Research On Bidding for The Olympic Games Based on Meta-Network and ISM Model

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Abstract. In view of the dwindling interest of countries to bid for hosting the Olympic Games, this paper proposes two models to assess the impact and feasibility of hosting the Olympic Games. The first model is an Olympic Impact D&A System Meta-Network model based on 20 indicators in four categories including economy, society, politics and environment, and the correlations between the indicators are classified and determined by Principal Component Analysis (PCA). The second model is based on Interpretive Structural Modeling (ISM), which proposes four new hosting methods and analyzes their centrality, causality and hierarchy in the new network. The results show that fixed location in developed countries and annual smaller game in developing countries are the two most advantageous methods.

Keywords: Olympic Impact D&A System Meta-Network model, PCA, ISM.

1. Introduction

The Olympic Games have long been regarded as one of the most important and prestigious international events. It provides opportunities for athletes to compete at the highest level and for nations to come together and celebrate their shared passion for sport. However, in recent years, the number of countries and cities willing to host the Olympics has decreased due to the economic, social, political and environmental challenges that come with hosting such a large event. By developing policies that prioritize sustainability and inclusivity, a platform that celebrates diversity and inspires people around the globe to participate in sports and physical activity can be created. This will not only have positive effects on individual health and well-being, but also contribute to the overall health and prosperity of the global community.

2. Olympic Impact D&A System Meta-Network Model

2.1. The principle of Meta-Network Model

Carley et al. proposed the concept of meta-networks, which are multi-level social net-works comprising multiple organizational components [1]. These networks have a hierarchical structure resembling a tree and can map multiple homogeneous or heterogeneous sub-networks. By analyzing the entire meta-network model or any sub-network within it, critical information about the structural characteristics of the system can be obtained.

According to Sameroff [2], any natural system such as society or an organization can be represented by a meta-network model. Building a meta-network model involves identifying nodes and establishing links between them. Meta-network nodes can represent various entities or elements in a system, including people, data, information, and resources.

2.2. Identification of network elements

To identify the critical elements of the Olympic Games impact, this study selected 20 key factors from the economic, social, environmental, and political categories based on relevant technical specifications, government documents, and related literature [3]. The 20 factors are shown in Table 1.

Table 1: Identification of Olympic Impact elements.

Category	ID	ID Meaning
Economic Impact	Ec1	Enhance the city’s economic level and international influence
	Ec2	Stimulate the development of tourism and hotel industry
	Ec3	Increase job opportunities
	Ec4	Improve infrastructure and public services, promoting urban development
	Ec5	Drive development in multiple sectors including construction, transportation, and communication
Social Impact	S1	Promote sports and improve public health awareness
	S2	Strengthen friendly exchange and cultural communication among nations
	S3	Enhance national pride and sense of honor
	S4	Raise national quality and spiritual civilization level
	S5	Promote global peace, cooperation, and unity
Environmental Impact	En1	Aggravate urban traffic congestion and environmental pollution
	En2	Consume and damage local environmental resources
	En3	Cause excessive consumption of social resources and energy
	En4	Increase the burden of urban waste and sewage treatment
	En5	Affect the life and environment of local residents
Political Impact	P1	Enhance the international status and political influence of the host country and city
	P2	Strengthen domestic and international political stability
	P3	Drive adjustments and upgrades in the policies and strategies of the host country and city
	P4	Enhance exchange and cooperation between governments and the public
	P5	Raise the influence and status of the International Olympic Committee.

2.3. The Establishment of Olympic Impact D&A System Meta-Network Model

2.3.1 The intuitive visualization of Meta-Network

Based on the identified 20 critical elements related to hosting the Olympic Games, four categories including Economy, Politics, Environment, and Social Impacts are identified as the meta-network four-dimensional nodes. To develop the Olympic Impact D&A system and analyze the correlations between the elements of entities involved in hosting the games, links are transformed between nodes, and the standard Olympic Impact D&A system meta-network is developed, as shown in Fig 1. The Olympic Games D&A system meta-network will be explained in detail below.

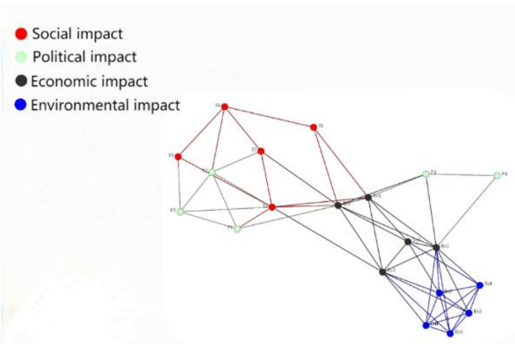

Fig 1: Olympic Impact D&A system detailed meta-network model.

This paper uses a network model to study the impact of hosting the Olympics and its links with 20 elements from four categories: economy, politics, society, and environment. The network model can show the direction and type of the associations between the elements. The associated sub-network based on the node relationship matrix will be presented and explained in Table 2 and Fig 2.

Table 2: Olympic Impact D&A system meta matrix.

	Economic Impact	Social Impact	Environmental Impact	Political Impact
Economic Impact	EcEc Network	Societal-Economic Nexus	Economic-Environmental Synergy Network	Eco-Political Feedback Loop System
Social Impact	--	SS Network	EnS Network	Political-Social Dynamics Matrix
Environmental Impact	--	--	EnEn Network	EnP Network
Political Impact	--	--	--	PP Network

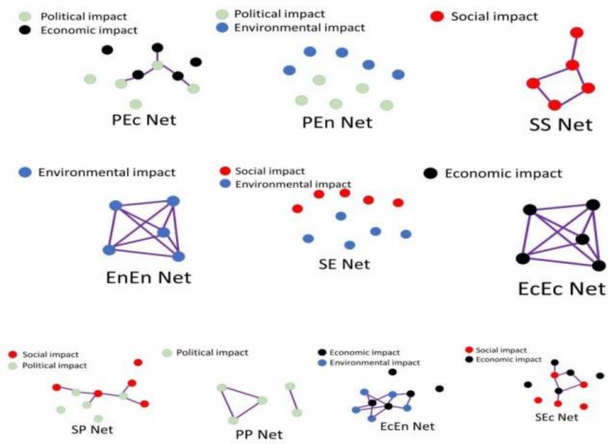

Fig 2: Olympic Impact D&A system meta-network sub-network system diagram

2.3.2 Refining the Meta-Network Model based on Principal Component Analysis (PCA)

The paper has constructed a network to study the impact of the Olympic Games, with 20 factors as nodes. Now, the focus is on analyzing the weight of the impact in relation to the structure of the network itself. Consider all nodes to be equally important and will be exploring the properties of the network to gain insights into its impact, which is shown below.

Authority Centrality (AC): AC is a measure of the importance of a node in a network based on the quality and quantity of its incoming links. It is calculated by summing the Hub scores of the nodes that link to it. The formula for Authority Centrality of a node i is:

$$Authority(i) = \sum_j Hub(j) \tag{1}$$

where j are the nodes that link to i, and $Hub(j)$ is the Hub score of nodes j.

Betweenness Centrality ($BetC$): $BetC$ is a measure of a node's importance in a network, based on the number of shortest paths that pass through it. It quantifies how often a node acts as a bridge between other nodes in the network. The formula to calculate the betweenness centrality of a node i is:

$$C_B(v) = \sum_{s \neq v \neq t \in V} \frac{\sigma(s, t|v)}{\sigma(s,t)} \tag{2}$$

where V is the set of nodes in the network, s and t are two distinct nodes in the network, $\sigma(s, t)$ is the total number of shortest paths from node s to node t, $\sigma(s, t|v)$ is the number of those shortest paths that pass-through node v and $C_B(v)$ is the betweenness centrality of node v.

Bonacich Power Centrality (BPC): BPC is a measure of centrality that takes into account the centrality of a node's neighbors. It is calculated by solving a system of linear equations that consider the influence of each node on the others, with a parameter called beta that controls the degree of influence of distant nodes. The formula for Bonacich Power Centrality is:

$$(I-\beta A)c = Ae \tag{3}$$

where I is an identity matrix, e is a vector of ones, A is the adjacency matrix, c is the Bonacich Power Centrality value of each node, and β is a parameter representing the degree of distance between nodes.

Closeness Centrality (CCl): CCl measures how close a node is to other nodes in a network by computing the inverse of the sum of distances from a node to all other nodes in the network. Nodes with higher Closeness Centrality have shorter paths to all other nodes and can monitor information flow in an organization better. The formula for Closeness Centrality is:

$$V*(N-1)/\sum_j D_{i,j} \tag{4}$$

where V is the maximum link value, N is the number of nodes in the network, $D_{i,j}$ is the shortest path length from node i to node j, and $\sum_j D_{i,j}$ is the sum of shortest path lengths from node i to all other nodes.

Contribution Centrality (CbC): CbC is a centrality measure that computes Eigenvector Centrality on a transformation of the input network, where link values are proportional to the dissimilarity of the nodes they connect. The measure emphasizes the importance of links that connect nodes with different neighborhoods, and de-emphasizes those that connect nodes with similar neighborhoods. The formula is expressed as:

$$c = \frac{\lambda}{Wc} \tag{5}$$

where c is the Contribution Centrality value of a node, W is the weighted matrix obtained by scaling the adjacency matrix A with the Jaccard distance, and λ is the normalization factor, i.e., the maximum eigenvalue.

Total-Degree Centrality (TDC): TDC is the normalized sum of a node's In-Degree and Out-Degree in a unimodal network with link values. The formula is:

$$\frac{\sum A(i,:)+\sum A(:,i)-A(i,i)}{2V(N-1)} \tag{6}$$

Where A is the input network with N nodes and maximum link value V.

Radiality Centrality (RC): RC is a measure of centrality in a network based on the closeness of a node to all other nodes, where closeness is defined as the network diameter minus the shortest path distance. The formula is:

$$\text{Radiality Centrality of node i} = \frac{\sum_{j=1}^{N}(\text{diameter}-D(i,j))}{(N-1)(\text{diameter}-v)} \tag{7}$$

Where $D(i,j)$ is the shortest path length from node i to j (or 0 if no path exists), $diameter$ is the maximum $D(i,j)$ over all (i,j) pairs, N is the number of nodes in the network, and v is the minimum link value.

PageRank Centrality (PRC) is a measure of the importance of a node in a network based on the importance of its incoming neighbors, calculated by modeling the behavior of a web surfer navigating through hyperlinked pages. The formula is:

$$x = \alpha Ax + (1-\alpha)e\frac{1}{n} \tag{8}$$

Where α is a damping factor, A is the normalized adjacency matrix of the input network, n is the number of nodes, and $(1-\alpha)e\frac{1}{n}$ represents the probability of random jumps. The term Ax represents the weighted influence of each node's in-neighbors on node x.

Out-Degree Centrality (ODC): ODC measures the number of links originating from a node, normalized by the maximum number of such links. The formula is:

$$C_{out}(i) = \frac{\sum_{j=1}^{n} A_{ij}}{V\times(n-1)} \tag{9}$$

Where A is the input network with maximum link value V, and n is the number of nodes. If the network A is unimodal and not using the diagonal, then the measure is normalized by $\mathrm{V} \times (\mathrm{n}-2)$.

Katz Centrality (KC): KC is a measure of node centrality in a network, based on the centrality of its neighbors. It takes into account both direct and indirect connections between nodes. The Katz Centrality of a node is calculated by solving a system of linear equations. The formula is:

$$c = \alpha(I - \beta A)^{-1} e \tag{10}$$

Where the centrality values are normalized by dividing by the largest eigenvalue of$(I - \beta A)$.

Now, 10 factors have been selected out. In the constructed Olympic impact network, the paper randomly removed eight nodes and compared it with the original network to determine the weight of each property in the network. Specifically, the paper conducted a comparative analysis by recording the values of selected indicators for each simulation scenario in 50 Monte Carlo simulations, which were then used as input data for PCA calculations [4].

The paper conducted principal component analysis on the maturity evaluation system using MATLAB, and found that the first five principal components accounted for 85% of the cumulative variance, with characteristic roots of 7.77, 1.74, 0.38, 0.07, and 0.03. These five components are selected as indicators for the analysis. A fragmentation diagram of the PCA results is shown in Fig 3.

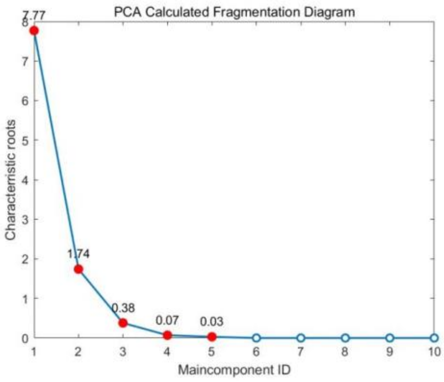

Fig 3: PCA fragmentation diagram

The results of the linear combination coefficients and weights of the PCA principal components are shown in Table 3.

Table 3: Linear combination coefficients and weighting results.

Name	Component 1	Component 2		
Feature Root	7.773	1.742	Comprehensive score coefficient	Weight
Variance Extraction	77.73%	17.42%		
AC	0.3569	0.0484	0.3004	10.52%
$BetC$	0.3446	0.181	0.3146	11.01%
BPC	0.127	0.6155	0.2165	7.58%
CCl	0.3574	0.0019	0.2923	10.23%
CbC	0.3391	0.1828	0.3105	10.87%
TDC	0.3565	0.0626	0.3027	10.60%
RC	0.353	0.1248	0.3112	10.90%
PRC	0.3308	0.2504	0.3161	11.07%
ODC	0.3545	0.0192	0.2931	10.26%
KC	0.0899	0.6856	0.199	6.97%

Equation 11 represents the formula for calculating the overall maturity score of the system. The weight distribution of the individual indicators used in this formula is illustrated in the form of a tree diagram, as depicted in Fig 4.

$$F = 0.1052AC + 0.1101BetC + 0.0758BPC + 0.1023CCl + 0.1087CbC + 0.106TDC + 0.109RC + 0.1107PRC + 0.1026ODC + 0.0697KC \tag{11}$$

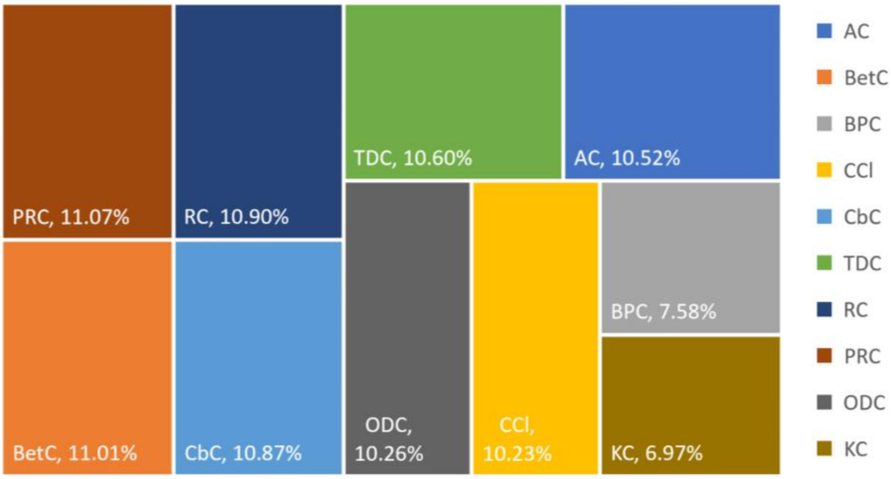

Fig 4: D&A system maturity assessment indicator weighting tree diagram.

3. DEMATEL-ISM Based NOF Model

3.1. Explanation of Four New Olympic Hosting Strategies

Faced with the embarrassment of many countries unwilling to host the Olympics, we must come up with some measures to solve this problem. Based on the ideas provided by Gisele [5], we conducted more in-depth research and proposed more targeted and feasible policies and strategies. For countries with the ability to host the Olympics, there are significant differences in their economic, social, environmental, and political levels. However, in order to obtain relatively universal conclusions and solutions, the paper roughly divided these countries into two categories: developed countries and developing countries. Strategies are stated as below.

A_1: hosting the Olympics at a fixed location in developed countries,

A_2: developed countries hosting the smaller-scaled Olympics annually,

A_3: hosting the Olympics at a fixed location in developing countries

A_4: developing countries hosting the smaller-scaled Olympics annually.

Next, we will use literature search and construct a model for evaluating new Olympic Games hosting formats (NOF model) to determine the superiority of these four strategies and decide which one will be the blueprint for future Olympic hosting.

3.2. Model Analysis based on DEMATEL-ISM

DEMATEL, which stands for Decision Making Trial and Evaluation Laboratory, is a complex system factor analysis method proposed by Fontela et al. [6]. The ISM method is a way to show the structural relationships of factors in a system using matrices and graphs. It helps to identify the key elements and simplify the system structure. It is useful for studying problems in fields like engineering and agriculture. It is suitable for analyzing and understanding complex systems with multiple influencing factors [7].

The DEMATEL method tends to be micro and the ISM method tends to be macro. Integrating DEMATEL and ISM to study the four types of hosting strategies can complement each other's advantages, improve computational efficiency, and comprehensively analyze the impact of the four hosting strategies on the 20 nodes in the previous model from the level of influence, path, and degree.

3.2.1 Determine Initial Direct Impact Matrix and Calculate the Complex Impact Matrix

In order to determine the influence coefficients between each node, this paper reviewed relevant literature [8] and scored the connections between factors based on the degree of closeness. The scores were assigned on a scale of 0 (no influence), 1 (slight influence), 2 (moderate influence), 3 (significant influence), 4 (very strong influence), and 5 (extremely strong influence). Ten sets of influence matrices were obtained and a direct influence matrix $\boldsymbol{S}$ was generated in table 4.

Table 4: Olympic hosting Initial direct impact matrix

	Ec_1	Ec_2	Ec_3	Ec_4	Ec_5	s_1	s_2	s_3	s_4	s_5	En_1	En_2	En_3	En_4	En_5	P_1	P_2	P_3	P_4	P_5	A_1	A_2	A_3	A_4
Ec_1	0	4	4	3	4	3	2	4	2	3	3	3	3	2	3	4	5	5	0	0	1	2	4	4
Ec_2	3	0	3	2	3	0	2	0	1	4	4	4	4	4	4	4	1	2	1	0	2	4	4	4
Ec_3	3	2	0	2	1	0	0	3	2	3	1	2	2	3	3	4	3	1	0	0	2	3	3	4
Ec_4	2	1	3	0	3	4	2	3	2	2	3	4	4	4	4	4	2	0	0	0	1	3	4	4
Ec_5	2	2	3	4	0	1	1	2	1	3	4	4	4	4	3	4	3	3	2	0	1	3	4	4
s_1	0	0	0	1	1	0	0	0	4	3	2	1	1	2	3	2	0	0	3	4	2	2	2	3
s_2	2	0	0	1	0	0	0	2	2	4	1	1	2	2	1	3	3	1	0	3	2	3	3	4
s_3	1	0	0	0	0	0	1	0	4	3	3	3	4	4	3	2	2	0	0	2	2	2	3	4
s_4	0	0	0	0	0	1	1	1	0	4	4	4	4	4	3	3	0	0	0	2	2	2	3	4
s_5	0	0	0	0	0	0	3	0	3	0	2	2	2	2	3	3	4	0	3	5	2	1	3	4
En_1	0	1	0	2	2	0	0	0	1	1	0	3	3	3	4	2	1	0	0	0	4	3	2	3
En_2	1	1	1	1	1	0	1	0	1	2	2	0	2	3	4	2	2	2	2	0	3	3	2	3
En_3	1	1	1	1	1	1	1	0	1	1	2	3	0	3	3	2	2	2	2	0	2	2	2	3
En_4	0	2	0	1	0	0	0	0	1	0	3	3	3	0	4	2	0	2	2	0	3	2	2	3
En_5	0	1	0	1	1	0	0	1	2	2	3	3	2	3	0	2	1	0	2	0	4	3	2	3
P_1	2	3	0	0	0	0	5	3	2	2	2	2	2	3	3	0	5	0	0	3	2	2	3	4
P_2	1	0	0	0	0	0	2	1	4	4	2	3	2	2	2	3	0	2	1	2	1	2	3	4
P_3	2	1	1	1	1	0	0	0	3	3	2	3	3	4	3	3	2	0	3	0	1	2	2	4
P_4	1	0	1	0	0	0	1	0	3	2	1	3	3	4	3	3	4	0	0	0	1	2	3	3
P_5	0	0	0	0	0	0	1	0	1	2	1	1	1	1	1	3	0	0	3	0	2	2	2	3
A_1	2	2	3	2	2	2	3	2	3	2	4	3	3	2	2	3	2	3	2	3	0	0	0	0
A_2	1	1	1	2	1	2	2	1	3	3	3	2	2	2	2	3	3	4	2	4	0	0	0	0
A_3	3	4	3	3	3	3	4	3	4	3	4	4	4	4	3	4	0	2	2	2	0	0	0	0
A_4	3	4	4	3	2	3	5	3	3	4	3	3	3	3	4	5	4	5	2	5	0	0	0	0

The initial direct influence matrix only reflects the direct influence relationships among the factors. The indirect influence relationships among the factors can be further analyzed by calculating the comprehensive influence matrix. Firstly, calculate the sum of each row and column of the initial direct influence matrix $\boldsymbol{S}$, and let the maximum value of all sums be denoted as α. Then, divide each element of the initial direct influence matrix $\boldsymbol{S}$ by α, and obtain the normalized direct matrix $\boldsymbol{A}$, as shown in formulas (12) and (13).

$$\alpha = max\left[max_{1\leq j\leq n}\sum_{i=1}^{m} S_{ij}, max_{1\leq i\leq n}\sum_{j=1}^{m} S_{ij}\right] \tag{12}$$

$$A = \frac{S}{\alpha} \tag{13}$$

Then calculate the complex impact matrix T (TABLE) according to formula (14), where $\boldsymbol{I}$ is identity matrix.

$$T = A(I - A)^{-1} \tag{14}$$

3.2.2 Calculate centrality degree and reason degree and construct reachability matrix

According to the comprehensive influence matrix T, the influence degree D, influenced degree R, centrality $D - R$, and causality degree $D - R$ of each factor are calculated [9]. The influence degree D is the sum of each row of the matrix T, which reflects the degree to which this row factor affects other factors; the influenced degree R is the sum of each column of the matrix T, which reflects the degree to which this column factor is influenced by other factors. The centrality $D + R$

is the sum of influence degree and influenced degree, and the larger the centrality value, the more important the factor is in the system. The causality degree $D-R$ is the difference between the influence degree and influenced degree, and when the causality degree value is greater than zero, it is the cause factor, indicating that this factor has a greater impact on other factors. When the causality degree is less than zero, it is the result factor, indicating that this factor is more influenced by other factors. The calculation results are shown in Table 5. The causal relationship diagram of the influencing factors is plotted with the centrality $D+2$ as the horizontal axis and the causality degree $D-R$ as the vertical axis, and the position of each factor is indicated as shown in table 5 and its scattered dots figure shown in Fig 5.

Table 5: DR TABLE

	D		R		$D+R$		$D-R$	
	D	rank	R	rank	$D+R$	rank	$D-R$	rank
Ec_1	2.6143	1	1.0994	20	3.7137	8	1.5149	1
Ec_2	2.2995	4	1.2	18	3.4995	11	1.0995	4
Ec_3	1.8384	7	1.0063	22	2.8448	20	0.8321	5
Ec_4	2.2264	6	1.1092	19	3.3356	15	1.1172	3
Ec_5	2.3577	3	0.9485	23	3.3062	17	1.4092	2
s_1	1.3037	22	0.7433	24	2.0471	24	0.5604	6
s_2	1.514	15	1.4938	14	3.0078	18	0.0201	12
s_3	1.5733	11	1.0761	21	2.6494	22	0.4972	7
s_4	1.5213	14	1.9498	10	3.4711	12	-0.4285	16
s_5	1.5106	16	2.1737	8	3.6843	9	-0.6632	18
En_1	1.3427	21	2.2195	7	3.5622	10	-0.8768	19
En_2	1.4762	17	2.3983	5	3.8744	5	-0.9221	21
En_3	1.4024	19	2.3284	6	3.7309	7	-0.926	22
En_4	1.2509	23	2.5172	4	3.768	6	-1.2663	24
En_5	1.3572	20	2.5672	2	3.9244	4	-1.2101	23
P_1	1.7921	9	2.5623	3	4.3544	2	-0.7702	20
P_2	1.5215	13	1.8426	11	3.3641	14	-0.3211	15
P_3	1.6658	10	1.3098	16	2.9756	19	0.356	8
P_4	1.4113	18	1.2405	17	2.6518	21	0.1707	11
P_5	0.9106	24	1.3839	15	2.2945	23	-0.4732	17
A_1	1.8137	8	1.5733	13	3.387	13	0.2404	10
A_2	1.5547	12	1.7543	12	3.309	16	-0.1996	14
A_3	2.2877	5	2.0055	9	4.2933	3	0.2822	9
A_4	2.586	2	2.6289	1	5.2149	1	-0.0429	13

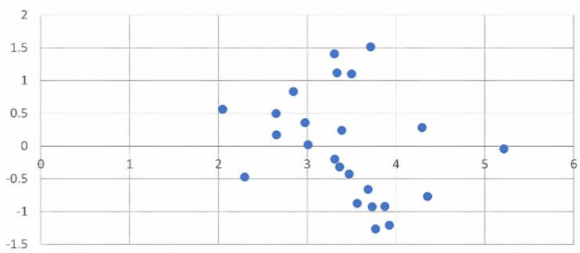

Fig 5: DR scattered chart

(1) Centrality degree analysis [10].

The figure and table show that hosting the Olympic Games is more important for developing countries than developed ones, because it affects many aspects of their systems. Hosting the Games in developing countries is the top recommendation among the policies.

(2) Reason degree analysis

The four proposals have similar effects on hosting the games, for developed and developing countries have different strengths and weaknesses. Hosting the games in one location is better than in four seasons, because it gets more attention and influence.

Based on the comprehensive influence matrix T, the overall influence matrix H is calculated using the formula (15), where I is the identity matrix.

$$H = T + I = h_{ij} \tag{15}$$

M is the reachable matrix that describes the direct and indirect relationships between influencing factors, showing the connected paths from one factor to another. M can be obtained from the comprehensive influence matrix T, by calculating the average value of all items in T to obtain the threshold λ of 0.0714, and then applying formula (16). The resulting M is shown in Table 6.

$$M = \left[m_{ij}\right]_{n\times n}, (ij = 1,2 \cdots n) \tag{16}$$

$$m_{ij} = \begin{cases} 0, & h_{ij} < \lambda \\ 1, & h_{ij} \geq \lambda \end{cases} \tag{17}$$

Table 6: Reachability matrix

	Ec_1	Ec_2	Ec_3	Ec_4	Ec_5	s_1	s_2	s_3	s_4	s_5	En_1	En_2	En_3	En_4	En_5	P_1	P_2	P_3	P_4	P_5	A_1	A_2	A_3	A_4
Ec_1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1
Ec_2	1	1	1	0	1	0	1	0	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1
Ec_3	1	0	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1
Ec_4	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1	1
Ec_5	0	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1
s_1	0	0	0	0	0	1	0	0	1	1	1	0	0	1	1	1	0	0	0	1	0	0	0	1
s_2	0	0	0	0	0	0	1	0	1	1	0	0	1	1	1	1	1	0	0	1	0	1	1	1
s_3	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	1
s_4	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	1
s_5	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	0	0	1	0	0	1	1
En_1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	1	1	0	1
En_2	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	1	1	0	1
En_3	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	1
En_4	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	1	0	0	1
En_5	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	1	1	0	1
P_1	0	1	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1
P_2	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1
P_3	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1
P_4	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	1	1	0	1	0	0	0	1	1
P_5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1
A_1	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1	0	0	1
A_2	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	0
A_3	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	0	0	1	0	0	1	1
A_4	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1

3.3. Construction of Multi-level Hierarchical Structure Model

Based on the reachable matrix M, the reachable set p, the precedent set q, and the common set r are obtained. p is the set of all columns corresponding to the elements 1 in the rows; q is the set of all rows corresponding to the elements 1 in the columns, and r is the intersection of the sets p and q. Then, the first round of hierarchical processing is performed, where the factors with equal p and r are considered as the highest-level factors and placed in the first layer of the ISM model diagram. After determining the factor set of the first layer, subsequent layers are determined according to the above principles. Based on the hierarchical results and the reachable matrix M, a multilayer hierarchical structure model is constructed in Fig 6.[redacted]

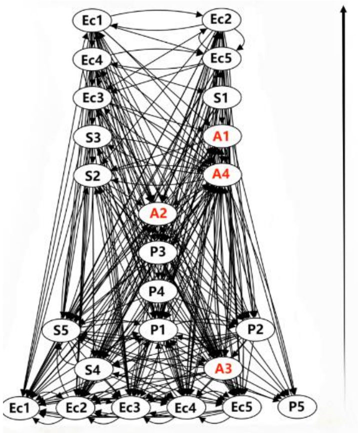

Fig 6: Hierarchy diagram

The paper constructed a hierarchical network structure and observed four policies. The paper found that these four policies, from the top level to the bottom level, were A_1, A_4, A_2, and A_3. This indicates that A_1 and A_4 are the ultimate goals of the system in the entire hierarchy and are the superior hosting plans. Therefore, developed countries can host the Olympics in one location and show their strengths. Developing countries can host the smaller Olympics in annually and reduce pressure and increase influence.

4. Conclusions

The paper is proposing two new Olympic hosting models: holding the Olympics in a fixed location in a developed country (A_1) and having developing countries host the smaller-scaled Olympics annually (A_4). Here are some feasibility suggestions for each.

Establish an Olympic city that is designed to be the core industry of the region, with top-tier sports facilities and accommodations. Create a comprehensive transportation network to ensure smooth and efficient travel for athletes and spectators. Invest in sustainable and environmentally-friendly technologies to reduce the carbon footprint of the event. Encourage public-private partnerships to fund the development of the Olympic city and facilities.

Introduce new and interesting sports, or include traditional sports that are unique to the host country, to attract more international attention and tourists. Develop the necessary infrastructure and facilities for year-round sports activities, such as indoor and outdoor arenas, skiing and snowboarding slopes, and aquatic centers. Implement measures to ensure the safety and security of athletes and spectators, including disaster preparedness plans and heightened security measures. Promote the host country's culture, heritage, and tourism industry to enhance the global image and economic development of the country.

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