

A Research on Measuring the Impact of Olympic Games Based on MOIM Model

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Abstract. Due to the high cost of hosting, the Olympic Games have gone from being a "sweet pastry" to a "hot potato". To quantify the impact of the Olympic Games on the host country, the impact of the Olympic Games on the host country's economy, land use, satisfaction (athletes and spectators), travel, opportunities for future improvement, host city/country prestige, and environmental factors were considered in the selection of indicators, and the absolute and relative impact methods were used to classify these variables. In model building, the weights of the indicators were determined comprehensively by combining the subjective and objective methods of EWM-AHP to establish the Olympic Games Impact Metric (MOIM) measurement model. Finally, by constructing a functional relationship between the indicator variables and the degree of impact of the Olympic Games on the host country, TOPSIS analysis is applied to quantitatively measure the impact of the Olympic Games on the host country.

Keywords: Olympics, the MOIM model, AHP-EWM, TOPSIS, Impact Measurement.

1. Introduction

Since its inception in 1896, the modern Olympic Games have been in sync with the pulse of the times and have developed into one of the most influential and large-scale social and cultural events of mankind. However, recently, the host city/country has experienced various short and long-term negative impacts, and the Olympic Games have changed from a "sweet pastry" to a "hot potato" [1].

To quantify the impact of the Olympic Games on the host country, scholars at home and abroad have put forward their views on the impact measurement. Yang Qiang and Chen Jin used the AHP method for impact measurement in their paper on the evaluation of the impact of red tourism in Guangyuan City based on the AHP method [2], while Yan Qiang and Li Natural used EWM for impact assessment [3]. However, AHP is influenced by the intention of decision makers and is more subjective, while EWM has objective advantages but cannot reflect the importance of participating decision makers to different indicators, given this, this paper analyzes through TOPSIS and uses a combination of EWM and AHP subjective and objective methods to comprehensively determine the weights of the indicators related to the impact measurement of the Olympic Games, and establishes the MOIM model that can be widely applied.

2. Olympic Impact Indicator Metric Model

When considering whether to host the Olympic Games, countries need to take into account various aspects to ensure that the development of the country and region is positively promoted while not causing unnecessary losses to the country and region. To this end, this paper considers the impact of the Olympic Games on the host country's economy, land use, satisfaction (athletes and spectators), travel, opportunities for future improvements, host city/country prestige, and environmental factors, and establishes Models for measuring Olympic impact by constructing a functional relationship between indicator variables and the degree of impact of the Olympic Games on the host country. metrics (MOIM) to quantitatively measure the impact of the Olympic Games on the host country.

2.1. The economic impact of the Olympic Games

Behind the glitz and glamour of the Olympic Games, what is inseparable is the huge economic support. With the long duration of the Olympic Games and the large number of projects, the money required for the whole preparation is very large. Therefore, the profit and loss of hosting the Olympic Games and the size of its share of GDP are the keys for a country to decide whether to apply for the Games.

However, the economic impact of the Olympic Games is complex and contains implicit components such as promoting the development of cities and improving the prestige of the country. The implicit components are difficult to quantify into specific economic values, so this paper breaks them down into other sub-indicators for analysis, and only the explicit economic components are considered here.

In order to measure the size of the impact of the Olympic Games on the economy, the difference between the explicit economic income and expenditure generated by hosting the Olympic Games as a percentage of the gross domestic product (GDP) of the year is used as the initial value for analysis in this paper, and when the value is positive, it indicates that the impact of hosting the Olympic Games on the economy of the place is benign, and the larger the value, the greater the impact.[4]

$$Y_{eco} = \delta \frac{\sum_{k=1}^8 x_k}{GDP} \quad (1)$$

In the formula, δ is a dummy dichotomous variable, when $x_k \in$ profits, $\delta = 1$; when $x_k \in$ loses, $\delta = -1$. x_1 denotes venue fees and basic measures for sports programs, x_2 denotes supporting transportation and accommodation security costs, x_3 denotes bidding fees, x_4 denotes other costs required for hosting, including technical support costs, medical costs, medal production and various other miscellaneous costs. x_5 denotes advertising and sponsorship revenue, x_6 denotes ticket revenue, x_7 denotes broadcasting rights revenue and licensing revenue, and x_8 denotes government grants.

2.2. Olympic impact on land use

The use and transformation of land resources by the Olympic Games will have different degrees of impact on urban and rural environments. On the one hand, the Olympic Games usually require the construction of a large number of venues, residences, and infrastructure, which will occupy a large amount of land resources. On the other hand, the Olympic Games will also accelerate the development of cities and promote urban expansion, causing agricultural land and ecological land to be transformed into urban land [5].

Therefore, this paper requires a careful analysis of the use of land resources by the Olympic Games. Among them, for the first aspect, the land occupied by the construction of the venues, this paper can be calculated by using the following formula:

$$x_9 = \frac{x_{10}}{\xi} \quad (2)$$

In the formula, x_9 denotes the area of land requisitioned, which refers to the area of land requisitioned for holding the Olympic Games, and x_{10} denotes the area actually occupied by the building. The occupied land use factor is the ratio of the area of land occupied by the building to its floor area. Generally speaking, the smaller the land use factor, the larger the area of land occupied by the venue.

For the second aspect, that is for the conversion of land resources due to the urban expansion brought by hosting the Olympic Games, this paper uses the land use change indicator to measure. This indicator is calculated using the following equation:

$$\gamma = \frac{x_{11} - x_{12}}{x_{12}} \quad (3)$$

In the equation, x_{11} denotes the area of urban land and x_{12} denotes the area of agricultural land.

2.3. Satisfaction of the Olympic Games for people (athletes and spectators)

This paper addresses the issue of the decrease in the number of countries bidding for the Olympics, and implementing it to each potential declaring country, this paper needs to consider the impact that this country's application for the Olympics will have on it.

Obviously, for the athletes of the bidding country, their medal-winning probability rises and their satisfaction increases due to the home-field advantage; for the spectators of the hosting country, the definition here includes but is not limited to the live audience, but is measured by their attention span. Compared to other countries, the audience of the bidding country is more likely to increase its sense of national unity and pride and promote the sports culture. Therefore, for this indicator, the team of this paper will limit the scope to analyze the satisfaction of the athletes and spectators of the bidding country, and for the athletes and spectators of other countries, the team of this paper will analyze them in the subindex of national prestige [6].

$$Y_{\text{sat}} = \exp \left(\frac{\mu_t\%}{\mu_T\%} + \frac{v_t\%}{v_T\%} \right) \quad (4)$$

In the formula, μ_t represents the total number of medals won by the athletes of the host country in that year, μ_T represents the average of the total number of medals won by the host country in the years when it participated in the Games in the past without being the host country, v_t represents the total attention of the spectators of the host country in that year, i.e., the sum of the number of live viewings, the number of broadcasts, and the engagement in related topics, and v_T represents the average of the total attention of the spectators of the host country in the years when it participated in the Games in the past without being the host country.

2.4. The impact of the Olympic Games on the country's tourism industry

The impact of the Olympic Games on a country's tourism industry is enormous. First of all, the Olympics is one of the largest sporting events in the world, it will attract millions of people from all over the world to watch the games and participate in related activities, and the country hosting the Olympics will be able to successfully showcase the local culture, traditions, and landscape during the event, all of which will bring a large number of tourists, media, and businessmen, thus boosting the tourism industry in the region. This paper uses an econometric model [7] based on the analysis of economic factors to obtain the most direct impact of year-on-year growth in the volume of tourists and year-on-year growth in tourism revenue on tourism consumption, based on which the formula for the impact of the Olympic Games on the country's tourism industry is as follows:

$$\ln(Y_{\text{tra}}) = c + \ln(TPI) + \ln(x_{14}) + \ln(x_{13}) \quad (5)$$

In the formula, c is a constant, usually taken as 0.558, which in this case represents the tourism impact factor; x_{13} represents year-over-year visitor growth, which refers to the growth in the number of visitors from the host country during the Olympic Games relative to the same time period in the previous year; TPI represents the Travel Property Index, which contains five dimensions of indices: release index, communication index, interaction index, word-of-mouth index and transaction. The Travel Property Index, which consists of five dimensions: Release Index, Communication Index, Interaction Index, Word of Mouth Index and Transaction Index, unifies the online asset performance index of single destinations, scenic spots and other tour operators through these five perspectives; x_{14} represents the year-on-year tourism revenue growth, which refers to the growth in visitor revenue of the host country during the Olympic Games compared to the same time period of the previous year.

2.5. The impact of the Olympic Games on the country's future improvement opportunities

The infinite possibilities that the Olympic Games bring for the future improvement of the host country, these possibilities can be considered in this paper as falling under the category of Olympic legacy. On the one hand, there is a legacy of long-term infrastructure and community development

projects from the Olympics, all of which will continue to create value long after the Games are over; on the other hand, the success of the Games will also bring benefits to the economy, sports development, and other aspects of the country and its people [8].

$$Y_{cha} = \sum_{k=15}^{18} x_k \quad (6)$$

In the formula, x_{15} indicates the amount of sustainable infrastructure investment, which refers to the original cost required for infrastructure that will continue to be used by the host country after the Games; x_{16} indicates the degree of completion of community development projects, which refers to the amount of participation in physical fitness activities, low-carbon living behaviors, etc. that the host country advocates during the Games and that people maintain or even grow after the Games; x_{17} indicates the amount of job growth opportunities in related industries created by the Games; and x_{18} indicates the amount of year-over-year GDP growth, which refers to the amount of GDP growth in the host country during the Games relative to the previous year.

2.6. The impact of the Olympic Games on the prestige of the host country

With the acceleration of globalization and the development of information technology, the Olympic Games are playing an increasingly important role in influencing the prestige of nations. However, national prestige is a relatively subjective concept, not a quantitative value, and is influenced by a combination of factors such as the hard and soft power of a country. To visually measure the impact of the Olympic Games on the prestige of the host country, the ranking of the overall national power of the country introduced in this paper is calculated as a quantitative value of prestige [9]:

$$Y_{rep} = \exp\left(\frac{\varphi_t\%}{\varphi_T\%}\right) \quad (7)$$

In the formula, φ_t denotes the ranking of the host country's overall national power in the year in which it hosted the Olympics; φ_T denotes the ranking of the host country's overall national power in the year prior to the year in which it hosted the Olympics.

2.7. The impact of the Olympic Games on the environment of the host country

During the Olympic Games, environmental quality may be affected to different degrees, and its impact on local environmental quality will involve several sub-indicators, such as atmospheric quality, water quality, soil quality, noise, etc. In this paper, by considering several sub-indicators together and combining them into Environment Quality Index (EQI) as one of the indicators to evaluate the environmental quality during the Olympic Games, we can assess the environmental quality more comprehensively [10].

$$Y_{env} = \exp\left(\frac{EQI_t\%}{EQI_T\%}\right) \quad (8)$$

In the formula, EQI_t indicates the value of the composite environmental quality index for the year in which the host country hosted the Olympics; EQI_T indicates the value of the composite environmental quality index for the previous year in which the host country hosted the Olympics.

3. Calculation processing

3.1. Indicator Data Processing

This paper looks for indicator data in the areas of the economy, land use, people's satisfaction (athletes and spectators), travel, opportunities for future improvements, the prestige domain of the host city/country, and the environment, using two basic methods to manipulate the massive data considering the applicability of the variables: the relative impact method and the absolute impact method.

(1) Relative Impact Method

The degree of impact of the Olympic Games on the host countries is different, and since each country has its different national conditions, the degree of impact of the change in the same indicator may be different in different countries, and the relative impact method is used to deal with these indicators in this paper. Among all 28 indicators introduced in this paper, 9 variables are treated by the absolute impact method. For the remaining 19 indicators, this paper uses the relative impact method, and this paper mainly uses the ratio to indicate the degree of relative impact.

Where the ratio of variables x_1 to x_8 to GDP represents the economic impact factor of the country; variable x_{10} - x_{12} takes into account the ratio of the actual land area to the occupied land use factor and the conversion of land resources due to the urban expansion caused by hosting the Olympic Games, the result of which is expressed as a land use impact factor; variable $\frac{\mu_t\%}{\mu_T\%}$ is the ratio of the total number of medals won by the athletes of the host country in that year to the average of the total number of medals won in the past years when they participated in the Games without being the host country. Variable $\frac{\nu_t\%}{\nu_T\%}$ is the ratio of the total attention of the spectators of the host country in that year to the average of the total attention of the spectators in the years when the host country participated in the Games in the past; Variable x_{13}, x_{14}, x_{18} is the year-on-year increase in the number of tourists, the year-on-year increase in tourism revenue and the year-on-year increase in gross domestic product, respectively; Variable $\frac{\varphi_t\%}{\varphi_T\%}$ is the ratio of the country's overall national power ranking in the year the host country hosted the Olympic Games to the country's overall national power ranking in the previous year the host country hosted the Olympic Games; Variable $\frac{EQI_t\%}{EQI_T\%}$ is the ratio of the composite environmental quality index value in the year the host country hosted the Olympics to its composite environmental quality index value in the year prior to the year in which the Olympics were held.

(2) Absolute impact method

The degree of impact of certain indicators need not be achieved by relative comparison, and for these indicators the absolute impact method is used in this paper. tpi and gdp are Travel Property Index and Gross Domestic Product, respectively, and variables x_{15} - x_{17} indicate the country's future improvement opportunities, which are a specific value and can be recorded as absolute impact.

3.2. Weights determination

When constructing the hierarchical model, the determination of the evaluation index weights plays a crucial role and directly affects the accuracy of the model evaluation. Entropy method is an objective assignment method, and hierarchical analysis method is a subjective assignment method; this paper combines EWM and AHP to determine the weights of indicators. This is a comprehensive evaluation method that combines subjective and objective and integrates multiple methods, which can effectively improve the correctness and rationality of the evaluation.

(1) EWM preparation

$$R_{ij} = \frac{t_{ij}}{\sum_{i=1}^n t_{ij}} \quad (9)$$

First, the paper needs to calculate the weights of the respective indicators for each country:

Based on the concepts of self-information and entropy in information theory, each of the evaluation metrics can be calculated as follows:

$$E_j = -\ln(n)^{-1} \sum_{i=1}^n o_{ij} \ln(R_{ij}) \quad (10)$$

According to the information entropy theory, this paper thus begins to calculate the weights of each evaluation index.

$$G_i = \frac{1-E_j}{n-\sum_j E_j} \quad (11)$$

(2) AHP

First, at the same level, this paper needs to construct a judgment matrix to judge the importance of indicators.

$$\begin{cases} F_{ij} = 1 \\ F_{ij} = \frac{1}{F_{ji}} > 0 \end{cases} \quad (12)$$

In the above equation, F_{ij} and F_{ji} denote different evaluation indicators, and $i, j = 1, 2, 3, \dots, n$, n denotes the number of indicators of the same level.

In order to ensure the significance of the judgment matrix, this paper performs a consistency check, and if $CR < 0$, the judgment matrix passes the consistency test as follows:

$$CI = \frac{\lambda_{\max}(X) - n}{n - 1} \quad (13)$$

$$CR = \frac{CI}{RI} \quad (14)$$

In the formula, $\lambda_{\max}$ represents the largest eigenvalue of the judgment matrix, n represents the number of indicators at the same level. If calculated $CR < 0.1$, then the judgment matrix can pass the consistency test.

Finally, based on the judgment matrix calculation, the subjective weight value J_i solved by the AHP method is obtained.

(3) Portfolio weights

The objective weights G_i and subjective weights V_i of each index were obtained by AHP method and EWM method.

$$\beta_i = mG_i + nJ_i \quad (15)$$

In the formula, β_i is the combined weight, m and n are the weight assignment coefficients.

The difference between subjective weight G_i and objective weight V_i should be equal to the difference between m and n while the sum of m and n is 1

$$\begin{cases} m + n = 1 \\ d(G_i, J_i) = d(m, n) \end{cases} \quad (16)$$

In the formula, $d(G_i, J_i) = \left[\frac{1}{2} \sum_{i=1}^n (G_i, J_i)^2 \right]^{\frac{1}{2}}$, $d(m, n) = |m - n|$. Solve the equation to get the values of m and n and bring U_i and V_i to get the combined weights W_{ijk} .

The weights after the calculation are shown in Figure 1:

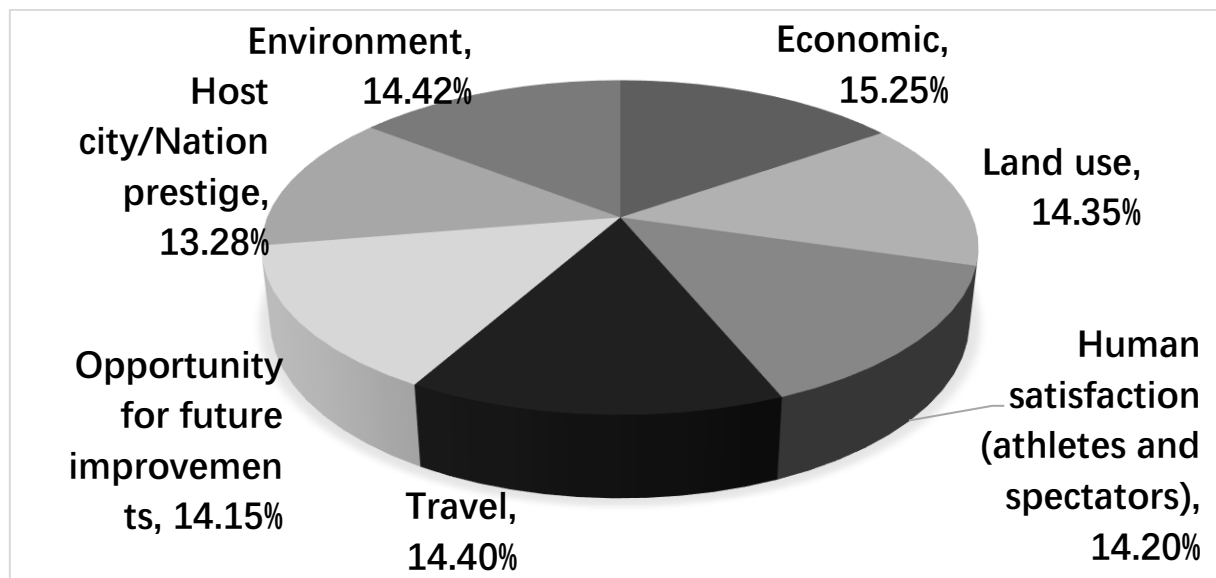


Figure 1. Weighting of indicators at each level

(4) TOPSIS-based score processing

The TOPSIS method (Technique for Order Preference by Similarity to Ideal Solution) is a commonly used comprehensive evaluation method, which can make full use of the information of the original data by ordering according to the approximation to the ideal solution, and its results can accurately reflect the gap between the evaluation solutions.

Here, based on the idea of the TOPSIS method, this paper treats the unprocessed initial values of the Olympic impact index model of the initial values are processed in the following way:

$$Y_i = \frac{Y_0 - Y_{min}}{Y_{max} - Y_{min}} \quad (17)$$

$$Y_{final} = \frac{Y_i}{\sum_{i=1}^n Y_i} \times 10 \quad (18)$$

In the equation, Y_i is the graded level of Olympic impact indicators obtained by TOPSIS method processing, Y_{max} denotes the theoretical maximum value, and Y_{min} denotes the theoretical minimum value.

The final score Y_{final} is obtained by normalizing Y_i and multiplying it by the maximum rank 10 of the impact level of the Olympic Games on the host city, and its score results are shown in Figure 2.

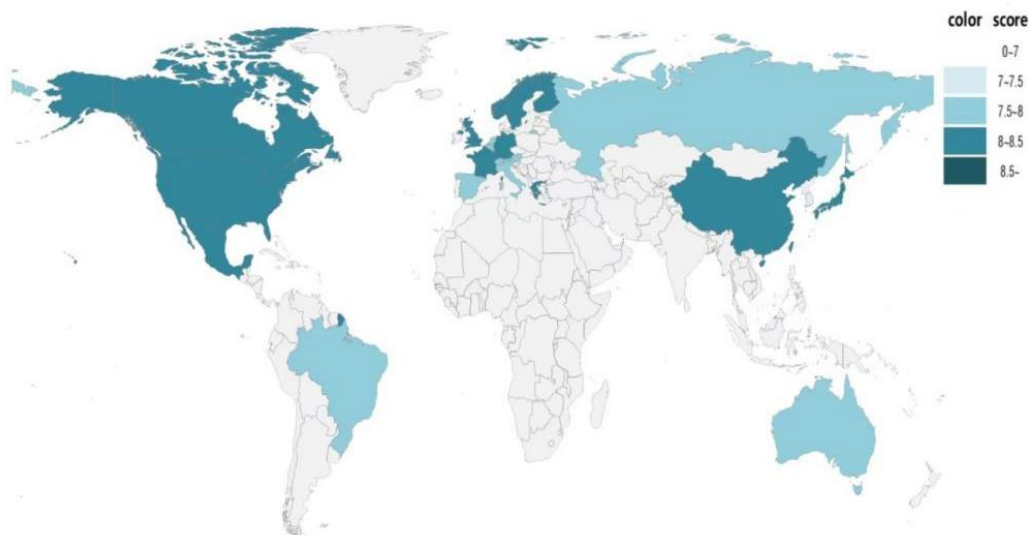


Figure 2. Olympic Games Host MOIM Score Heat Map

4. Conclusions

In this paper, To quantify the impact of the Olympic Games on the host country, we consider the economy, land use, people's satisfaction (athletes and spectators), tourism, opportunities for future improvement, prestige ,and environmental factors, based on which we select the corresponding 28 indicator variables and construct a functional relationship between the indicator variables and the impact degree of the Olympic Games on the host country, and considering the applicability of the variables, this paper applies the absolute impact method and the relative impact method to Considering the applicability of the variables, this paper applies the absolute impact method and the relative impact method to deal with them.The analysis was conducted with TOPSIS and a combination of EWM and AHP subjective and objective methods were used to synthesize the weights of indicators, and a MOIM model that can be widely applied was established to inspire the calculation of impact measurement of Olympic Games hosting.

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