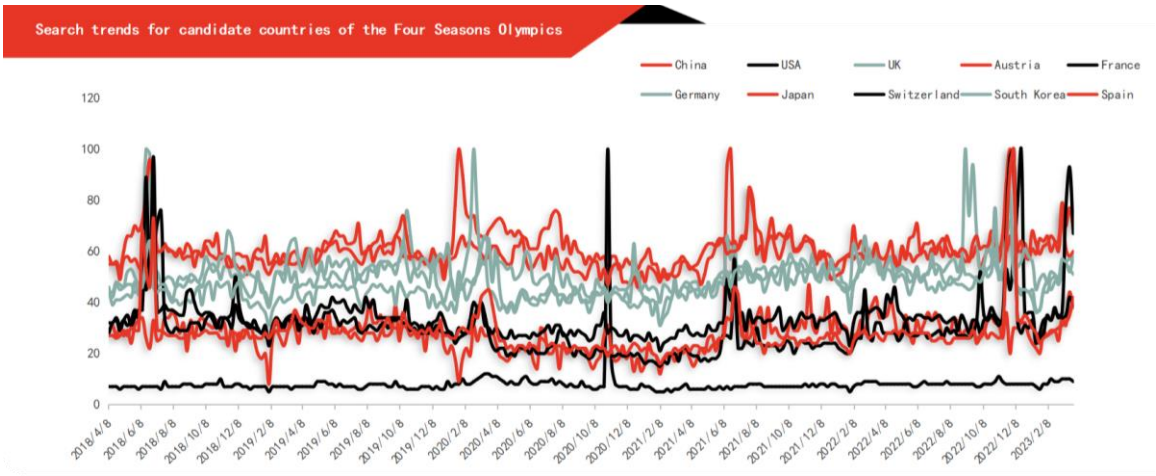


Fig 3. Multidimensional cluster plot

For selecting representative countries for the four-season Olympics, we analyzed the Google Trends Index for 130 countries based on their search trend from 2018 to 2023. France, the UK, the US, and South Korea were chosen as representative countries for the Spring, Summer, Fall, and Winter Olympics, respectively. The paper posted graphs of 10 countries as a demonstration,as shown in Fig 3.

France, Great Britain, the United States, and South Korea were chosen as representative countries for the four-season Olympics based on their long tradition and excellent performance in the history of Olympic Games[10]. They also have a consistent high search trend on Google. France's location in the heart of Europe with a mild summer climate is suitable for hosting the Spring Olympics, while the UK's mild and humid summer climate is ideal for the Summer Olympics. The US's pleasant fall climate is perfect for the Fall Olympics, and South Korea's cold winter climate is suitable for the Winter Olympics. The geographical location and climatic conditions of these countries make them suitable choices for representative countries.

3.2. Four Seasons Olympic Rotation Arrangement

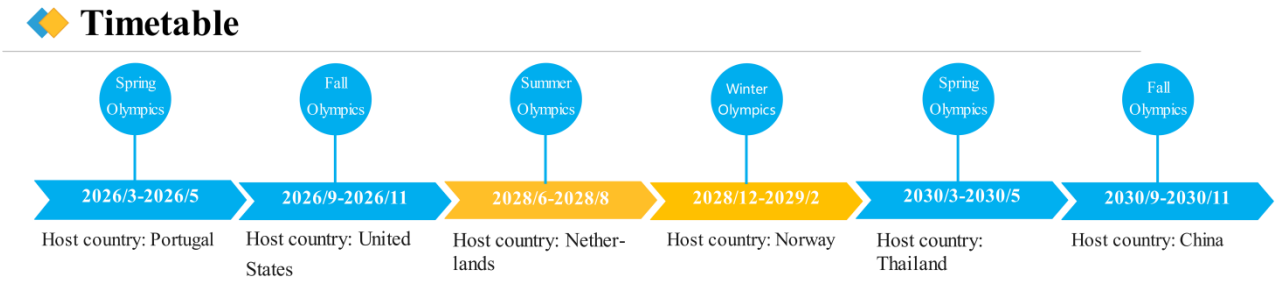


Fig 4. Timetable

In our study, we have provided a timeline in Fig 4 to illustrate the proposed program. We have assumed that the program will commence from 2026, and that the spring and autumn Olympics will be grouped together, as will the summer and winter Olympics. It is important to note that these two groups need to be held one year apart, which we refer to as the transitional period. During this period, preparations can be made for the next group of Olympic Games, such as conducting Olympic preliminary work and site layout planning.

The paper believe that this arrangement of the two sets of Olympic Games and the two sets of transitional periods is essential for completing a full four-season Olympic cycle before the start of the

next cycle. Our proposed program ensures that there is ample time for proper planning and execution of the Olympic Games, while allowing for sufficient time to prepare for the next cycle. Overall, this timeline will provide a solid foundation for the successful hosting of the Olympic Games and will help to maximize the benefits for the host country and its citizens.

4. Conclusion

The paper considered countries that had hosted the Winter and Summer Olympic Games as candidates for permanent venues for both events. the paper then evaluated these candidate countries based on our comprehensive assessment model, which included multiple primary criteria and secondary indicators. Using the EWM-Topsis model, the paper assigned the paperights to each criterion and calculated a score for each candidate country. Based on this evaluation, the paper recommended London, UK as the most suitable candidate for a permanent venue for the Summer Olympics and Lake Placid, USA as the most suitable candidate for a permanent venue for the Winter Olympics.first assigned the major Olympic events to each season based on reasonable criteria. Then, indicators related to the natural environment and the number of airports, and constructed a new evaluation model to select four-season Olympic venues. To cluster the candidate countries based on the paper righted Euclidean distances, the paper selected representative countries for each season using Google Trends as a reference. the paper then used a country clustering model based on the paper righted Euclidean distances to select candidate countries for each season. the paper propose to combine the Spring and Fall Olympics, as well as the Summer and Winter Olympics, with a one-year interval the two sets of Olympics, to randomly select candidate countries in a four-year cycle of four seasons.

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