# Prediction on Future Olympic Strategy Based on Hierarchical Analysis Method

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**Abstract.** In this paper, we focus on the issue of Olympic Games hosting strategy. Firstly, we analyze the impact of the Olympic Games on the hosting countries from multiple perspectives. Secondly, we select the impact indicators of hosting the Olympic Games and representative countries, and use hierarchical analysis to evaluate the most suitable countries for hosting the Olympic Games. Then we utilize the gray prediction model to predict the indicators of the strategy and judge the feasibility of the strategy. Finally, we choose the strategy of hosting both Summer and Winter Olympics in fixed countries.

**Keywords:** Olympics hosting strategy, hierarchical analysis, gray prediction model

## 1 Introduction

Hosting Olympic Games is supposed to be competitive, however recently hosting the Olympic Games has had a negative impact on the host city/country in the short and long term[1]. So the International Olympic Committee (IOC) is facing the problem of decreasing the number of declarations for both Summer and Winter Olympic Game[2]. There are many innovative solutions to these problems[3]. Our main research strategy is that both Summer and Winter Olympics should have a fixed location. This option may alleviate the burden of hosting such a large event to some extent[4].

In this paper, we focus on the issue of the Olympic Games strategy. The first step was to first characterize the impact of the Olympic Games on the host country from several aspects, and to find relevant literature and data through websites to analyze the impact of the Olympic Games on the host country's economy, land use, people's satisfaction[5], travel[6], future improvement opportunities, and the reputation of the host country[7]. Based on the impact of the Olympic Games[8], we identified national GDP per capita, population density, railroad mileage, land area, medical care level, green space area and temperature data as the final impact indicators[9][10]. It is also necessary to select representative countries and use hierarchical analysis[11] to determine the target level, decision level, and criterion level, as well as construct a judgment matrix and consistency test, and then evaluate the country scores, and select the country with the highest score as the fixed country for hosting the Olympic Games. For the selected strategy using SPSSPRO for gray series prediction, we used the gray prediction model in SPSSPRO to predict the value of GDP per capita after hosting the Olympic Games[12], and observed whether hosting the Olympic Games has a positive impact on the value of GDP per capita[13], and whether the growth rate of GDP per capita will also increase

MSEA 2023, May 26-28, Nanjing, People's Republic of China
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DOI 10.4108/eai.26-5-2023.2334456

in the long run due to the influence of the Olympic Games[14], then judging its feasibility in terms of national prestige, humanities, and land use; determining the best timeline for implementation based on the temperature of countries that have hosted the Olympics in the past, as well as the customs and cultural background of the host country; and considering the impact of other potential strategies on the indicators[15].

## 2 Data collection and processing

Based on the characteristics of cities in countries that have hosted the Olympic Games in the past, as well as the comprehensive strength and development level of each country, the reference range of countries selected to host the Olympic Games in fixed countries are twelve countries, namely the United States, China, Japan, Australia, Brazil, Greece, Italy, Mexico, Spain, Sweden, the United Kingdom and France.

By searching the website "Fast Money", we obtained the GDP per capita of each country in the world for the five-year period of 2017-2021, as well as the population density (number of people per $km^2$) of each country in the world from 2017-2021, and the forest area ($km^2$) of each country in the world from 2016-2020 respectively. By looking up "Measuring performance on the Healthcare Access and Quality Index for 195 countries and territories and selected locations" published by the medical journal "The Lancet locations" to obtain the ranking and scores of the world's health care standards. The number of railroad miles and the area of the selected range of countries were obtained by searching the literature. The five-year GDP per capita, population density, and forest area of the selected countries are averaged to obtain the final data of these three indicators. Applying SPSSPRO "normalization" method to the index data to standardize the scale. To remove unreasonable data and add missing data in the selected data by using 3 sigma principle and box plot.

## 3 Results and analysis

### 3.1 Economic benefits

**Table 1.** Canada, Japan, South Korea held the Olympic Games GDP change table

| Time / Country | Two years before hosting | One year before hosting | Hold that year | One year after hosting | Two years after hosting |
|---|---|---|---|---|---|
| **Canada** | 7033 | 7511 | 8809 | 8919 | 9123 |
| **Japan** | 639 | 724 | 843 | 928 | 1068 |
| **Korea** | 2834 | 3554 | 4748 | 5817 | 6610 |

Table 1. shows the GDP per capita values of the Montreal Olympics held in Canada in 1976, the Tokyo Olympics held in Japan in 1964 and the Seoul Olympics held in Korea in 1988 two years before, in the year of two years after the hosting of the Olympics, respectively, which more clearly visualizes the short-term and long-term impacts of hosting the Olympics on the host countries.

### 3.2 Application of hierarchical analysis method

#### 3.2.1 Establishing a hierarchical model

The goal of decision making, the factors to be considered (decision criteria) and the decision object are divided into the highest level, the middle level and the lowest level according to their mutual relationship, and the hierarchical structure is drawn, as shown in the Fig.1.

Top level: selection of fixed countries in summer/winter. Middle layer: GDP per capita, population density, railroad mileage, green area, land area, medical level, summer/winter temperature. Bottom layer: USA, China, Japan, Australia, Brazil, Greece, Italy, Mexico, Spain, Sweden, UK, France.

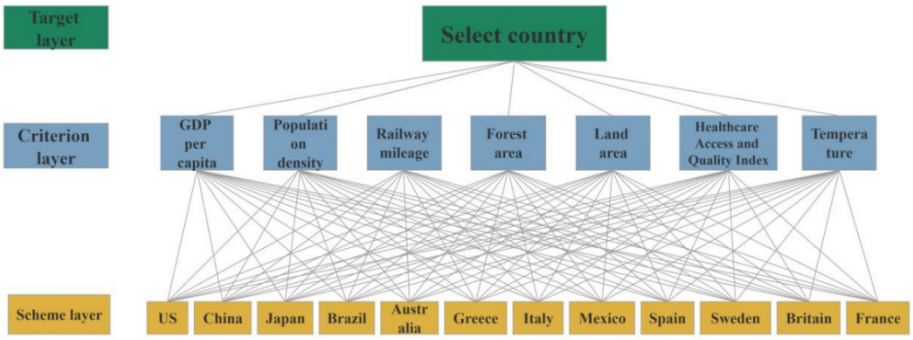


**Fig. 1.** Hierarchy diagram

#### 3.2.2 Construction of judgment matrix

Construct the judgment matrix through the consistent matrix method, i.e., not to compare all factors together, but to compare them with each other two by two; at this time, the relative scale is used to minimize the difficulty of comparing factors of different nature with each other, so as to improve the accuracy.

#### 3.2.3 Consistency test

Calculate the consistency index, see equation (1).

$$CI=\frac{\lambda \max - n}{n-1} \tag{1}$$

Determine the corresponding average random consistency index, as shown in Table 2.

**Table 2**. coincidence indicator

| n | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RI | 0 | 0 | 0.52 | 0.89 | 1.12 | 1.26 | 1.36 | 1.41 | 1.46 | 1.49 | 1.32 | 1.54 | 1.56 | 1.58 | 1.59 |

Calculate the consistency ratio $CR$, and make a judgment, see equation (2).

$$CR = \frac{CI}{RI} \tag{2}$$

### 3.2.4 Selection of the summer fixed optimal country and Selection of the optimal country for winter fixing

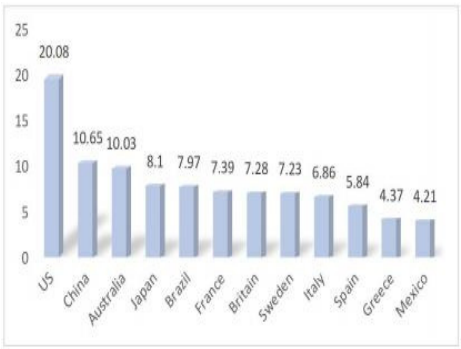


**Fig.2.** Comprehensive score of the Summer Olympics

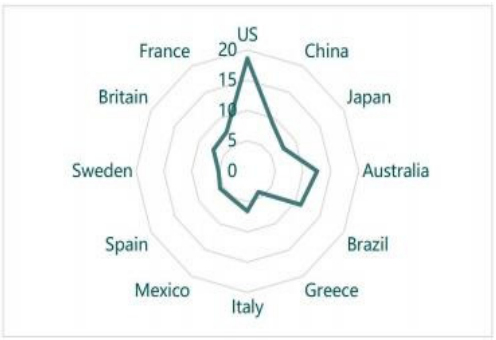


**Fig.3.** Radar chart of the combined results of the Winter Olympics

Through MATLAB comprehensive analysis and Fig.2., the graphs can visually show that the United States is the best country for summer fixing. Through MATLAB comprehensive analysis and Fig.3., the overall score of the Winter Olympics is derived,and the radar chart can visually show that the United States is the best country for winter fixation.

### 3.3 Establishing a model by using the theory of gray prediction model

Before building the gray prediction model GM (1, 1), the time series is tested by the rank-ratio test. The gray prediction model can be tested to determine whether it is reasonable or not, and only the model that passes the test can be used for prediction. The system mainly uses the posterior difference ratio value to test the gray prediction model.

According to the method, SPSSPRO is used to find the parameter $a$ as well as the parameter $u$. Then, it is brought back to the gray prediction model to obtain the GDP per capita of the country in 10 years after hosting the Olympic Games.

**Table 3**. American GDP per capita over 10 years

| Index entry | Original value | Tier ratio |
|---|---|---|
| **1985** | 1.82 | - |
| **1986** | 1.91 | 0.953 |
| **1987** | 2 | 0.955 |
| **1988** | 2.14 | 0.935 |
| **1989** | 2.29 | 0.934 |

| | | |
|---|---|---|
| **1990** | 2.39 | 0.958 |
| **1991** | 2.43 | 0.984 |
| **1992** | 2.54 | 0.957 |
| **1993** | 2.64 | 0.962 |
| **1994** | 2.77 | 0.953 |
| **1995** | 2.87 | 0.965 |

**Table 4**. Table of fitting results

| Time after Olympics | Predicted GDP | True value of GDP |
|---|---|---|
| **1** | 3.023 | 2.997 |
| **2** | 3.157 | 3.146 |
| **3** | 3.297 | 3.285 |
| **4** | 3.444 | 3.452 |
| **5** | 3.597 | 3.633 |
| **6** | 3.757 | 3.713 |
| **7** | 3.924 | 3.780 |
| **8** | 4.098 | 3.949 |
| **9** | 4.281 | 4.172 |
| **10** | 4.471 | 4.412 |

Though Table 3. and Table 4., it can be seen that from 1999 onward, the true value of GDP per capita was higher than the predicted value. This indicates that the economic impact of the Olympic Games on the host country is positive and, in the long run, can promote its healthy development.

## 4 Conclusions

This work proposes an evaluation model to assess the suitability of a representative country to host the Olympic Games, where the impact indicators include: GDP per capita, population density, railroad mileage, green space, land area, level of medical care, and summer/winter temperature, with a composite score for each country derived through hierarchical analysis, resulting in the highest score for the United States. Therefore, we suggest that the location of the future fixed country to host the Summer and Winter Olympics should be the United States. We used a gray prediction model to predict the feasibility of such a scenario, i.e., the long-term economic impact, and found that the country's GDP per capita showed a significant increase after hosting the Olympics. Based on the temperature of the countries that have hosted the Olympic Games in the past, we determined the dates of the Summer Olympics to be July 25-August 9, with a duration of no more than 16 days, and the dates of the Winter Olympics to be February 8-February 19, with a duration of 12 days. At the same time, such a scenario would also enhance international visibility and drive the development of industrial structure.

## Footnotes

Jun Wang[2*] and Xiaoli Jiang[3*] are the corresponding authors of this article.

## Acknowledgments

This work was supported by the National Natural Science Foundation of China (61976027, 11871117), Department of Education of Liaoning Province (LJKZ1026, LJKZ1030, LJ2019011), Liaoning Natural Foundation Guidance Plan (2019-ZD-0502), Liaoning Revitalization Talents Program (XLYC2008002).

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