Problem Chosen	2023 MCM/ICM Summary Sheet	Team Control Number
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Make the Olympics Great Again!

Summary

"From around the world to flower as one"

As more and more countries have lost their interest in hosting Olympics due to the asymmetry of costs and benefits, IOC is now in a great need for an innovative approach to help them out of the dilemma. Therefore, we make a policy proposal through the following models to select the most appropriate country to hold the Olympics permanently.

First, we establish an **Impact Evaluation Model** to measure the impact of the Games on the host countries. We select 9 indicators from 3 dimensions of economy, ecology and society. For the indicators that reflect the overall situation of the country, which contains information of both impacts of the Olympics and other macro factors, we innovatively introduce a **Time Backtracking Model** in the calculation of them. In this model we define the real impact as the ratio of change in actual data after hosting the Olympic Games to data under the situation without hosting the Olympic Games (**counterfactual**), which is simulated by the **Grey Forecast Model (GM)**. Next, the indicators are summarized into three factors corresponding to the dimensions through the **Principal Component Analysis (PCA)**. We use the **Entropy Weight Method (EWM)** to determine the weights, and construct an **Olympic Impact Index (OIX)** for each country by **Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)**. For the Summer Olympics, Australia scores highest on OIX; for the Winter Olympics, South Korea ranks first.

The impact of the Olympic Games is important for a policy, but the feasibility of it should not be ignored as well. Therefore, we develop a **Risk Model** to measure feasibility. From a macro perspective, we establish a **Risk Probability Model** based on **Weibull Distribution**, in which **Cluster Analysis** is used to divide countries into 3 levels according to risk level and parameters are set respectively for each category to analyze the risks at different stages of policies. Countries with high risk tolerance are at the highest risk in the declaration and preparation stage, general risk-tolerant countries face moderate levels of risk throughout the whole policy period, and those with low risk tolerance have a high level of risk after preparation. For the micro perspective, we construct the **Economic Press Index (EPI)** to measure the economic feasibility of a single Olympic Games. Greece and Russia, whose EPI is significantly higher than that of other countries, are considered unsuitable as regular host countries of the Olympic Games.

Then, we do scenario analysis on the timeline to implement and impacts of potential strategies to provide a practical reference for the implementation of our policy.

Finally, we draw a conclusion that Olympics should be held in a permanent location - the Summer Games in **Australia** and the Winter Games in **South Korea**.

Keywords: Time Backtracking Model, counterfactual, PCA, EWM, TOPSIS, Weibull Distribution

Contents

1 Introduction

1.1 Background

The Olympics, representing the greatest global sporting event, have been passed down from a thousand years ago to the present day. The Olympic sports bring the world together for a grand sporting festival that promotes peace, friendship, unity and fair competitions. However, in recent years, due to various factors such as COVID-19 and the volatile international political landscape, countries are not as enthusiastic to host an Olympic Game as they were yesterday. Since 2004, the number of countries bidding for it has been on a significant downward trend **(Figure 1)**. Therefore, the IOC is facing the dilemma of the lack of attractiveness of the Summer and Winter Olympic Games. This has prompted us to think about how to mitigate the negative long-term or short-term impacts experienced by Olympic host cities and host countries in the post-epidemic era, which has become an immediate priority.

In order to meet the world environmental theme of sustainable development, energy saving and emission reduction, changing the actual hosting strategy of the Olympic Games has become a new idea. Decisions such as reducing the investment in Olympic venues by fixing the host country for the games, or using the principle of small quantification to split the original Summer and Winter Olympics into four smaller ones, may solve these problems and rekindle the Olympic passion.

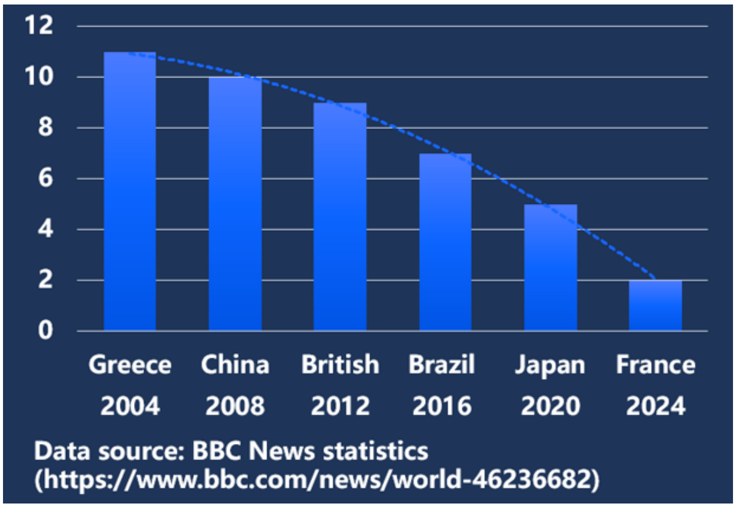

Figure 1: Bids to Host The Summer Olympics

1.2 Restatement of the Problem

By analyzing the topic and taking into account the current situation, we conclude that the Olympic Games are being conducted in a dilemma, due to the asymmetry of costs and benefits. In order to make the Olympic Games run smoothly, we urgently need an innovative policy that will increase the attractiveness of the Games for the host country (i.e. minimize its negative impacts or maximize its positive benefits). To do so we need to address the following questions:

Problem 1: Establish a model to assess the multifaceted impacts of hosting the Olympic

Games, as a benchmark for policy selection.

Problem 2: Develop a model to measure the feasibility of the policy, combine it with the impact of the Olympics derived from Problem 1, and achieve the optimization of the way to host the Olympics.

Problem 3: Integrate the timeline to implement and the impacts of potential strategies to give a practical reference that can be applied to the implementation of the policy.

1.3 Our Work

To solve Problem 1, we establish an **Impact Evaluation Model**. We consider the impacts of the Olympic Games in 3 dimensions: economy, ecology and society, and introduce a total of 9 indicators to calculate an index that comprehensively reflects the impacts: the **Olympic Impact Index (OIX)**. In the construction of the indicators, we believe that the real impacts of the Olympic Games need to be reflected by the difference between the two cases of “having hosted” and “not hosting”. Since the "not hosting" scenario is a counterfactual that cannot be directly measured for the host country, we introduce a **Time Backtracking Model** to simulate it.

As for Problem 2, we develop a **Risk Model** to measure the feasibility. For the macro level, we establish a **Risk Probability Model** to measure the overall condition of the country; for the micro level, we construct an **Economic Press Index (EPI)** to compare the feasibility of different countries to host the Olympic Games.

When it comes to Problem 3, we refine the scenario analysis for the implement phase and potential strategies by referring to the framework provided by the International Olympic Committee.

The flow chart of our work and the mathematical methods used are shown in **Figure 2**.

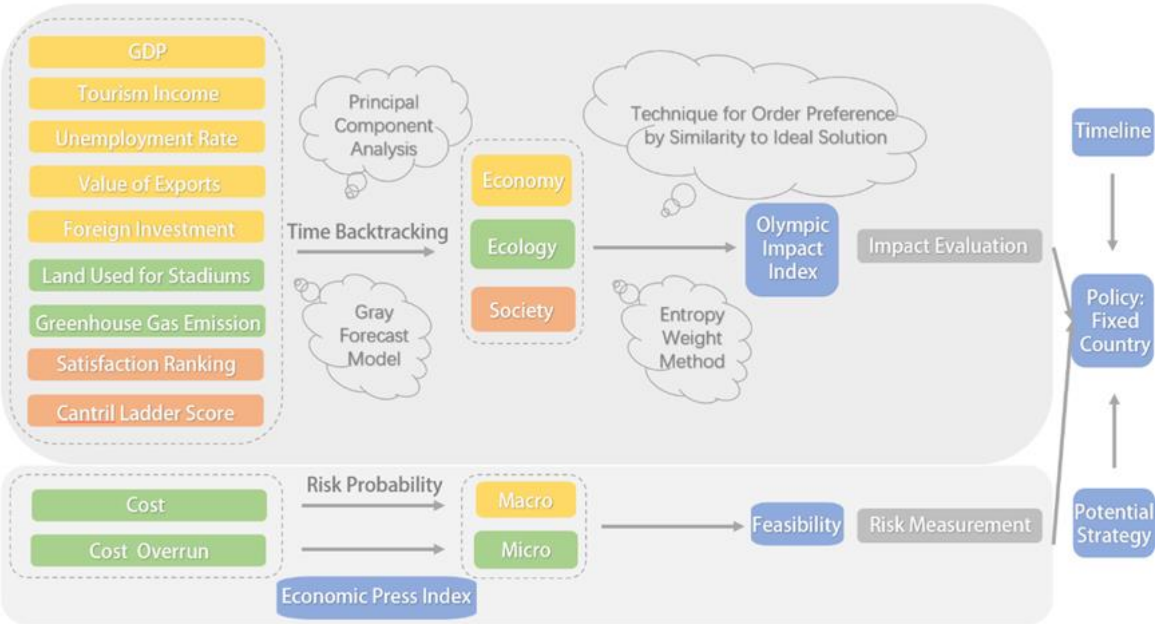

Figure 2: Flow Chart of Our Work and Mathematical Methods used

2 Model Preparation

2.1 Assumptions and Justification

Assumption 1: The current value of macroeconomic indicators such as the economy of each country is only affected by the previous period and has no significant correlation with other factors.

Justification: A simplified idea that enables us to estimate indicator data in "no hosting " situation by means of Grey Forecast Model, providing an effective simulation method for counterfactual.

Assumption 2: Continuous hosting of the Olympic Games in the same country brings positive benefits.

Justification: Holding the Olympic Games in the same country means that fixed assets such as venue facilities don't need a large amount of money to make new preparations, and the host country only need to pay a predictable and stable maintenance cost on a regular basis. In addition, the cost can be effectively saved in other aspects as a result of considerable experience in holding the games.

Assumption 3: The higher score a country has in economic, ecological and social factors, the higher its risk tolerance is.

Justification: The higher the score is, the higher the development level of the country is in the relevant dimension, which means it can resist risks more effectively through redistribution among domestic factors of production, international consultations and other means, thus having a stronger risk tolerance.

2.2 Notations

The key mathematical notations used in this paper are listed in Table 1.

Table 1: Notations

Symbol	Description	Unit
GDP	GDP at constant 2005 prices	dollar
Tourism	tourism income	billion dollars
Unrate	unemployment rate	%
Export	value of exports at constant 2005 prices	dollar
Investment	foreign investment/GDP	%
Land	land used for stadiums	%
GHgas	greenhouse gas emission	kiloton/capita
Satisfaction	voted satisfaction ranking	-
Reputation	Cantril Ladder Score	-

Note: The table shows the units of the original data.

2.3 Data Pre-processing

2.3.1 Data Collection

There is a huge gap between the scales, participating countries and economic impacts of the Olympic Games before 2000 and that at the post-2000 era of economic globalization, due to the international political factors back then. So, for the samples, we selected all 11 cities and corresponding countries[1] that have hosted the Summer and Winter Olympic Games from 2000 to 2021. As for Beijing, where the 2022 Winter Olympics was held, also hosted the Summer Olympics in 2008, we only selected the latter one as a reference to avoid ambiguity in our following analysis.

In order to ensure the reliability and comprehensiveness of the data sources, the websites from which we collected our data are listed in **Table 2**.

Table 2: Data Source

Data source	Website
CSMAR	http://www.csmar.com/channels/31.html
World In Data	https://ourworldindata.org/
World Bank Open Data	https://data.worldbank.org/
Wikipedia	https://meta.wikimedia.org/
UNdata	http://data.un.org/Default.aspx
Olympic rankdata	https://www.ranker.com/list/the-best-olympic-games/tfdg?ref=profile_pub

2.3.2 Data Filling

Although we have collected most of the data through various websites, there are still some data missing due to incomplete statistics from statistical agencies or authoritative reports. Generally, there are two methods of data processing, filling in missing values or discarding variables with too high a missing rate. However, for the model we introduce later, due to the limited samples, the information of each variable is precious and cannot be discarded freely, and the impact of each missing data on the model identification results is magnified. In order to solve such problems, we use the following methods to fill in our data.

a) For data with few missing values, we use the traditional mean interpolation method.

b) For data with good fitting properties and overall distributed evenly at both ends of the curve, we fit the data with a regression model and use the resulting function to predict the missing data.

c) For two data sets with sufficiently similar distribution patterns, if one of them is complete, we can first calculate the constraint rule for it and then use the resulting model to predict the other data set to achieve the completion of the missing data. The model prediction accuracy is calculated, and if the RMSE satisfies the actual accuracy requirement, then this model is used for prediction; if not, then the optimization problem with constraints will be solved and the parameters are obtained by iterating repeatedly.

An example of filling tourism income data for Greece is used for further illustration. In the subsequent analysis, we need the data from 1992 to 2019, but due to missing statistics, data for Greece are not available until 2011. Since this dataset has a very high missing rate, it is clear that method a and b are inappropriate. For the **Cluster Analysis** of the economic, ecological and cultural countries of countries around the world, we find that the overall situations of Greece and Italy are the most similar **(Figure 3)**, so the data can be filled using method c. Based on the **Ant Colony Algorithm** under the relevant data constraints, the filling of the tourism income for Greece from 1992 to 2010 is achieved.

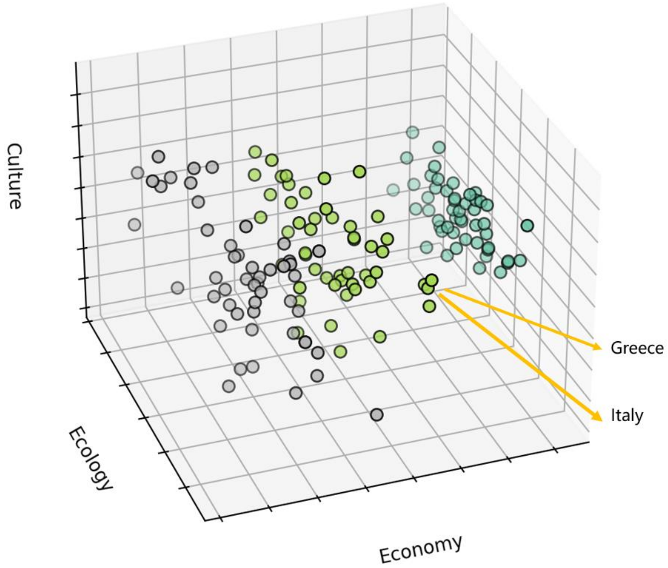

Figure 3: Country Similarity Clustering Results

3 Establish Olympic Impact Evaluation Model

3.1 Dimensions and Indicators

The impact of the Olympic Games should be multi-layered and comprehensive, so we need to make a comprehensive assessment of the city hosting the Games and its corresponding country. We have selected 9 indicators from 3 dimensions: economy, ecology and society, which together form an Olympic Impact Index (OIX), as shown in **Figure 4**.

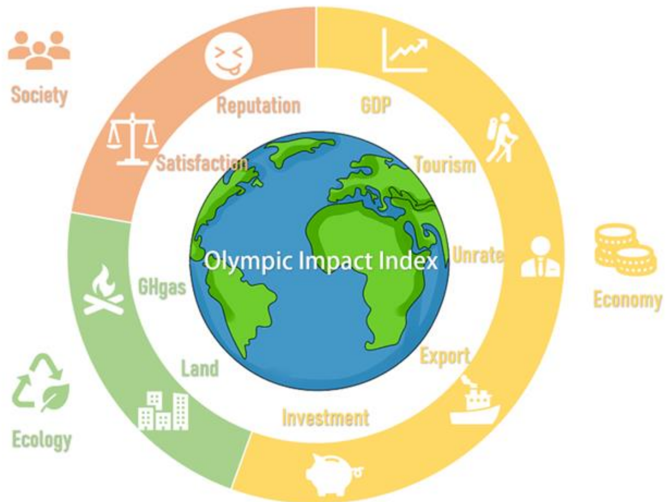

Figure 4: Dimensions and Indicators

- Economy

The economy is an important dimension to evaluate the impacts of the Olympic Games. They may attract more foreign tourists to visit and foreign businessmen to invest. In addition, in order to host the Olympics, the government may employ more residents to build the Olympic projects, thus increasing the number of employment and reducing the unemployment rate. Apart from that, the hosting of the Olympics may also boost the country's foreign trade. All these effects may contribute to the growth of the national economy. Therefore, we choose **GDP**, tourism income (**Tourism**), value of exports (**Export**), ratio of foreign investment to GDP (**Investment**), and unemployment rate (**Unrate**) as economic indicators.

- Ecology

The ecological impacts of the Olympic Games on cities and countries are also very noticeable. The preparation of the infrastructure for the Olympic Games may consume large amounts of land resources and therefore has a negative ecological impact. In addition, the Olympic Games may also generate significant energy consumption. The less negative the ecological impacts are, the better it is for the host city. Hence, we choose the percentage of land used for stadiums (**Land**) and the greenhouse gas emission (**GHgas**) as indicators of this dimension.

- Society

As a global sports event, the Olympic Games also have an important social impact on the host country. On the one hand, many cities want to promote their culture and values by hosting the Olympics, and a successful Olympics may improve people's perception of the country and bring more positive experiences to them. On the other hand, the infrastructure left after the Olympic Games can be opened to the public to improve people's happiness in life. Thus, as for social indicators, we choose the voted satisfaction ranking of each Olympic Games **(Satisfaction)** and national happiness index, which is Cantril Ladder Score, as the proxy variable of nation prestige **(Reputaion)**.

3.2 Introduce the Time Backtracking Model

We want to capture the real impact of the Olympics. For Land, Satisfaction and Reputation, they reflect the information of a single Olympic Games and can be directly measured by raw data; however, the raw data of other indicators reflect the overall situation of the country in the statistical meaning, which not only includes the impact of the Olympic Games, but also macro factors such as economic cycles and development trends, the latter accounting for a much larger part. For example, there is a upward trend in GDP, which can be seen from **Figure 5**. Therefore, it is obviously inappropriate to directly use the actual data at a certain point in time as the measurement. We believe that the impact of the Olympics should be measured by the change in the value of the indicators, so we need two sets of data, the actual data directly available after the Olympics and that in the absence of the Olympics. However, "no Olympics" is a **counterfactual** (the opposite of the real situation, which cannot happen) for the host country and is not directly available.

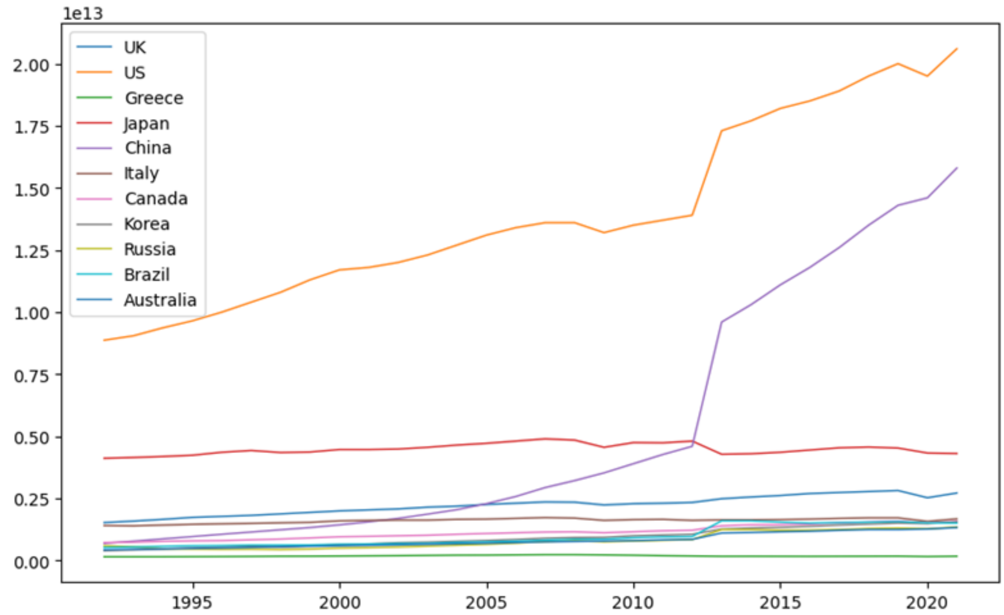

Figure 5: GDP

To simulate this situation, we introduce a **Time Backtracking Model** based on **Gray Forecast Model (GM)**. The Gray Forecast Model is a forecasting method that builds a mathematical model to makes forecasts with a small amount of incomplete information. Compared with other forecasting models such as ARIMA, GM(1, 1) has a greater ability in forecasting short-term data, and it does not need many training samples. As we only need to predict the data of the year which the Olympics Games is held for each country based on the previous data, this model perfectly meets our needs.

Step 1 Predict the Data for "no Olympics"

Suppose a country hosts the Olympic Games in year i as t_i, and the data period starts at t_1. The data values of the country from period t_1 to t_{i-1} are selected as the training set, and the predicted value is calculated as Y_i by GM (1, 1).

Step 2 Measure the Relative Change in Data

We define impact as the ratio of change in actual data to forecast data:

$$\text{Rate} = \frac{\mathrm{Y_i'} - Y_i}{Y_i} \tag{1}$$

where, $\mathrm{Y_i'}$ is the actual value at t_i.

3.3 Summarize Principal Components by PCA

Before applying the constructed indicators to calculate OIX, we still have a few more issues to address.

The **first** is to determine the type of indicators. Obviously, the higher the values of GDP, Export, Investment, Tourism, and Reputation, the more the host country gains from the Olympics, so they are Very Large indicators with a positive contribution to the OIX score. On the contrary, the higher the values of Unrate, GHgas, Land, and Satisfaction, the more negative the impacts of the Olympics are, so they are Very Small indicators with a negative contribution to the OIX score. For the very small indicators, we need the following treatment:

$$x_i^{adjusted} = max_i - x_i \tag{2}$$

where, x_i represents the 4 indicators and max_i is the maximum of each.

Second, we found some correlation between the indicators, which may affect the validity of OIX. The correlation heat map is shown in the **Figure 6**.

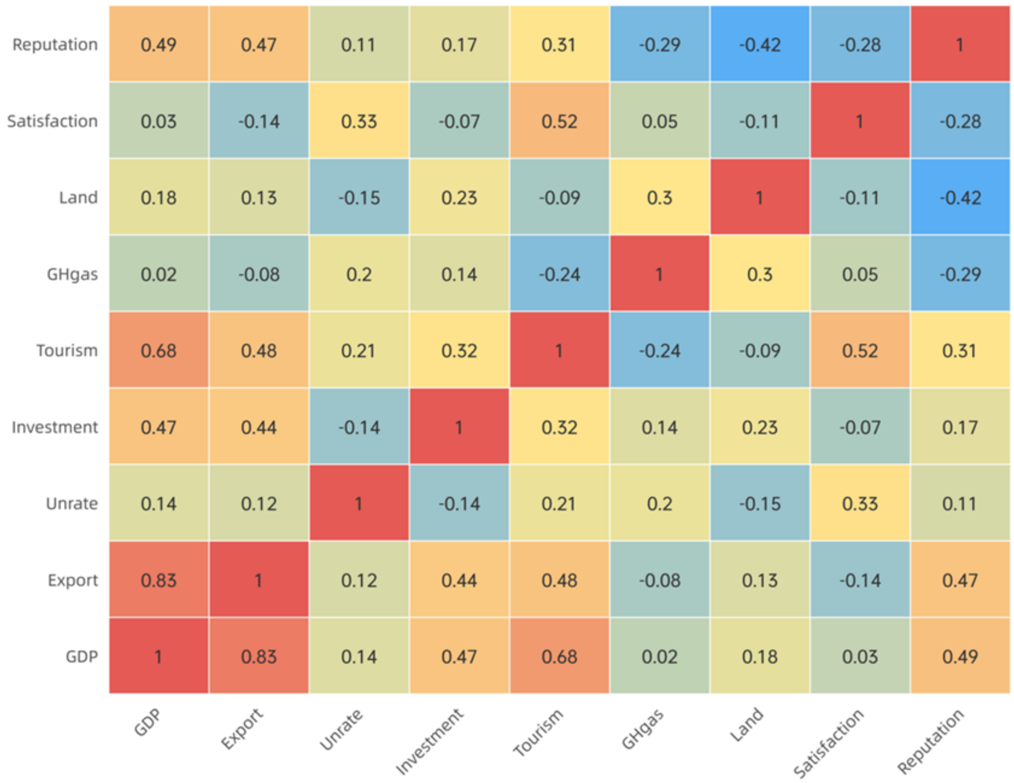

Figure 6: Correlation Heat Map of Indicators

It can be seen that GDP is highly correlated with Export, and its correlations with Tourism and Investment are also high, which is in line with our expectation - income from export trade, tourism, and foreign investment are all important components of GDP. In addition, we also find that Reputation is correlated with GDP and Export, indicating that countries with higher happiness indexes tend to have higher levels of economic development.

Since these indicators examine the impact of the Olympics from the perspective of different impact mechanisms, we believe that the information they reflect is valuable and cannot be discarded arbitrarily. Therefore, we wish to reduce the dimensionality of the indicators with the help of **Principal Component Analysis (PCA)**.

The KMO value of the indicators is 0.63 (greater than 0.5), and the p-value of Bartlett Test is 0.042 (less than 0.05), indicating that there is indeed a strong linear correlation between the indicators and a simplified data structure can been achieved, which is suitable for PCA.

Step 1 Standardize Indicators

Set the number of samples as n and the number of indicators as p, then the initial sample matrix X is defined as:

$$X = (x_{ij})_{n\times p}\ i = 1, \dots, n; j = 1, \dots, p \tag{3}$$

The idea of standardization is to eliminate the effect of different magnitudes and to normalize the indicators, and the process can be expressed as follows:

$$Z_{ij} = \frac{X_{ij} - \overline{X_J}}{\sigma_j} \tag{4}$$

$$\overline{X_J} = \frac{\sum_{i=1}^{n} X_{ij}}{n}, \sigma_j^2 = \frac{\sum_{i=1}^{n} (X_{ij} - \overline{X_J})^2}{n-1} \tag{5}$$

Step 2 Calculate Covariance Matrix

Check the correlation between indicators by covariance matrix R:

$$\mathrm{R}=(r_{ij})_{p\times p} \tag{6}$$

$$r_{ij} = Cov(z_i, z_j) \tag{7}$$

Step 3 Calculate Principal Components

The principal components are calculated by linear combination of the initial indicators, which is a circular process. That is to say the data have the maximum variance (mean square of the distance of each point from the origin) after mapping to the direction of the first principal component; the second principal component is uncorrelated (i.e. perpendicular to each other) with the first principal component and calculated in the same way, and so on.

So we solve for the eigenvalues λ and eigenvectors t of the covariance matrix as follows:

$$|R - \lambda E| = 0 \tag{8}$$

$$(R - \lambda E)t = 0 \tag{9}$$

The eigenvector of covariance matrix always points to the direction with the largest direction - the same as the principal components, so each eigenvector corresponds to a principal component. Arrange the eigenvectors in rows from top to bottom according to the corresponding eigenvalues to form the principal component load matrix T.

Step 4 Choose Principal Components

According to the calculation method of principal components, the first principal component contains most of the information of the initial indicators, while the remaining principal components contain decreasing information.

We set the selection criteria of principal components to explain more than 70% of the initial information cumulatively. The cumulative explanation variance percentage diagram is shown in **Figure 7**. The first 3 principal components can meet this standard.

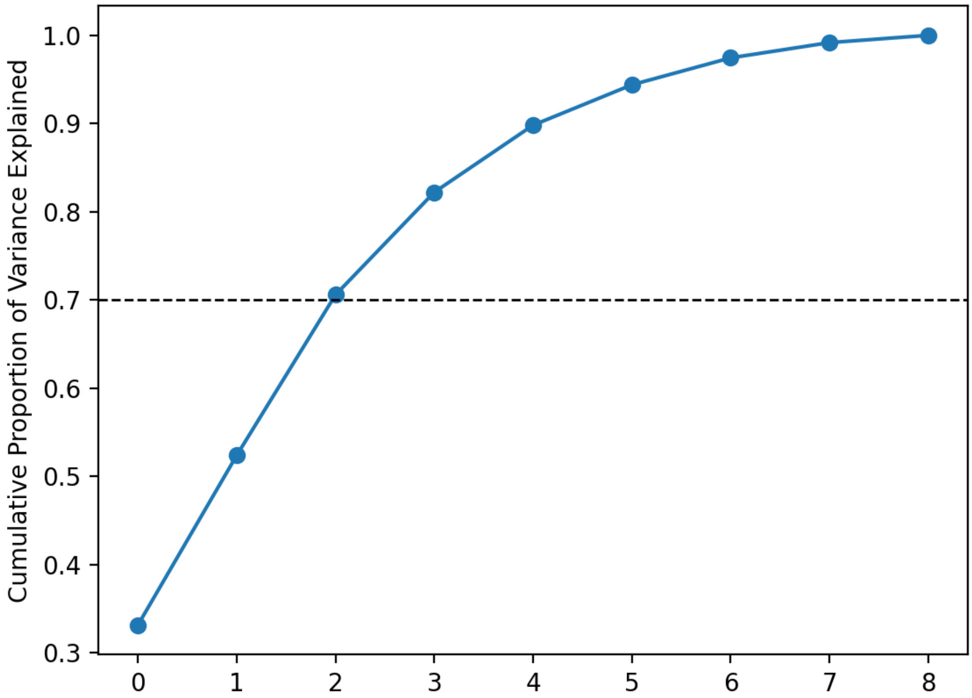

Figure 7: Cumulative Proportion of Variance Explained

The information contained in these 3 principal components is shown in **Figure 8**.

Figure 8: Composition of Principal Components

The first contains a lot of information on GDP, Export, Tourism, and Investment, which belong to the economic dimension, so it can be summarized as the **Economy** factor. The information of the second focuses on Land and GHgas, reflecting the impact of the Olympics on the ecological environment, which is the **Ecology** factor. The third focuses on describing the impact on Satisfaction and Reputation, and is named as **Society** factor. These three factors exactly correspond to the three dimensions we propose for measuring impact, and in turn reflect the rationality of our indicator selection.

Finally, we separately compare the impact of the Summer and Winter Olympics in these three dimensions, and the radar plot of the factor scores can be seen from **Figure 9**.

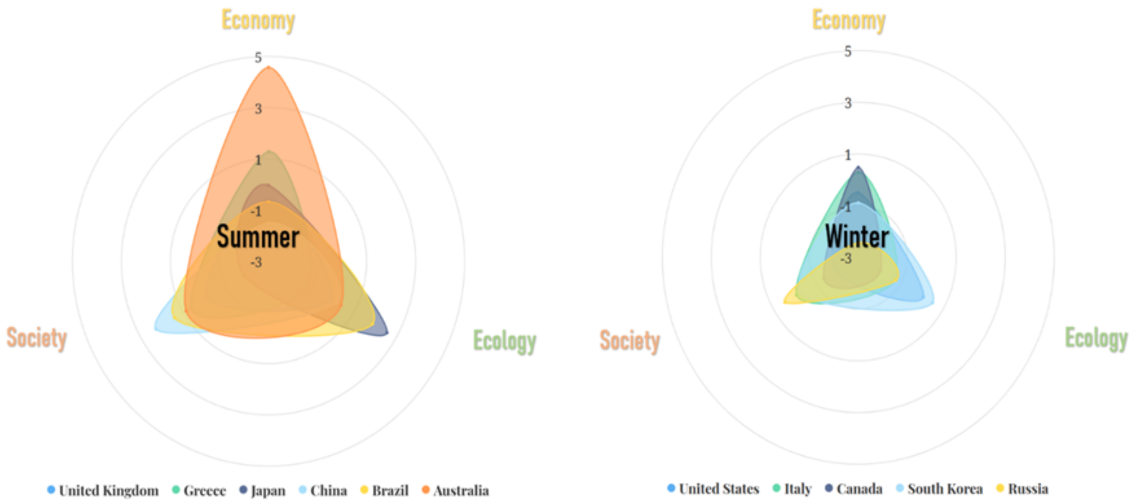

Figure 9: Factor Scores of Different Countries in Olympics

The reason for comparing the Olympics in different seasons separately is that some countries are suitable for only one type of Olympics (for example, Brazil is located in a tropical area and does not have the geographical conditions to host the Winter Olympics) and therefore are not comparable to other countries. It can be seen that the positive impact caused by the Summer Olympics is on average higher than that of the Winter Olympics, with different countries enjoying relative advantages in different dimensions.

3.4 Construct OIX by TOPSIS based on EWM

3.4.1 Calculate Weights of Factors by EWM

Since different countries have different Olympic impact scores in different dimensions, it is not possible to directly select the most suitable country to host the Olympic Games. We need an OIX that reflects the impacts of different dimensions in a comprehensive way, so we use the **Entropy Weight Method (EWM)** to determine the weights of different factors.

EWM is a weighting method that determines objective weights based on the variability of the indicators, which avoids bias caused by human factors and therefore has a higher precision and objectivity compared to those subjective assignment methods such as AHP.

Step 1 Standardize Factors

When applying PCA we have already made the corresponding way out for the Very Small indicators, so here we just need to further scale them to fall in the specified interval, thus removing the effect of different magnitudes between different data and making the indicators comparable. In our paper, the treatment is done using the deviation normalization method:

$$z = \frac{x'_{ij} - \min(x'_j)}{\max(x'_j) - \min(x'_j)} \tag{10}$$

Step 2 Calculate Information Entropy

The information entropy represents the amount of information and is calculated as follows:

$$E_j = -k \sum_{i=1}^{n} p_{ij} \ln(p_{ij}) \tag{11}$$

$$p_{ij} = \frac{z_{ij}}{\sum_{i=1}^{n} z_{ij}} , i = 1, \dots, n. j = 1, \dots, m \tag{12}$$

$$k = \frac{1}{\ln(n)} > 0, E_j \geq 0 \tag{13}$$

where, we set the number of countries as n and the number of factors as p, and z_{ij} represents the j^{th} factor of the i^{th} country.

Step 3 Calculate Variation Coefficients and Weights

Since the information entropy E_j is used to measure the information utility value of j^{th} indicator, and when there is complete disorder ($E_j = 1$), the utility value of the factor for comprehensive evaluation is zero. Therefore, a difference is needed here to calculate the information utility value of an indicator:

$$d_j = 1 - E_j \tag{14}$$

We can get the weight w_j of the j^{th} factor:

$$w_j = \frac{d_j}{\sum_j^m d_j} \tag{15}$$

3.4.2 Construct Olympic Impact Index by TOPSIS

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is a commonly used intra-group composite evaluation method that can evaluate the merits of objects in a comprehensive and fair manner using normalized data. We use the final obtained scores to construct the OIX for each country in order to rank and compare them. The method does not have strict restrictions on the number of samples and variables, which meets our needs.

Step 1 Determine the Optimal and Inferior Solutions

The normalized matrix Z can be expressed as:

$$Z = \begin{pmatrix} z_{11} & \cdots & z_{1n} \\ \vdots & \ddots & \vdots \\ z_{p1} & \cdots & z_{pn} \end{pmatrix}$$

The optimal solution Z^+ and inferior solution Z^- consist of the maximum and minimum values of the elements in each column of Z, respectively, and are denoted as:

$$Z^+ = \{Z_1^+, Z_2^+, \ldots Z_m^+\} \tag{16}$$

$$Z^- = \{Z_1^-, Z_2^-, \ldots Z_m^-\} \tag{17}$$

Based on this, we can calculate the distance between each evaluation object and the optimal and inferior solutions, respectively:

$$D_i^+ = \sqrt{\sum_{j=1}^{m} w_j \left(Z_j^+ - z_{ij}\right)^2}, \quad D_i^- = \sqrt{\sum_{j=1}^{m} w_j \left(Z_j^- - z_{ij}\right)^2}, \tag{18}$$

Step 2 Calculate OIX

The closeness between each evaluation object and the optimal solution can be expressed as:

$$C_i = \frac{D_i^-}{D_i^+ - D_i^-} \tag{19}$$

where, $0 < C_i < 1$ and the closer the value of C_i is to 1, the better the evaluation object will be.

Therefore, we construct our OIX for each country as:

$$OIX_i = 100 * C_i \tag{20}$$

In the previous analysis, we have found that the economic, ecological and social impacts of the summer and winter Olympics have a significantly different pattern, so in the process of constructing and evaluating the OIX, we consider them separately. The summer and winter OIX rankings of different countries are shown in **Figure 10**.

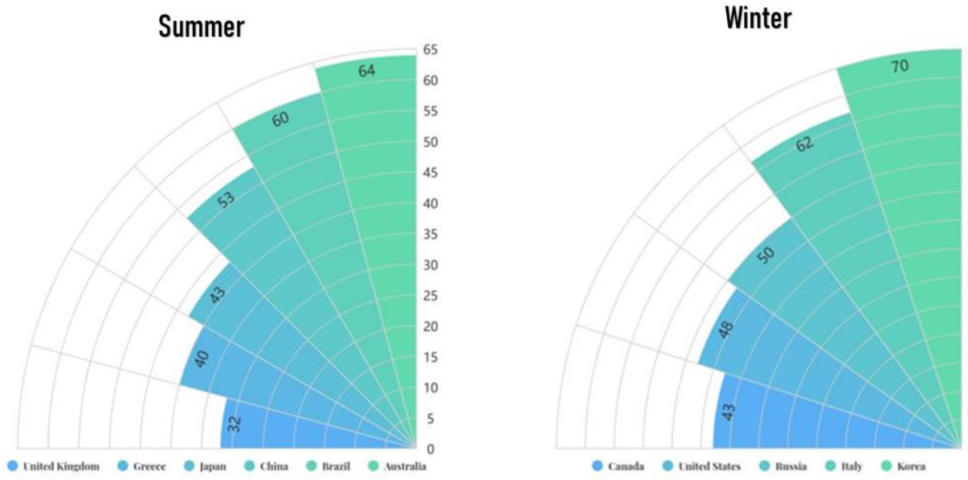

Figure 10: OIX Ranking of Summer and Winter Olympics

For the Summer Games, Australia has the highest OIX. The 27th Olympic Games in Sydney in 2000 generated A$765 million in direct revenue and made a new record of $780 million in ticket sales, which was the highest economic performance of any modern Olympic Games. In addition, it had a strong performance in tourism growth and prestige growth. For the Winter Olympics, South Korea's OIX ranked first. According to a report by the Korea Institute of Hyundai Economics, the Winter Olympics brought $18.7 billion to the Korean economy, with subsequent benefits of up to $38.9 billion over 10 years. The results of our Impact Evaluation Model are consistent with publicly available data, which justifies its validity.

4 Develop Risk Model

4.1 Establish Risk Probability Model by Weibull Distribution

In addition to the impacts of the Olympics, the feasibility of the policy is also a very important aspect to consider. The first thing to do for this part is the evaluation of overall risk of the country, so we develop a **Risk Probability Model** based on **Weibull Distribution (WD)**.

Step 1 Cluster Countries by Risk Level

Based on the results of the **Cluster Analysis** of countries based on economic, ecological and social factors, we find that there are three types of countries in the world: strong risk-tolerant countries, average risk-tolerant countries and weak risk-tolerant countries. The risk tolerance of different countries is shown in **Figure 11**.

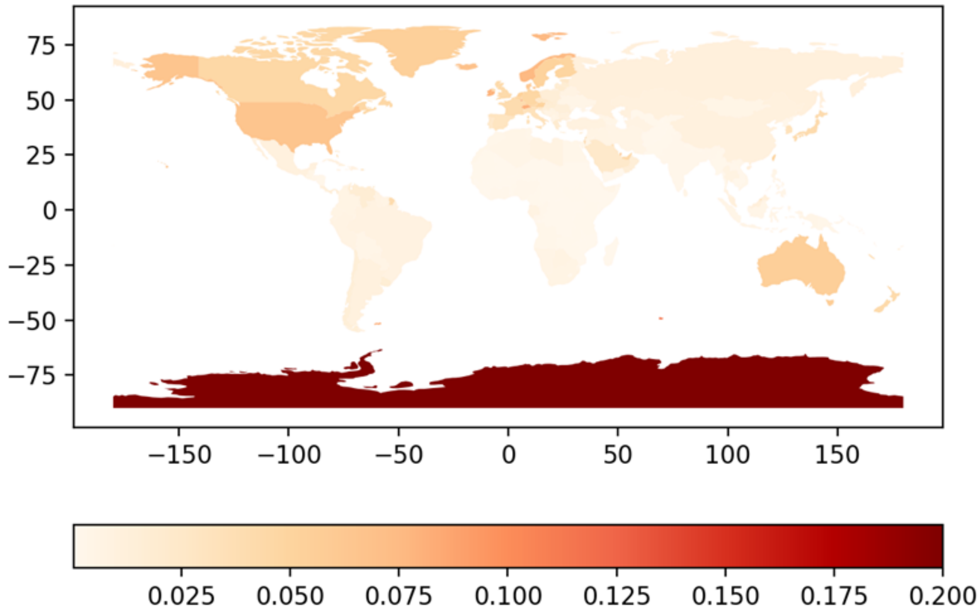

Figure 11: Risk Tolerance Around the World

Step 2 Set Parameters

The impact of the risk tolerance of different countries on Weibull Distribution is reflected in the parameters k and γ as follows:

$$(t, \gamma, k) = \begin{cases} \frac{k}{\gamma}\left(\frac{t}{\gamma}\right)^{k-1} e^{-(t/\gamma)^k} & t \geq 0 \\ 0 & t < 0 \end{cases} \tag{21}$$

where, k represents the rate of increase of risk over time and the larger it is, the faster the rate of risk increases, which means the corresponding highest risk probability will also increase; γ represents the scaling parameter, which affects the size of risk over time.

For the three categories of countries with different risk tolerances, we set different parameters k and γ by the optimization algorithm, as shown in the **Table 3**.

Table 3: Parameters

Country	γ	k
US	50	2
UK	60	2.5
Greece	70	2.5
Japan	70	2
China	60	2.5
Italy	65	2.5
Canada	65	2
South Korea	70	2.5
Russia	80	3
Brazil	70	3
Australia	60	2

Bringing the above parameters into the Weibull Distribution yields the risk probability for each country, so we can compare the risk between different countries at a given time period, which can be seen from **Figure 12**.

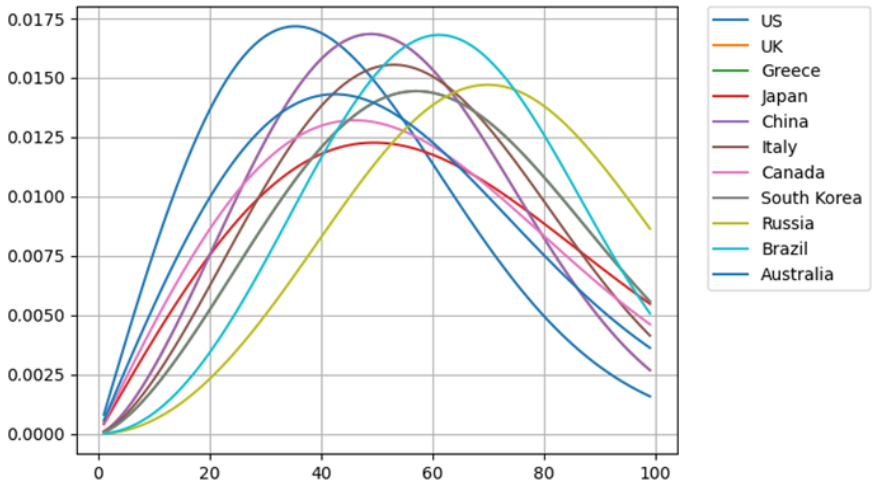

Figure 12: Risk Comparison

From the above chart, we can see that the risk of strong risk-tolerant countries such as USA, UK, Japan, China and Australia is mainly concentrated in the declaration and preparation stage of the Olympic Games, where the competition is fierce and therefore the risk grows rapidly. While in the actual process of implementation, the risk decreases because of the actual developed capacity of their own. The general risk-tolerant countries such as Japan, Italy, Greece, Canada, and South Korea have moderate risk throughout the whole stage and do not generate large risks at a certain stage. As for weak risk-tolerant countries as Russia and Brazil, the risk is mainly concentrated after the preparation due to their unique geographical location.

Knowing the level of risk for each country at different stages of the Olympic Games not only provides a perspective on feasibility, but will also help us in the subsequent analysis of the timeline.

4.2 Construct Economic Press Index

As for the micro view, it is necessary to assess whether the host city has sufficient funds, facilities and other infrastructure and resources to support hosting the Games. If the host city does not have sufficient resources or has difficulty meeting the demands of the Games, then hosting the Games will be an unfeasible task.

When considering the case of successive Olympic Games in the same location, continued losses may lead to an eventual failure. Therefore, we need to ensure that the city hosting the Olympic Games has sufficient funds or can recover the investment in the Games and make a profit after four years (when the next Games will be held). Therefore, we obtained the cost and cost overrun rates[1] of previous Olympic Games based on The Oxford Olympics

[1] The cost overrun rate is the percentage by which actual expenses exceed planned expenses.

Study 2016[2] , shown in **Figure 13**.

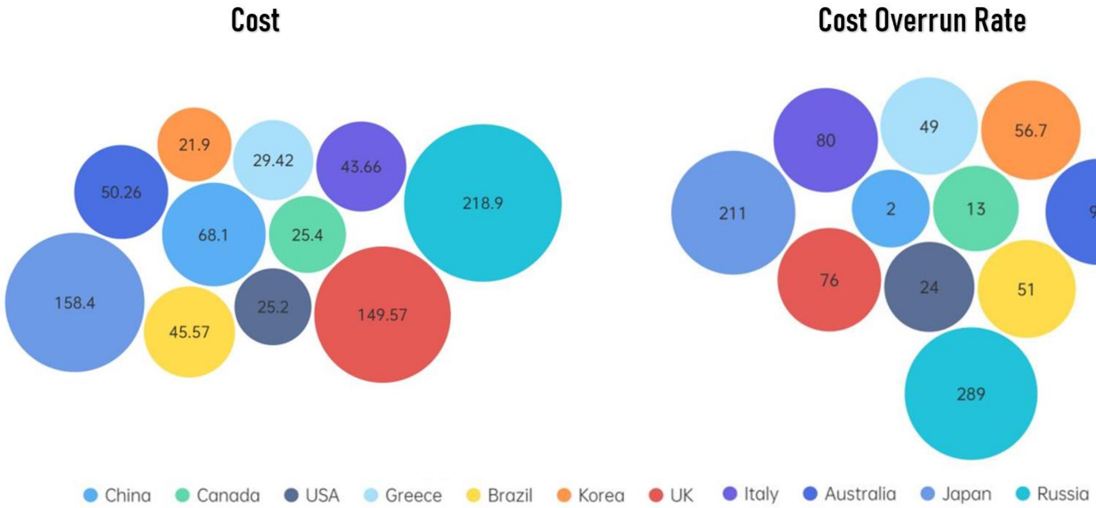

Figure 13: Costs and Cost Overrun Rates of Different Countries

To measure the economic pressure of hosting the Olympic Games, we choose the ratio of the cost of hosting the Olympic Games to the GDP of the year, and this ratio is called **Economic Pressure Index (EPI)**. The greater EPI is, the greater economic pressure a country faces and the more likely the program is about to fail. The results of the calculation of EPI for the Summer and Winter Olympic Games countries are shown in **Figure 14**.

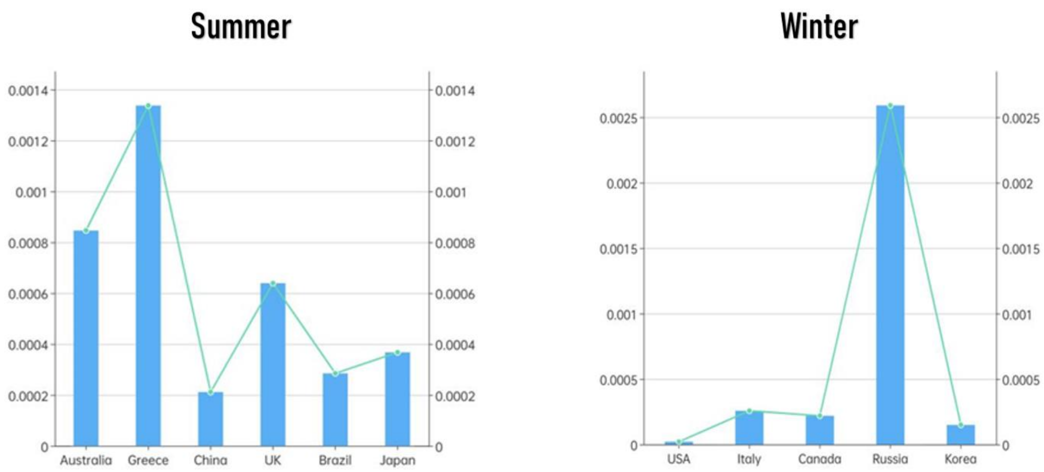

Figure 14: EPI for Different Countries of Summer and Winter Olympics

The charts shows that the economic burden of Greece and Russia far exceeds that of other countries, so we consider Greece and Russia as unfeasible countries at the micro level.

[2] The Oxford Olympics Study 2016: Cost and Cost Overrun at the Games

5 Scenario Analysis

5.1 Timeline to Implement

From application to the Olympic Committee to the end of the Games, it is a long and complex process for the organizers. Since the Olympic Games in our proposal will be held there every four years, we only have four years to prepare compared to the original proposal, but we can optimize based on the experience of the previous Games to achieve efficient results. Therefore, we suggest that the timeline can be roughly divided into five phases, as shown in **Figure 15**.

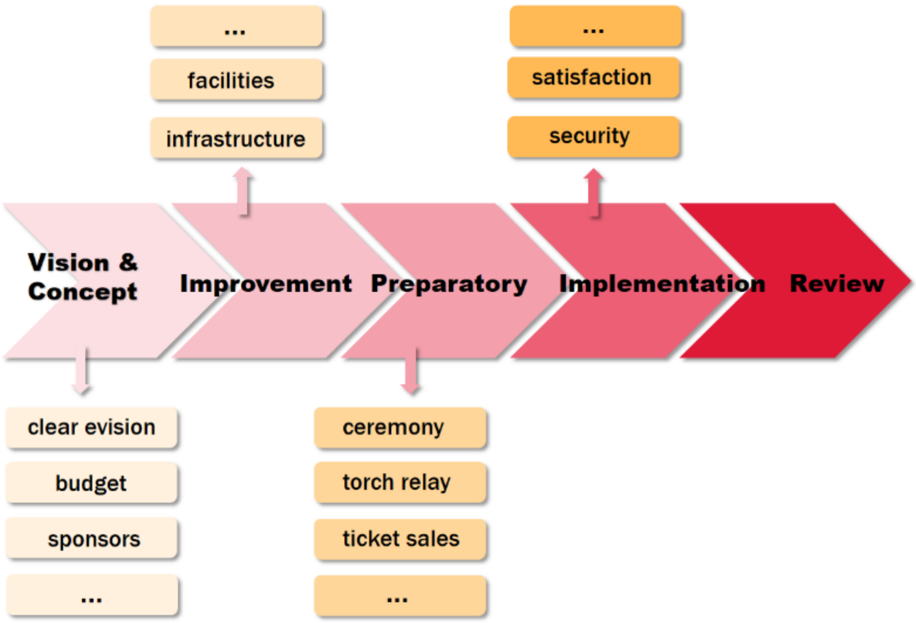

Figure 15: Timeline

1: Vision and Concept Phase

At this stage, the host city needs to enumerate a detailed plan, which includes budget funds, city planning, planned sports, sponsors, security measures, etc. The document will be submitted to the IOC for review. In addition, the IOC will visit the field to examine the feasibility of the plans in the document and whether it still has the capacity to run the Games. This phase is expected to take one year.

2: Improvement Phase

After receiving permission from the Olympic Committee, the government will recruit staff and volunteers who will work together with the IOC to prepare for the Games. During this phase, we need to renovate and inspect the infrastructure such as stadiums, athletes' dormitories and Olympic Village. The time frame for this phase is flexible, and it is best for cities to allow two years for this, or one year if the facilities are largely undamaged or have little need for improvement compared to the previous Games.

3: Preparatory Phase

During this phase, we will be specific in implementing our plans, such as determining athletes' meals, accommodation allocations, sports schedules, ticket sales, etc. Rehearsals for the opening and closing ceremonies of the Olympic Games begin during this phase. The Olympic torch relay ceremony is completed at least five months prior to the opening ceremony. This phase needs to start at least at the beginning of the year of the Olympic Games.

4: Implementation Phase

The time period from the opening ceremony to the closing ceremony of the Olympic Games will be considered as the implementation phase. During this phase, we will continuously monitor the security measures, equipment, and traffic situation to ensure the running of the Games. We also need to ensure the safety and satisfaction of the athletes and audience .

5: Review Phase

After the Olympic Games, the IOC and the government will jointly evaluate the performance of the Olympic Games implementation process. The strengths and weaknesses of the Games' implementation will be analyzed, as well as whether or how much the budget was exceeded. The results of the analysis will be documented and made available to the public to be used as a reference for the next Olympic Games.

5.2 Impacts of Potential Strategies

In the analysis of potential strategies, we consider the following three factors, as shown in **Figure 16**:

(1) Security capability: The security capability of the Olympic Games represents the security capability of a country. Therefore, the quality of security directly affects the national reputation in the OIX model proposed by us, affects our index in the social dimension.

(2) Organizational capacity: Organizational capacity represents a country's action force, and the action force indirectly reflects a country's economic governance and development level organizational capacity has an affect on the economic dimension of our OIX.

(3) Environmental protection: Environmental protection ability represents whether the Olympic Games can meet the green, recyclable ecological concept, so environmental protection directly has an influence in the ecological dimension of OIX.

Figure 16: Sensitivity Analysis

6 Memorandum

TO: ICMG
FROM: Team#2333630 of 2023 ICM
DATW: April 3, 2023
SUBJECT: Suggestions for a better Olympics

Dear ICMG Members:

It’s our great honor to present to you some policy and strategy recommendations in terms of hosting the Olympic Games. We have done this by considering many factors in terms of the influence on previous host cities, the feasibility of the policy, the timeline for implementation, and some of the potential impacts. Our detailed suggestions are as following.

First, facing the challenges of the Olympics, we propose better measures to save the cost of hosting the Games by suggesting that two locations could be chosen and that the Summer Olympics and Winter Olympics could be held at the same location all the time. By holding the Games in the same location consecutively, we can take advantage of existing infrastructure such as stadiums and Olympic villages.

Therefore, we established an index to evaluate the impact of the Olympic host, called OIX, based on economic, ecological and social aspects, to serve as a reference for our selection. We also considered feasibility as a constraint to our choice in selecting host cities. Finally, we chose Australia and Korea as our hosts for the Summer and Winter Olympics, both of which have successfully hosted the Olympics and are our best choices .

Secondly, in the process of hosting the Olympics, we recommend that a variety of factors be taken into account to advance the overall work and ensure the success of the Games. This require cooperation between IOC and the government, community and local volunteers. So we need to have a long term and well thought out plan in advance of the Olympic project, these plans need to take into account various influences such as safety and security factors, transportation factors, and equity factors.

Lastly, in order to expand the influence of the Olympic Games, we have made some suggestions that can improve the attractiveness of the Games to the public. For example, by adding more interesting and diverse sports such as e-sports, we can follow the trend of the times and make the Games more attractive. In addition, high-quality opening and closing ceremonies and mascot designs are important means of attracting a wider audience and increasing the cultural impact of the hosts. In this way, we can achieve better cultural communication power by combining the Olympic brand and city characteristics.

In conclusion, we hope these suggestions will help you in the development of the Games to better build a sustainable, diverse and influential Games. If you have questions about our recommendations please feel free to contact us.

Sincerely yours
ICM 2023 Team#2333630

7 Sensitivity Analysis

In the previously mentioned Weibull Distribution based Risk Probability Model with two parameters k and γ, we test the **robustness** of the model by varying the parameters. In the original model, we set values of 50-80 for k and 2-3 for γ. We vary the parameters by the control variables method, and the results are shown in **Figure 17**.

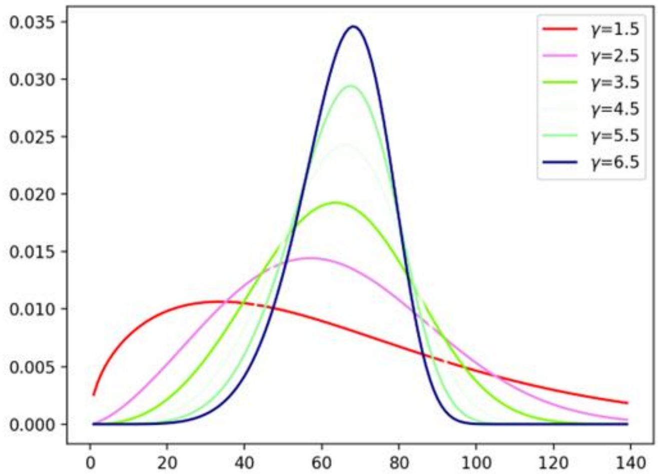

Figure 17: Sensitivity Analysis

Our model has a good robustness of:

- The effect of the change in the value of γ is consistent with the assumptions we make for the case of country **risk forecasting**: countries with high risk tolerance will have smaller values of γ and the probability of occurrence of risk will be smaller in the first period; countries with lower risk tolerance on the contrary.
- The value of k is the **scaling factor**, and the main effect is the magnitude of the occurrence of risk, i.e., the probability we estimate, which does not need to be discussed in detail here.

8 Conclusion

First, we confirm that our plan is to hold the Winter and Summer Olympic Games in two locations all the time. Therefore, we developed an OIX index to evaluate the combined influence of the Olympic hosts. We selected 11 countries and 9 variables after data filling or bringing into the **Time Backtracking Model**. After determining the weight by PCA and EWM, we obtained the OIX of each country based on TOPSIS model and conducted the ranking.

Then, we conducted a feasibility analysis of the host city by analyzing the economic pressures index of each country and using risk models. Our risk model has a good robustness. According to the result, we eliminated Russia, Greece and Brazil from the list. Finally, combining our feasibility analysis with OIX, we chose **Australia** as the site for the Summer Games and **South Korea** for the Winter Games.

In light of our policy and previous experience in hosting the Games, we have outlined a detailed five-stage timetable for the Games. At the same time, we analyze the impact of potential strategies on our indicators.

Finally, we wrote a memo to the Olympic Committee and put forward some innovative and sincere suggestions about holding the Olympic Games.

9 Model Evaluation

9.1 Strengths

1. For countries with large missing data, we use **Cluster Analysis** to find countries with complete and comparable data in the corresponding indicators worldwide and use their data patterns to fill the missing values. In the process of fitting, we use the **Particle Swarm Optimization** to optimize the model parameters for the existing data with a constraint on the number of iterations, thus ensuring the scientific accuracy and integrity of the data under the condition of limited sample.

2. We consider the difference between the “having hosted” and “not hosting” data to measure the impact of the Olympics on a certain indicator. For the latter **counterfactual**, we used **Gray Forecast Model** based on data before the year of the event to simulate and capture the true impact.

3. We use **Principal Component Analysis** to extract three factors from the relevant indicators, corresponding to the three dimensions of economy, ecology and society, and further determine the weights by **Entropy Weight Method** to obtain an objective and scientific impact index of the Olympic Games.

4. Using the **Olympic Impact Index** score as a benchmark, we have considered the feasibility of implementing the policy of fixed country from macro and micro perspectives. Especially for the macro level, we develop a **Risk Probability Model** based on **Weibull Distribution** to measure the overall risk of the country. Thus the proposed policy recommendation is more scientific.

9.2 Weaknesses

1. We ignore subjective indicators such as autonomous willingness to host the Olympics because we lack sufficient data to support this part of the analysis, which may lead to bias in our constructed Olympic Impact Index and policy recommendation based on it may be opposed by the countries concerned.

2. The Olympic Impact Index we constructed is an overall score derived from multiple indicators, which means that we can use this scoring rule to calculate an overall score for the three already given factors, but cannot finely derive the index score for a future point in time. In this regard, we plan to refine the analysis of future trends for each indicator and build a reasonable predictive model for it so that the model can be guaranteed to be evolvable.

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