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A Comprehensive Policy Model Developed for the Success of the Olympic Games

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Abstract: The Olympics, the world's largest sporting event, unite the world through sports, but the high cost of hosting the games has deterred many countries. This paper mainly puts forward innovative strategies and policies for the successful hosting of the Olympic Games, focusing on the problem of how to reduce the cost of the host country, improve the efficiency and reduce the economic risks.
Keywords: Olympic; The joint hosting strategy; Comprehensive score

1. Background

Since 1894, hosting the Olympics has been a source of national pride, enhancing global standing and showcasing prosperity. Economically, it can be lucrative; the 1984 Los Angeles Games netted $223 million, spotlighting the event's potential. Politically, it boosts influence; Barcelona's 1992 Olympics catapulted the city into fame and fast-tracked urban development by decades.However, since 2014, the high costs and risks have cooled interest, leading to a global reluctance in bidding for major sports events. This shift poses a significant challenge to the IOC. Innovators worldwide are now assessing various factors to devise optimal solutions for this issue.

2. Model I: The Olympic quality evaluation model

2.1 Identification of the indicators and the data collection

We've integrated Olympic Games backgrounds into our system, considering economic, social impacts, public satisfaction, and host site improvements. We revised the original framework, emphasizing economic evaluation, tourism development, and national prestige. Authorized data sources include the World Bank, IOC websites, UN Statistics, and Kaggle. Focusing on economically developed nations, we derived 10 secondary indicators for our system. This outlines our tailored indicator methodology for assessing Olympic qualities.

2.2 Data standardization

Standardize the original data, through the analysis of the impact of the Olympic Games has eight, respectively economy (X1), land use (X2), human satisfaction (X3), travel (X4), the future improvement opportunities (X5), the host city / national prestige (X6), international trade (X7), government revenue (X8).There are 22 evaluation objects, and the value of the j th index of the i th evaluation object is $\boldsymbol{a_{ij}}$. Converting each index $\boldsymbol{a_{ij}}$ into a standardized index value $\widetilde{\boldsymbol{a_{ij}}}$

$$\widetilde{a_{ij}} = \frac{a_{ij} - \mu_j}{s_j}, \ (i = 1,2, \ldots, 22; j = 1,2, \ldots, 8),$$

Where $\boldsymbol{\mu_j = \frac{1}{8}\sum_{i=1}^{22} a_{ij}}$, $\boldsymbol{s_j = \sqrt{\frac{1}{8-1}\sum_{i=1}^{22}(a_{ij}-\mu_j)^2}}$, $\boldsymbol{j = (1, 2, \cdots, 8)}$,That $\boldsymbol{\mu_j, s_j}$ is the sample mean and sample standard deviation of the j th indicator.

2.3 The correlation coefficient matrix R, eigenvalues and eigenvectors are calculated

We want to analyze the Olympic Games held each indicators of the correlation and dependence, for the final comprehensive quality evaluation to provide more reliable basis, if the economy and national prestige, travel, future improvement opportunities, people of the Olympic satisfaction index have strong correlation, so the Olympic quality evaluation system is more convincing.

$r_{ij} = \frac{\sum_{k=1}^{8} \widetilde{a_{ki}} \cdot \widetilde{a_{kj}}}{8-1}, (i, j = 1,2, \cdots, 8)$

The calculated eigenvalue of the correlation coefficient matrix R is

$[3.1654\ ,\ 1.5597\ ,\ 1.0620\ ,\ 0.9597\ ,\ 0.4974\ ,\ 0.3429\ ,\ 0.2819\ ,\ 0.1310]\ \theta_1 \geq \theta_2 \geq \ldots \geq \theta_8 \geq 0$ The eigenvector is $u_1, u_2, \cdots u_8, u_j = [u_{1j}, u_{2j}, \cdots, u_{8j}]^T$

And the corresponding eigenvectors, there are feature vectors composed of 8 new indicator variables. $\delta_j = u_{1j}\tau_1^3 + u_{2j}e^{\tau_2} + u_{3j}\tau_3 + \cdots + u_{8j}\tau_8$

δ_1: *economic* , δ_2: *travel* , ⋯ , δ_8:host country or host city reputation

In Equation δ_1 it is the economy, δ_2 is travel, δ_8 is National prestige

$$[\delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6, \delta_7, \delta_8]^T = [3.17, 1.56, 1.06, 0.96, 0.50, 0.34, 0.28, 0.13]^T$$

2.4 Evaluation of the overall Olympic quality of various countries

Our hypothesis evaluates eight Olympic quality indicators. Some show insignificance; our model calculates each index's contribution rate. Removing less impactful indicators refines to significant ones. Incrementally adding until 85%-95% contribution, we select top 'p' indices for calculating Olympic quality.Calculate information and cumulative contribution of characteristic values $\theta_j (j = 1,2, \cdots, 8)$:

$$b_j = \frac{\theta_j}{\sum_{k=1}^{8} \theta_k} \quad (j = 1,2, \cdots, 8), \alpha_p = \frac{\sum_{k=1}^{p} \theta_k}{\sum_{k=1}^{m} \theta_k}$$

The b_j is called the information contribution rate of index θ_j, α_p is the cumulative contribution rate of indicators $\theta_j (j = 1,2, \cdots, 8)$, when α_p is close to 1 (generally take α_p=0.85,0.90,0.95), the top p index variables $\delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6, \delta_7, \delta_8$ as p principal components, replace the original 8 index variables, thus comprehensive analysis of p indicators.

Calculate the composite score:

$$Z = \sum_{j=1}^{p} b_j \delta_j$$

Denotes the information contribution rate of the jth principal component, assessed via the composite score. With a score of 2.735, the U.S. leads, followed by China at 1.344, Spain at 0.439, and Norway at the low end with -0.752. Summarily, the U.S. exhibits the highest Olympic quality, signifying its strongest capability to host. Our subsequent model analysis will exemplify the joint hosting benefits using the U.S. as a case study.

2.5 Comprehensive Olympic quality evaluation of neighboring countries

2.5.1 Comprehensive Olympic quality evaluation of neighboring countries

For analyzing co-hosting the Olympics with the U.S., we consider neighbors: Canada, Mexico, Jamaica, and Cuba. Using hierarchical analysis, we assess them based on economic condition, travel logistics, host reputation, and future enhancement opportunities. Pairwise comparisons will rate each factor's impact using a 1-9 scale for decision-making Step by step in order of importance: $a_{ij} = 1, 3, 5, 7, 9$

a_{ij} =2,4,6,8 between the two adjacent judgments. According to the suggestions of the relevant paper experts, the judgment matrix of the criterion layer is obtained as follows:

$$\begin{bmatrix} 1 & 9 & 9 & 1/3 \\ 1/9 & 1 & 1/3 & 1/5 \\ 1/9 & 3 & 1 & 1/3 \\ 3 & 5 & 3 & 1 \end{bmatrix}$$

The judgment matrix of the scheme layer is as

$$\begin{bmatrix} 1 & 3 & 5 & 6 \\ 1/3 & 1 & 3 & 6 \\ 1/5 & 1/3 & 1 & 2 \\ 1/6 & 1/6 & 1/2 & 1 \end{bmatrix} \begin{bmatrix} 1 & 1/3 & 1/4 & 1/5 \\ 3 & 1 & 1/3 & 1/4 \\ 4 & 3 & 1 & 1/2 \\ 5 & 4 & 2 & 1 \end{bmatrix} \begin{bmatrix} 1 & 1/3 & 5 & 6 \\ 3 & 1 & 7 & 8 \\ 1/5 & 1/7 & 1 & 1 \\ 1/6 & 1/8 & 1 & 1 \end{bmatrix} \begin{bmatrix} 1 & 3 & 5 & 6 \\ 1/3 & 1 & 4 & 5 \\ 1/5 & 1/4 & 1 & 2 \\ 1/6 & 1/5 & 1/2 & 1 \end{bmatrix}$$

2.5.2 Consistency test of judgment matrix

In order to make our obtained matrix data more reliable and applied to the following evaluation model, we conducted a consistency test of the matrix to exclude the unreasonable data of the correlation matrix, and make correction and optimization.

Step 1: Calculate the consistency index CI, $\mathbf{CI} = \frac{\theta_{\max}-n}{n-1}$

Step 2: Find the corresponding average random consistency index RI

Step 3: Calculate the consistency proportion CR, $\mathbf{CR} = \frac{CI}{RI}$

The CR of the calculated judgment matrix is 0.097595,0.043244,0.042881,0.030554,0.049551, CR <0.1, so the consistency of all judgment matrices is considered acceptable; otherwise, the judgment matrix is corrected.

2.5.3 Eigenvalue method for weights

Weights are computed as the proportional ratio of standards. Initially, we identify matrix A's maximum eigenvalue and its associated eigenvector. Normalizing this eigenvector yields our weights. For a maximum eigenvalue of 4.0816, with a consistency ratio CR=0.030554, the eigenvector [0.55235, 0.28576, 0.098534, 0.063364] normalizes to [0.287691, 0.582062, 0.065511, 0.060597]. Applying the eigenvalue method, we calculate each index's weight. Multiplying each index's weight by its respective country's score and summing these products gives the final composite score for that country.Canada score is 0.51,Mexico score is0.30,Jamaica score is 0.11,Cuba score is 0.08. so we will measure the overall, benefits and cost of the United States and Canada.

3. Model II: The feasibility test of the policy

3.1 Factors and model assumptions

Using our Olympic quality and neighboring countries evaluation models, we chose a strong duo, the U.S. and Canada, to co-host the Olympics. Considering post-event economic gains as the dependent variable, we factor in economy usage, land utilization, tourism, national or host city prestige, and future enhancement prospects. Comparing solo versus joint hosting economic benefits completes our policy test.Suppose that the relationship between the dependent variable Y and the independent variable $X_1, X_2, \cdots, X_5$ is Independent Variable

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \epsilon$$

ϵ:random error, and meet the expected value and variance are$E(\epsilon) = 0$， $Var = \sigma^2$, $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ is called regression coefficient

Where ϵ is called the random error, and meets the expected value and the variance of $E(\epsilon) = 0$， $Var = \sigma^2$, $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ is called the regression coefficient

$$Y = \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{pmatrix}, X = \begin{pmatrix} 1 & x_{11} & x_{12} & \cdots & x_{15} \\ 1 & x_{21} & x_{22} & \cdots & x_{25} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 1 & x_{51} & x_{52} & \cdots & x_{55} \end{pmatrix}, \beta = \begin{pmatrix} \beta_1 \\ \beta_2 \\ \vdots \\ \beta_5 \end{pmatrix} \epsilon = \begin{pmatrix} \epsilon_1 \\ \epsilon_2 \\ \vdots \\ \epsilon_5 \end{pmatrix}$$

$$Y = X\beta + \varepsilon$$

3.2 Curve fitting and feature estimation

To sum up, through the known mathematical knowledge such as expected value, variance, residual difference, each unknown quantity of the formula, the optimal regression model was obtained by using the stepwise regression method:

$Y=3742.163+6.971X_1-1.631X_2-1.387X_3+5.3322X_5$.

3.3 Joint benefit forecast estimation and policyevaluation

After rigorous model testing and evaluation, integrating data from multiple collaborating nations, it's clear that co-hosting the Olympics offers greater overall benefits compared to solo hosting. Solo hosts face significant loss risks. Shared benefits and risks between two countries lower the overall Olympic risk, alleviating concerns over costs and fiscal pressures on governments, thus boosting nations' eagerness to bid for hosting rights.

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