
Prospects of Olympic Events — *Insights from Mathematical Models*

Abstract

This study presents a strategic framework designed to maintain the Olympic Games' global prominence by critically assessing and selecting Sports Development Events (SDEs) that align with current societal values. Our analysis is grounded in six key dimensions: universality, gender equality, environmental sustainability, inclusivity and diversity, relevance and innovation, and safety and fair play. We have developed a model that integrates data from the last three Olympic Games, employing a combination of subjective, objective, and predictive scoring mechanisms to achieve a nuanced assessment of key performance indicators.

We began by identifying the six primary dimensions as the foundational first-level indicators, which were then refined into more detailed second-level indicators, culminating in the creation of quantifiable third-level indicators. The Analytic Hierarchy Process (AHP) was utilized to assign weights among the first and second-level indicators, ensuring a precise determination of the relative importance of all quantified indicators within our model. Additionally, we applied the entropy weight method using data from the last three Olympic Games, and based on the findings from both AHP and the entropy weight method, we calculated the Total Weights.

Our results highlight the significance of universality and gender equality in preserving the Olympics' global appeal and equitable character. Esports, cricket, and mixed martial arts (MMA) are identified as potential sports for Olympic inclusion by 2032, according to our model's scoring. These sports are favored for their broad appeal, particularly among younger audiences, and their progress towards gender inclusivity.

We conducted a thorough examination of the model's stability and consistency, confirming its robustness and applicability. Moreover, we incorporated a Long Short-Term Memory (LSTM) model to forecast trends in the tertiary indicators within our framework, thereby validating the rationality of our total weightings. The outcomes confirm the feasibility of the Total Weights assigned by our model.

By identifying and advocating for sports that engage a diverse audience and reflect current values, our model not only promotes societal benefits such as increased physical activity and international collaboration but also supports the Olympic Movement's aspiration to inspire and guide the world in sports, culture, and education. This approach ensures that the Olympic Games continue to be a symbol of aspiration, unity, and progress for future generations.

Key words: *Olympics, SDE Score, AHP, Entropy Weight, LSTM Model, prediction*

Contents

1	Introduction	3
1.1	Background	3
1.2	Problem Restatement	3
2	Preliminary Information	4
2.1	Variables	4
2.2	Assumptions and Justification	4
3	Index Selection and Quantification	5
3.1	Overall View	5
3.2	Description	5
4	Determine the Weight	10
4.1	Analytic Hierarchy Process	10
4.1.1	Weight of Primary Indicators	10
4.1.2	Weight of Subordinate Indicators	11
4.1.3	Combination of the Weight	13
4.2	Entropy Weight Method	13
4.2.1	Pretreatment to the Data	13
4.3	Weight Determination	13
4.4	Verification and Integration of AHP and Entropy Weight Method	15
5	LSTM Model for Prediction	17
5.1	Introduction	17
5.2	Data Processing	17
5.3	Model building	18
5.4	Training of the model and verification	18
5.5	Prediction and Result	19
6	Finding Events that Increase or Decrease	19
6.1	Selected Event for 2032 Olympics	19
6.2	Recommend sorting	19
7	Model Stability and Ranking Consistency Analysis	21
7.1	Model Stability Analysis	21
7.2	Graphical analysis	21
7.3	Ranking Consistency Analysis	22
7.4	Heat Map Display	22
7.5	Selecting the Optimal α -Value	22

A letter to the IOC

Dear Members of the International Olympic Committee (IOC):

Hello!

We are pleased to present our key findings and recommendations aimed at supporting the Olympic Games in maintaining their lasting influence and positive global role. Our research is structured around six critical aspects: universality, gender equality, sustainability, inclusion and diversity, relevance and innovation, and safety and fair competition. These elements were evaluated to understand their impact on the success of Olympic events and to propose three potential SDEs for inclusion in the Olympic program.

Our model applies data from the past three Olympic Games and integrates subjective scoring, objective scoring, and predictive scoring, ensuring that the weighting of indicators is balanced and comprehensive.

Here are some considerations:

1. Universality and gender equality have emerged as the most fundamental aspects of the Olympic Games. Our research shows that these two aspects play a key role in maintaining the global appeal and fairness of the event. Universality ensures that athletes and audiences from all over the world can participate in and enjoy the SDEs, while gender equality guarantees equitable treatment and opportunities for all genders.
2. Sustainability, inclusion and diversity, relevance and innovation, and safety and fair competition, while important, are relatively lower weighted. This suggests that while these factors contribute positively to development and viewer experience of the Games, their immediate impact is not as pronounced as that of universality and gender equality.

These considerations are supported by our data, showing that SDEs with consistently high scores share these characteristics.

Next, our findings indicate that esports, cricket, and mixed martial arts (MMA) are three potential SDEs with promising prospects for inclusion in the Olympic Games by 2032. Esports scored approximately 5.116, reflecting its global popularity, particularly among youth in Asia, North America, and Europe. Efforts to foster gender inclusivity in esports are also notable, with initiatives focused on reducing stereotypes and increasing opportunities for women. Cricket, with a score of around 6.823, boasts a fanbase exceeding a billion and has seen growth in gender equality through investments in leagues such as the Women's Premier League (WPL) and ICC events. MMA scored approximately 5.205, supported by its widespread following across continents and enhanced gender representation through the success of prominent female athletes such as Ronda Rousey and Amanda Nunes.

While these three SDEs show promise, it is important to acknowledge that their ratings in sustainability, innovation, and social aspects vary and may require strategic development over

time.

As the pinnacle of global sporting events, the Olympic Games must evolve with the changing world while maintaining their core values of tradition and fairness. Our findings underscore the importance of prioritizing accessibility and gender equality. Furthermore, an expanded focus on sustainability and technological innovation will help ensure that the Games remain competitive and appealing to future generations. We are confident that these recommendations will help the Olympic Games continue to flourish as a globally celebrated event.

Thank you for considering our research and recommendations. We hope these insights will provide valuable guidance for future planning and decision-making.

Sincerely,
Team # 15303

1. Introduction

1.1. Background

As the Olympic Games continue to be held, their global influence has been expanding. In response, the IOC proposed a development strategy to enhance the consistency of the Olympic Games with modern values and align them with contemporary contexts. This approach aims to attract a global audience's attention to Olympic sports and events, ensuring the Games' enduring global influence. One way to implement this idea is by modernizing and innovating the disciplines, sports, and events (SDEs) in the Olympic Games. Such modifications are not fanciful. Throughout the Games' history, the IOC has carefully considered various factors to introduce new events, reintroduce past ones, or remove some after a period^[1].

For example, in 2020, karate, rock climbing, surfing, and skateboarding made their Olympic debuts. In 2024, four new events will be introduced: breaking, sport climbing, skateboarding, and surfing, although karate will not be part of Paris 2024 Games. Tug-of-war, once a staple in field and small-scale competitions, was an Olympic event from the 1900 Paris Olympics until its removal after the 1920 Antwerp Games. Moreover, baseball and softball are set to return to the 2028 Los Angeles Games after a 20-year hiatus.

1.2. Problem Restatement

Considering the background information and conditions identified in the problem statement, we need to solve the following problems:

- **Problem1:** Identify the key factors affecting the selection of Olympic events (quantitative and qualitative, constant and variable, deterministic and probabilistic) and provide reasonable explanations for the selection.
- **Problem2:** Build a model based on the derived factors to help the IOC evaluate social and economic development projects (SDEs) that conform to the Olympic standards.
- **Problem3:** Test at least three niche sports with the model to explore the general applicability of the model and confirm their place in the Olympic Games.
- **Problem4:** Identify three new or reintroduced sports showcase events for the 2032 Games in Brisbane and rank them in order of priority. Predict which sports are likely to be included in the Games in 2036 or later.
- **Problem5:** Using sensitivity analysis is performed to solve the problem of model robustness, determine the weight of each factor, and analyze the advantages and disadvantages of these factors, as a decision tool.
- **Problem6:** Draft a letter to the IOC summarizing the results of the study in relatively lucid terms, including the impact of the model on SDEs, recommendations for additions and deletions, and rationale.

2. Preliminary Information

2.1. Variables

Table 1: Variables Table

Variables	Definition
A_{Λ}	Paired comparison matrix within indicator set Λ
w_{Λ}^T	Weight vector of indicator set Λ obtained via AHP
C.R.	Coefficient Ratio
x_{ij}	The data of the i -th element and $j \in \Lambda$ -th indicator
\tilde{w}_{Λ}^T	Weight vector of indicator set Λ obtained via Entropy Weight
α	Composite coefficient of weights obtained by AHP and Entropy Weight

2.2. Assumptions and Justification

- (1) **Assumption:** We assume that the data can be obtained from IOC officially authorized media.

Justification: The media reported data was from IOC, so the media can represent IOC, since that IOC didn't make the data public.

- (2) **Assumption:** We assume that the data is plausible and consistent, without significant difference due to different IOC authorized media.

Justification: The data source is the same, but the officially authorized media can report different aspects of the data, and the differences caused by the reports are too much, and should not affect the nature of the data itself, so we minimize this uncertainty to ensure that the establishment of the model will not be too complicated.

- (3) **Assumption:** We canceled 56 SDEs from a range of 74 SDEs, and we assume that the left 18 SDEs we searched for determining indicators are objective enough.

Justification: Searching data for 74 SDEs is too complicated, we tend to select the ones that are relatively representative and accessible comparing to other SDEs, and those typical data will be more useful for us to build models.

- (4) **Assumption:** We assume that the three levels of indicators are in line with official and scientific standards.

Justification: The establishment of those indicators is based on IOC official standards and PESTEL, the combination of the two strategies will enhance the model's reasonability and validity.

3. Index Selection and Quantification

3.1. Overall View

After conducting literature research and brainstorming sessions, we have selected the three-level indicators as shown in the table below. The primary indicators are categorized by different fields, the secondary indicators further refine these categories, and the tertiary indicators are used for quantification.

Table 2: Index Table

Primary(1-6)	Secondary(A-N)	Tertiary(X_i)
1.Universality	A.Global participation	Number of Participating Countries
		Viewership
	B.Economic Feasibility	Hosting Cost
		Maintenance Cost
	C.Infrastructure Needs	Proportion Using Existing Facilities
2.Gender Equality	D.Male and Female Participation	Male-to-Female Event Ratio
	E.Event Setup	Parity of Entries
3.Sustainability	F.Environmental Impact	Carbon Emission
		Proportion of Renewable Energy Usage
	G.Social Responsibility	Number of Volunteers
		Number of Employment Opportunities
4.Inclusion and Diversity	H.Cultural Representation	Diversity of Athletes' Origin
	I.Global Coverage	Number of Regions Covered by Athletes
5.Relevance and Innovation	J.Youth Appeal	Audience Proportion Aged 18-35
	K.Technological Innovation	Usage of VR/AR Technology
	L.Tradition and Modernity	History and Innovation Balance Score
6.Safety and Fair	M.Athlete Protection Measures	Safety Equipment Coverage
		Safety Equipment Coverage
	N.Anti-doping Standard	Anti-Doping Compliance
		Popularity of Anti-Doping Standards

3.2. Description

1. **Universality:** It is a fundamental requirement of the Olympic Movement. Only sports that are widely promoted enough can provide a fair competitive stage for athletes and serve as a bond for peaceful exchange among countries. Universality includes the following aspects:

- A. **Global participation:** Sports with widespread global participation can embody the principle of fairness. Specifically, we quantify this with **A1. Number of Participating Countries** and **A2. Viewership**^[2].

- B. Economic Feasibility:** It is mainly concerned with the cost of hosting Olympic events and the potential economic return. Here, we use **B1. Hosting Cost**, **B2. Maintenance Cost** and **B3. Maintenance Cost** to quantify the evaluation. The financial investment required to host an Olympic event is a very large figure, and the economic affordability of different countries is different, and the economic feasibility of the event must be considered in terms of cost-effectiveness. In addition, the maintenance of facilities after the event is also an important economic factor. ^[3]
- C. Infrastructure Needs:** Infrastructure construction is crucial for improving the performance, viewing experience, and smoothness of competitions. Therefore, we have chosen it as a secondary indicator and quantified it using **C1. Proportions Using Existing Facilities**.
2. **Gender equality:** It is a key evaluation criterion in Olympic events and aims to ensure that the events provide equal opportunities, resources and treatment for male and female athletes. In assessing gender equality in Olympic events, we need in-depth analysis of the allocation of infrastructure, the participation of male and female athletes, and the gender balance of sports Settings. Therefore, we have refined the primary indicator of gender equality into two secondary indicators: the Infrastructure Usage Rate and the Male and Female Participation Ratio. Gender equality includes the following aspect:
- D. Male and Female Participation Ratio:** It is one of the core indicators to measure gender equality in Olympic events. It reflects the participation of both male and female athletes in the event. The ideal gender equality should be reflected by **D1. Male-to-Female event ratio** as close as possible. By analyzing this indicator, we can judge whether the event provides equal opportunities for male and female athletes.
- E. Event Setup:** The gender balance of entries reflects the participation of male and female athletes in each sport. Assess whether the event provides equal opportunities for male and female athletes to compete. If the number of participants in certain events is heavily skewed towards one gender or the other, this may indicate a gender bias in the event setup. It quantified by **E1. Parity of Entries**.
3. **Sustainability:** Long-term impact of the events on the environment, society and communities, ensuring that the events can be held without compromising the resources of future generations. The realization of sustainability should not only consider the economic benefits of the event, but also consider its performance in terms of environmental protection, social responsibility and community benefits.
- F. Environmental impact:** Environmental impact refers to the impact of the event on the natural environment, including resource consumption, carbon emissions, waste disposal and other factors. In assessing the environmental impact, the focus is on

whether the negative impact of the event on the environment is minimized, and whether the event is organized in a green, low-carbon and environmentally friendly manner. **F1. Carbon emissions** and **F2. Proportion of renewable energy usage** are listed as quantitative indicators to specify Environmental impact indicator.

- G. Social responsibility:** Social responsibility focuses on the event's contribution to society, including the promotion of equity, inclusion, diversity and social welfare. This includes assessing whether the activity can have a positive impact on society by promoting education, creating jobs, supporting public welfare activities, etc. **G1. Number of volunteers** can quantify the indicator. Meanwhile, community benefit assessment of the positive impact of activities on local communities, including infrastructure development, community growth and local economic promotion. Community interest is key to the long-term success of the event, as it relates to the health of the local economy and society. **G2. Number of employment opportunities** quantifies Community benefits.

- 4. Inclusion and Diversity:** They are key principles of the Olympic Movement, which aims to ensure that the Games represent and celebrate the rich cultures, backgrounds and perspectives from around the world. Only sports that embrace and promote these values can provide a level and inclusive playing field for athletes and promote solidarity and mutual respect among nations. Inclusion and diversity emphasize creating equal opportunities for diverse groups to participate, showcasing diverse cultural expressions, and engaging audiences from all groups.^[4] These aspects help to strengthen the event's role as a platform for global connections and cross-cultural exchanges. Inclusion and Diversity includes the following aspects:

- H. Cultural Representation:** Cultural representation concerns whether Olympic events adequately represent the diversity of different regions and cultures around the world. This is not only reflected in the geographical diversity of athletes participating, but also whether the event can showcase the characteristics and values of different cultures. Through the promotion of cultural representation, the event can attract a wider audience and enhance the global influence and inclusiveness of the event. Specifically, we quantify this with **H1. Number of Regions Covered by Athletes**. This quantitative measure measures the number of different regions or countries from which athletes are participating. The regional diversity reflects the global appeal and cultural representation of the event. The more geographically dispersed the athletes, the more international the event will be, attracting spectators from a wider range of cultures and backgrounds.
- I. Global Coverage:** In today's world values, the connotation of cultural diversity and inclusiveness is to cover as many regions, races, and cultures as possible around the

world. Therefore, if a sport wants to join the Olympics, it should be able to cover all parts of the world, allowing athletes from all countries to freely participate in the competition. This can be quantified by indicator **I1. Number of Regions Covered by Athletes**.

5. **Relevance and Innovation** It is a key indicator to assess whether the Olympic events meet the needs of The Times and maintain the vitality of innovation. In modern sporting events, relevance is reflected not only in the adoption of new technologies, but also in the balance of traditional and modern elements. Events need to be innovative in terms of attracting young audiences, enhancing the spectator experience, and driving technological advances, while preserving and respecting the traditional values of sporting events.

J. **Youth Appeal:** It is concerned with the ability of the event to attract young viewers, especially in the 18 to 35 age group. Youth and young audiences are an important part of the future of the sports and entertainment industry, and capturing the interest of this demographic is crucial to the long-term growth of the event. The degree of innovation and modernization of the event in terms of program setup, promotion, social media interaction, etc., will affect its appeal to young audiences. Specifically, we quantify this with **J1. Audience Proportion Aged 18-35**. This quantitative measure measures the proportion of spectators aged 18 to 35 at an event. Using this ratio, we can quantify the event's appeal to younger viewers and understand whether the event has succeeded in attracting this key demographic. Youth and young audiences are an important part of the future of the sports and entertainment industry, and capturing the interest of this demographic is crucial to the long-term growth of the event.

K. **Technological Innovation:** It focuses on how Olympic events can leverage emerging technologies (such as virtual reality, augmented reality, artificial intelligence, and more) to enhance the event experience, increase interactivity, and modernize the sports industry. As technology continues to advance, how the event engages spectators through these innovations and improves the game and spectator experience is a key factor in the event's continued appeal. Specifically, we quantify this with **K1. Number of Competitions Using VR/AR Technology**. This quantitative metric measures the number of Olympic events using virtual reality (VR) and augmented reality (AR) technologies. By tracking the application of these technologies, we can understand the prevalence of technological innovation in the event. The application of VR/AR technology can greatly enhance the spectator experience, increase interactivity, and bring innovative presentation to the event.

L. **Tradition and Modernity Balance:** The balance between tradition and modernity focuses on how to adapt to the needs and development of modern society while maintaining the traditional charm of Olympic events. The Olympic Games have a

profound historical background and traditional culture, which are the basis for the success of the games. However, as technology and society advance, how to incorporate modern elements, appeal to younger generations of spectators and increase the global relevance of the event is an important issue to balance. Specifically, we quantify this with **L1.History and Innovation Balance Score**. This quantitative indicator comprehensively assesses the balance between traditional and modern elements of the Olympic Games. By scoring the degree of integration of historical traditions and modern innovations, the performance of the event in terms of innovation and preservation of traditions can be judged. If the event is too radical in innovation and ignores tradition, it may lose the interest of traditional audiences; On the other hand, being too conservative may miss the opportunity to attract a younger generation of viewers.

6. **Safety and fair competition** They are the foundations of the Olympic program, ensuring the physical health and safety of athletes and the fairness of competition. The index covers athlete protection, anti-doping standards and safety equipment, with the goal of providing a fair, transparent and safe competitive environment for athletes. Safety and fair competition includes the following aspects:

M. **Athlete protection:** It measures ensure the physical safety and mental health of athletes in competition, including medical insurance, injury prevention, rehabilitation and other aspects. Specifically, we quantify this with **M1. Number of Injury Cases** and **M2. Proportion of Athletes Equipped with Safety Gear**. For M1, the index measures the number of athlete injuries that occur during an event to assess the effectiveness of safety measures at the event. For M2, this indicator measures the proportion of athletes who wear necessary safety equipment during an event and reflects the implementation of athlete safety measures at the event.

N. **Anti-doping standards:** It assess how events are maintained fair through strict anti-doping measures, ensuring that all athletes can compete without interference from doping. Specifically, we quantify this with **N1. Number of Doping Violations** and **N2. Proportion of Athletes Undergoing Compliance Testing**. For N1, the index measures the number of athletes who have been disciplined for doping violations at an event and aims to assess the effectiveness of anti-doping measures at the event. For N2, it measures the proportion of athletes tested for drug compliance and reflects the strength and rigour of anti-doping rules at events.

4. Determine the Weight

4.1. Analytic Hierarchy Process

4.1.1. Weight of Primary Indicators

For the first level index judgment, matrix pairwise comparison method was used to determine the importance of indicators. A widely used scale, Saaty scale, as shown in the table below, can quantify the relative importance of indicators in a qualitative context and assign different coefficients^[5].

Table 3: Scale Definition Table

Scale a_{ij}	Meaning
1	C_i and C_j have equal impact
3	C_i has slightly more impact than C_j
5	C_i has more impact than C_j
7	C_i has significantly more impact than C_j
9	C_i has an absolutely stronger impact than C_j
2, 4, 6, 8	The impact ratio between C_i and C_j lies between two adjacent levels above
$1/2, \dots, 1/9$	The impact ratio of C_j to C_i is the reciprocal of the above a_{ij}

The judgment matrix of the first level index:

Table 4: Primary Indicator Judgment Matrix

	1	2	3	4	5	6
1	1	3	5	4	3	2
2	1/3	1	3	2	2	2
3	1/5	1/3	1	1/2	1	1/2
4	1/4	1/2	2	1	1	1
5	1/3	1/2	1	1	1	1
6	1/2	1/2	2	1	1	1

Simply evaluating based on the Saaty scale may lead to a certain degree of weight imbalance. Therefore, it is necessary to calculate the consistency ratio (C.R.) coefficient.

Firstly, by solving the eigenvalues of the matrix, the maximum eigenvalue is obtained, and then the C.I. coefficient is calculated:

$$\text{C.I.} = \frac{\lambda_{\max} - n}{n - 1},$$

Then, we can calculate C.R. via

$$\text{C.R.} = \frac{\text{C.I.}}{\text{R.I.}} \begin{cases} < 0.1, & \text{the matrix is consistent} \\ \geq 0.1, & \text{the matrix is not consistent} \end{cases}$$

Obtained by consistency test:

$$w_{\{1,2,3,4,5\}}^T = (0.385, 0.201, 0.072, 0.111, 0.105)$$

$$\text{C.R.} = 0.0216 \ll 0.1$$

Indicating that our scoring falls within a reasonable range.

4.1.2. Weight of Subordinate Indicators

Universality and Gender equality are relatively important indicators, and the universality and global appeal of the Olympic Games are crucial to their success, ensuring the participation of athletes from all countries and regions. This is why the universality ratio is the largest. In recent years, gender equality has received more and more attention in the Olympic Games, which is also the reason why gender equality has a relatively large weight.

The remaining four first-level indicators, while important in Olympic events, are the direction of progressive development, as opposed to universality and gender equality. Universality and gender equality are directly related to the global appeal and fairness of the event, and are the core basis for the success of Olympic events, while other indicators more reflect the long-term development and detailed adjustment of the event, so their weight is more balanced and low.

Judgment matrix A_A for secondary indicators:

Table 5: universality

	A	B	C
A	1	3	4
B	1/3	1	2
C	1/4	1/2	1

Table 6: Gender Equality Matrix

	D	E
D	1	2
E	1/2	1

Table 7: Sustainability Matrix

	F	G
F	1	3
G	1/3	1

Table 8: Inclusiveness and Diversity Matrix

	H	I
H	1	3
I	1/3	1

Table 9: Relevance and Innovation Matrix

	J	K	L
J	1	3	3
K	1/3	1	2
L	1/3	1/2	1

Table 10: Safety and Fair Competition Matrix

	M	N
M	1	3
N	1/3	1

The weight of the secondary index affiliated to universality is

$$\mathbf{w}_{\{A,B,C\}}^T = (0.623, 0.239, 0.137)$$

The weight of the secondary index affiliated to gender equality is

$$\mathbf{w}_{\{D,E\}}^T = (0.667, 0.333)$$

The weight of the secondary index affiliated to sustainability is

$$\mathbf{w}_{\{F,G\}}^T = (0.750, 0.250)$$

The weight of the secondary index affiliated to inclusiveness and diversity is

$$\mathbf{w}_{\{H,I\}}^T = (0.750, 0.250)$$

The weight of the secondary index affiliated to relevance and innovation is

$$\mathbf{w}_{\{J,K,L\}}^T = (0.567, 0.237, 0.200)$$

The weight of the secondary index affiliated to safety and fair competition is

$$\mathbf{w}_{\{M,N\}}^T = (0.750, 0.250)$$

4.1.3. Combination of the Weight

By combining the weights of primary and secondary indicators, the weights of each secondary indicator under the AHP method can be obtained, as shown in the table below

Table 11: AHP Weights for Secondary Indicators

Indicator	Weight	Indicator	Weight
A	0.623	H	0.750
B	0.239	I	0.250
C	0.137	J	0.567
D	0.667	K	0.237
E	0.333	L	0.200
F	0.750	M	0.750
G	0.250	N	0.250

4.2. Entropy Weight Method

4.2.1. Pretreatment to the Data

Considering the subjectivity of the AHP method, we also adopted another objective weighting method — the Entropy Weight Method to determine the weight of each indicator, so as to comprehensively evaluate the advantages and disadvantages of different SDEs.

Entropy weight method is based on the concept of entropy in information theory, which determines the weight of each indicator mainly by measuring the amount of information. The indicator with lower entropy means more information, so it should be given higher weight. The index with higher entropy means less information, and the weight should be reduced accordingly. The construction process of entropy weight method model will be introduced in detail below.

Since the units of the data and magnitude of different indicators may be different, the original data needs to be standardized. The commonly used formula is

$$x'_{ij} = \frac{x_{ij} - x_j^{\min}}{x_j^{\max} - x_j^{\min}}$$

where x_{ij} is the original value, and x_j^{\min} and x_j^{\max} are the minimum and maximum values of the j -th indicator, respectively.

x_{ij} is original data, x_j^{\min} and x_j^{\max} are the minimum and the maximum of j index, respectively. After the manipulation, all of the data will be limited on the close interval $[0, 1]$.

4.3. Weight Determination

For each indicator J , entropy E is an important parameter to measure the information content of the indicator. The greater the information entropy, the smaller the distinguishing effect of the index on decision making, and the weight should be reduced accordingly. On the other hand, the

smaller the information entropy is, it means that the index has a greater distinguishing effect on decision making and should be given a higher weight^[6].

$$E_j = -\frac{1}{\ln m} \sum_{i=1}^m p_{ij} \ln p_{ij}$$

$$p_{ij} = \frac{x'_{ij}}{\sum_{i=1}^m x'_{ij}}$$

where p_{ij} is the ratio of standardized data.

The weight of each indicator is calculated according to information entropy, and the formula is as follows:

$$\tilde{w}_j = \frac{1 - E_j}{\sum_{j=1}^n (1 - E_j)}$$

where E_j is the entropy of the j index, and n is the total number of indicators. This formula ensures that the weights of all metrics sum to 1. The smaller the entropy value E_j is, the higher the dispersion of the index and the greater its weight will be.

The entropy weight method requires a high level of data integrity. Due to the difficulty in collecting or processing some data, we further selected and integrated the initial indicators, reorganized the indicator levels, and displayed them in the following table.

As a result, we finally derived the weight of each indicator, as following shows:

Table 12: Primary Indicator Weights

Primary Indicator	Weight
Universality	0.24011
Gender Equality	0.19756
Sustainability	0.15576
Inclusion and Diversity	0.20118
Relevance and Innovation	0.02679
Safety and Fair Competition	0.17860

Table 13: Secondary Indicator Weights

Secondary Indicator	Weight	Secondary Indicator	Weight
Global Participation	0.06349	Cultural Representation	0.19556
Economic Feasibility	0.17662	Youth Appeal	0.00562
Male and Female Participation Ratio	0.19755	Technological Innovation	0.02479
Environmental Impact	0.13015	Tradition and Modernity Balance	0.00200
Social Responsibility	0.00001	Athlete Protection Measures	0.16975
Community Benefits	0.02561	Anti-doping Standard	0.00885

Table 14: Tertiary Indicator Weights

Tertiary Indicator	Weight	Tertiary Indicator	Weight
Global Participation	0.02517	Community Benefit	0.01315
International Audience Coverage	0.03832	Diversity of Regions of Athletes	0.19556
Hosting Costs	0.10223	Proportion of Young Audience	0.00562
Utilization rate of existing facilities	0.07439	Virtual Element Participation	0.02479
Maintenance Costs	0.19556	Tradition and Modernity Balance	0.0020
Male and Female Participation Ratio	0.0020	Injury rates of athletes	0.05562
Carbon Emission	0.12701	Safety Equipment Coverage	0.11413
Renewable Resource Usage	0.00314	Anti-Doping Compliance	0.00353
Community Participation	0.01246	Popularity of Anti-Doping Standards	0.00532

4.4. Verification and Integration of AHP and Entropy Weight Method

Using the weights determined by the AHP method and historical data collected by the modeling team, we obtained scores for the following sports in each year

Table 15: Scores of sports events weighted via AHP (excerpt)

Project Name	Year	Percentage	Composite	Rank
short	2016	14.0303253	14.0303253	55
short	2020	17.4976809	17.4976809	49
short	2024	20.9841915	20.9841915	45
basketball	2016	32.6915446	32.6915446	27
basketball	2020	37.7033524	37.7033524	24
basketball	2024	42.6987415	42.6987415	20
skateboard	2016	4.9042653	4.9042653	69
skateboard	2020	4.9042653	4.9042653	69
skateboard	2024	8.38803953	8.38803953	64
...				

The entropy weight method is the same. More detailed data will not be listed here. The scoring of newly added events in the past few Olympic Games under our model is shown in the table below, where we simply average the weights obtained from the two methods, i.e. combine them with $\alpha = 0.5$:

$$\mathbf{w}_{\text{final}}^T = \frac{1}{2} \cdot \mathbf{w}_{\Lambda}^t + \frac{1}{2} \cdot \tilde{\mathbf{w}}_{\Lambda}^T$$

Table 16: Project Score Table

Project Name	Year	AHP Score	Entropy Weight Score	Total Score
Climbing	2020	3.85	17	10.43
Climbing	2024	7.61	25	16.31
Surfing	2020	0.36	4.57	2.47
Surfing	2024	4.45	7.49	5.97
Skateboarding	2020	5.04	0.36	2.70
Skateboarding	2024	8.64	4.45	6.54
Luge	2016	3.04	0.44	1.74
Luge	2020	5.18	2.93	4.06
Luge	2024	7.32	5.43	6.38
Water Polo	2016	19.57	14.92	17.25
Water Polo	2020	22.32	17.56	19.94
Water Polo	2024	25.23	20.65	22.94
Freestyle Skiing	2016	27.96	22.93	25.45
Freestyle Skiing	2020	32.32	27.82	30.07
Freestyle Skiing	2024	36.67	32.71	34.69

Based on this, we can verify our model from multiple aspects:

For new projects (2020, 2024):

Emerging sports such as climbing and skateboarding show high AHP and entropy weight scores, especially in 2024. The overall score for these events has further improved (e.g. climbing from 10.43 in 2020 to 16.31 in 2024). This shows that these projects have significantly improved in terms of innovation and audience appeal.

Surfing made an initial appearance in 2020 with a relatively low rating (2.47), but saw an increase in ratings in 2024 (5.97), reflecting a gradual increase in recognition of the program's sustainability and audience interest.

For ongoing projects:

Bobsledding, water polo, and freestyle skiing have consistent ratings for sports that have been in the Olympics since 1988 or earlier. Freestyle skiing, in particular, showed a high total score in 2024 (34.69 points), indicating that it still has an advantage in maintaining audience appeal and relevance.

The entropy weight score of water polo continues to be high, especially reaching 22.94 in 2024, further supporting its long-term importance as an Olympic sport.

Universality of the model and verification results:

Through AHP scoring and entropy weight analysis of these events, we verify the applicability of the model in evaluating emerging and ongoing Olympic events. The model results show that:

- New additions were rated relatively low in the early stages, but improved over time and with increased audience recognition.

- Sustained events, while maintaining high ratings over time, also reflect their irreplaceable importance and audience base in the event.

Conclusion:

Our model successfully confirms the Olympic status of these SDEs and demonstrates their broad applicability. New projects gradually improve their ratings through innovation and audience appeal, while the steady high scores of continuing projects reflect their long-term value and the traditional support of the Games. The results of model analysis not only support the current Olympic status of these projects, but also provide a reliable reference for the evaluation of future projects.

5. LSTM Model for Prediction

5.1. Introduction

In this study, we used the Long Short-Term Memory (LSTM) model to predict the scores of each project in the next three years (2028, 2032, and 2036). LSTM is a special type of Recurrent Neural Network (RNN) that can effectively capture long-term dependencies in time series data, especially for tasks where we need to predict future score trends from historical data after statistical calculations^[7].

LSTM is a kind of neural network with memory ability. By introducing gate control unit (including input gate, forget gate and output gate), it can effectively solve the problem of gradient disappearance and gradient explosion in traditional RNN. At the heart of LSTM is the cell state and a series of gating mechanisms that together determine the retention and discarding of information to better capture long-term dependencies in time series.

5.2. Data Processing

To use LSTM model to predict future scores, we firstly processed the data with following steps:

1. Data collection and collation: We collected the scores of some SDEs over the past few years and organized the data into a time series format.
2. Data standardization: In order to speed up model training and improve convergence, we standardized the data and scaled each indicator value to the range [0, 1].
3. Time series data set construction: The input sample is constructed using the sliding window method with time step of 2, that is, the data of the past two terms is used to predict the future score situation.

The form of the constructed sample set is as follows:

$$X = \{x_{t-2}, x_{t-1}\}, y = x_t$$

where X represents input data, y represents the corresponding output target.

5.3. Model building

We constructed a LSTM model, details are below:

1. Input layer: The time step is 2, and the input dimension is the number of features of the historical data.
2. LSTM Layer: An LSTM layer with 50 cells to capture time dependencies.
3. Fully connected layer: A dense layer used to generate predicted values for future scores with an output dimension equal to the number of target features.
4. Activation function and loss function: The model uses Mean Squared Error (MSE) as the loss function, and the optimizer is Adam.

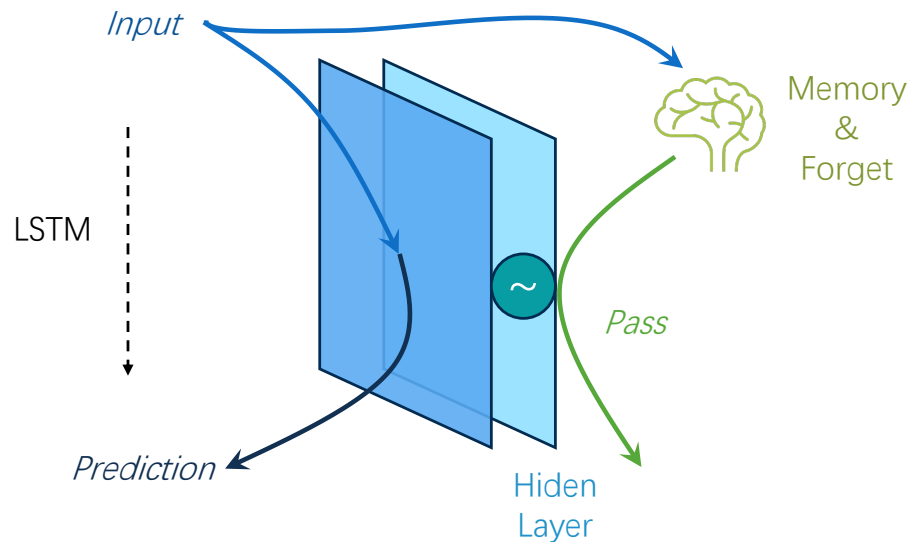


Figure 1: Mechanism of LSTM Model

5.4. Training of the model and verification

During training, we divide the data into a training set and a set, and the model optimizes the parameters by minimizing the loss function on the validation set. The model training process consists of the following steps:

1. Data input: Input the standardized time series data into the LSTM model.
2. Backpropagation and weight update: The Adam optimizer is used to update the model parameters.
3. Early Stop Strategy: Set a certain number of training sessions (e.g. 100 rounds) and monitor losses on the verification set to prevent overfitting.

5.5. Prediction and Result

After the model training was completed, we used the data from the past two sessions as input to predict the scores of each project in 2028, 2032 and 2036. The prediction steps are as follows:

1. Initial input: Use the last two known scores as input.
2. Recursive prediction: Recursive prediction is carried out through the LSTM model, that is, the result is used as a new input after each prediction to continue to predict the future score.
3. Anti-normalization: Inversely transform the predicted result from the standardized state to the actual score.

Finally, we got the predicted scores of each project in the next three sessions, and saved the summary results in the table for further analysis.

By applying the LSTM model, we successfully predicted the scores of each project in the next three sessions. Using historical trends in time series, the method captures complex time dependencies and provides a scientific basis for evaluating the future performance of each project.

6. Finding Events that Increase or Decrease

6.1. Selected Event for 2032 Olympics

As a result of our model evaluation, **cricket**, **e-sports**, and **mixed martial arts** were selected as the final events to participate in the 2032 Olympics. Here are our reasons and statistical analysis.

1.Cricket: According to the table, it was shown that in 2032, cricket had a high CRICKET score of 10.13577827, entropy score of 13.64651539 and aggregate score of 6.823257695. Cricket is very popular in commonwealth countries, especially Australia, and has been fitted for the Brisbane Olympics in 2032.

2. Mixed martial Arts (MMA): The mixed martial arts event in 2032's statistics (e.g. Ahp score 10.5915339, entropy score 10.40931914, overall score 5.20465957) also shows the potential of attractiveness and global participation in the event. The MMA integration could inject new vitality and diversity into the Olympics.

3. E-sports (esports): Especially given its attractiveness to young audiences and its global growth, e-sports' 2032 score (AHP score 11.36094929, entropy score 10.23194102, overall score 5.11597051) also showed significant potential. Including it in the Olympics helps attract a new generation of spectators and increase the modern feel of the event.

6.2. Recommend sorting

- Selection: Cricket - due to its high popularity and high rating in Australia.
- Second choice: Mixed Martial Arts (MMA)- Diversify the diversity of Olympic events to attract a diverse audience base.
- Third choice: e-sports (esports) – to attract young audiences and promote digitalization and innovation.

The selection of these events helped increase global interest in and attendance at the 2032 Brisbane Games.

For sports that have the potential to participate in the 2036 Olympics, we first calculate the scores of various sports using a model. Except for the world's popular sports, we introduce the following sports that we recognize as having the potential to participate in 2036.

1. Short track

- Overall score: 9.19
- Analysis: Short track has a lower aggregate score than popular sports, but it is analyzed as a potential candidate due to its global attractiveness and uniqueness. The technicality and visibility can attract more spectators, especially winter sports enthusiasts.

2. Freestyle skiing

- Overall rating: 23.95
- Analysis: Freestyle skiing received relatively high ratings and proved particularly popular with young spectators and extreme sports enthusiasts. It will increase its influence and participation in future Olympic Games.

3. Figure skating

- Overall score: 16.90 points
- Analysis: Figure skating has relatively high artistry and appreciability. Although it falls short of some core sports, the combination of artistry and athleticism is likely to attract more spectators and the attention of the Olympic Committee.

4. Shooting

- Overall score: 19.05
- Analysis: Shooting is a sport with a long history. Although the heat is relatively low, there are stable sponsors and performances in several countries, making it likely that it will be maintained or re-adopted at future Olympics.

5. Table tennis

- Overall rating: 8.60
- Analysis: Table tennis is a high participation sport around the world, especially in the Asian region. Even at a low valuation, the technology will be one of the options available at the 2036 Olympics.

According to the statistical table, these sports are currently less hot than mainstream sports, but they may have some potential at the 2036 Olympics. Future decisions could consider the global audience base, cultural adaptation and attractiveness of these sports as grounds for Olympic competition.

7. Model Stability and Ranking Consistency Analysis

7.1. Model Stability Analysis

In the interval of α from 0 to 1, we perform a comprehensive calculation and sensitivity analysis of the weights in steps of 0.1. As shown in the figure, the weight change is relatively stable in some specific intervals, especially when approaching the interval of $\alpha = 0.4$ to $\alpha = 0.6$, the overall weight change is the smallest. This shows that the model can maintain good stability in this interval, so that the adjustment of weights will not significantly affect the overall evaluation results.

7.2. Graphical analysis

In the bar chart of sensitivity analysis, we can see that the average total weight of Perturbed Element 1,2, 1,3 and other positions has the most obvious change, about 0.012, which indicates that these indicators have a great impact on the model results when the weight is adjusted. In contrast, the average total weight of elements such as 3,4, 4,5, and 5,6 changes less (about 0.004 to 0.006), indicating less sensitivity to the model output.

Table 17: AHP Sensitivity Analysis Results

Element	Factor	Original Weights	Weights	Total Weight Change
1,2	1.1	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.31, 0.20, 0.071, 0.11, 0.10, 0.13]	0.012
1,2	0.9	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.38, 0.20, 0.072, 0.11, 0.11, 0.13]	0.013
1,3	1.1	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.38, 0.20, 0.070, 0.11, 0.10, 0.13]	0.007
1,3	0.9	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.38, 0.19, 0.073, 0.11, 0.10, 0.13]	0.009
1,4	1.1	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.39, 0.20, 0.072, 0.11, 0.10, 0.13]	0.009
1,4	0.9	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.37, 0.20, 0.072, 0.11, 0.10, 0.13]	0.011
1,5	1.1	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	0.008
1,5	0.9	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	0.008
1,6	1.1	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.38, 0.20, 0.071, 0.11, 0.11, 0.13]	0.009
1,6	0.9	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.38, 0.20, 0.072, 0.11, 0.11, 0.13]	0.008
2,3	1.1	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.34, 0.20, 0.070, 0.11, 0.11, 0.13]	0.007
2,3	0.9	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.34, 0.20, 0.073, 0.11, 0.11, 0.13]	0.006
2,4	1.1	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.38, 0.20, 0.073, 0.11, 0.11, 0.13]	0.006
2,4	0.9	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.38, 0.20, 0.073, 0.11, 0.11, 0.13]	0.006
2,5	1.1	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.38, 0.20, 0.071, 0.11, 0.11, 0.13]	0.006
2,5	0.9	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.39, 0.20, 0.072, 0.11, 0.11, 0.13]	0.005
2,6	1.1	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.38, 0.20, 0.073, 0.11, 0.10, 0.13]	0.007
2,6	0.9	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.38, 0.20, 0.071, 0.11, 0.11, 0.13]	0.006
3,4	1.1	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.38, 0.20, 0.071, 0.11, 0.10, 0.13]	0.004
3,4	0.9	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	0.005
3,5	1.1	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.38, 0.20, 0.073, 0.11, 0.10, 0.13]	0.005
3,5	0.9	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	0.004
4,5	1.1	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.38, 0.20, 0.071, 0.11, 0.10, 0.13]	0.004
4,5	0.9	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.38, 0.20, 0.073, 0.11, 0.10, 0.13]	0.005
4,6	1.1	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	0.005
4,6	0.9	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.38, 0.20, 0.071, 0.11, 0.11, 0.13]	0.005
5,6	1.1	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	0.004
5,6	0.9	[0.38, 0.20, 0.072, 0.11, 0.10, 0.13]	[0.38, 0.20, 0.071, 0.11, 0.11, 0.13]	0.004

7.3. Ranking Consistency Analysis

In order to analyze ranking consistency under different α -values, we calculated the overall score and corresponding ranking under each α -value, and used Spearman rank correlation coefficients to evaluate the change in ranking. The results show that when α is in the range of 0.4 to 0.6, the ranking consistency maintains a high level, and the Spearman coefficient is close to 1, indicating that the ranking changes are small, and the model shows stability within this range.

7.4. Heat Map Display

In order to more intuitively show the impact of different α values on the ranking, we drew the ranking heat map. In the heat map, the ranking of each Olympic event under different α -values is represented by color, and the darker the color, the greater the change in ranking. It is observed that when α is between 0.4 and 0.6, the color change in the heat map is minimal, indicating that within this range, the ranking of the model changes less and the performance is the most stable.

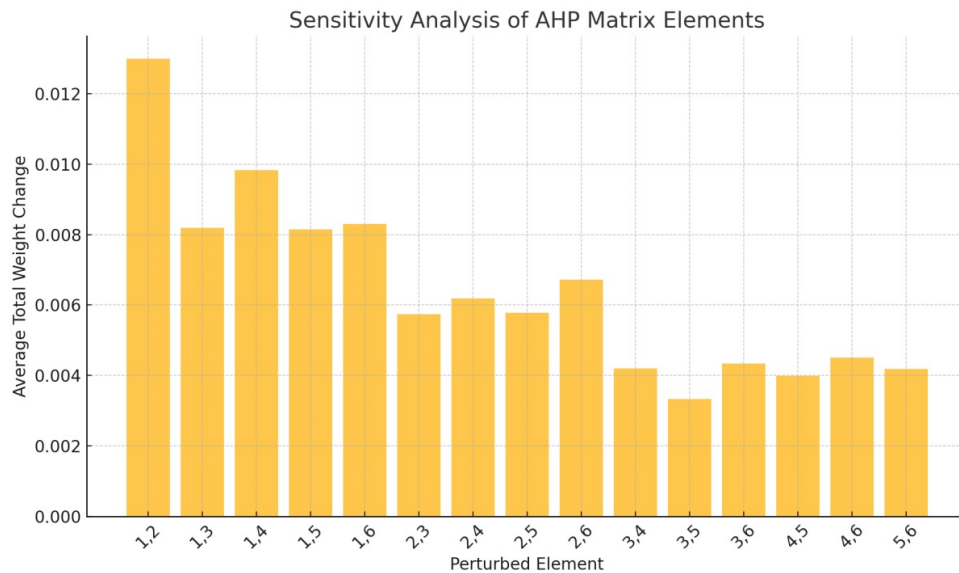


Figure 2: Sensitivity Analysis of AHP Matrix Elements

7.5. Selecting the Optimal α -Value

Based on the above analysis, we choose $\alpha = 0.5$ as the best combination parameter. This parameter achieves a good balance between AHP and entropy weight method, and ensures the stability and ranking consistency of the model during weight adjustment. In addition, combined with the graph and data from the sensitivity analysis, we verify that the model shows a high robustness to changes in input parameters when $\alpha = 0.5$.

References

- [1] Allen Guttmann. *The Olympics: A history of the modern games*. University of Illinois Press, 2002.
- [2] John M. Bryson, Barbara C. Crosby, and Laura Bloomberg. *Introduction*, pages xvii–xxvi. Georgetown University Press, 2015.
- [3] Barry Borgan and Trevor Mules. Economic impact of sporting events. *Annals of Tourism Research*, 19(4):700–710, 1992.
- [4] Lincoln Allison and Terry Monnington. Sport, prestige and international relations. *Government and Opposition*, 37(1):106–134, 2002.
- [5] T.L. Saaty and K. Peniwati. *Group Decision Making: Drawing Out and Reconciling Differences*. RWS Publications, 2013.
- [6] Xinwei Gao and Ruichao An. Research on the coordinated development capacity of china’s hydrogen energy industry chain. *Journal of Cleaner Production*, 377:134177, 2022.
- [7] Alex Graves and Alex Graves. Long short-term memory. *Supervised sequence labelling with recurrent neural networks*, pages 37–45, 2012.

Report on Use of AI

1. OpenAI ChatGPT (Nov 16, 2024 version, ChatGPT-4o)

Query1: What aspects and factors should be considered when selecting new and removed events for the next Olympic Games?

Output: When choosing events to add or remove for the next Olympic Games, several key aspects and factors should be evaluated comprehensively:

Major Aspects and Relevant Factors:

1. Popularity and Accessibility of the Event - Global Participation: The extent of the sport's popularity worldwide, including how many countries and regions have athletes participating. - Audience Appeal: Whether the event attracts a large audience and generates widespread attention and viewership. - Infrastructure Cost: The ease of constructing necessary infrastructure and the associated costs. - Accessibility: The feasibility of promoting the sport in more countries and regions, ensuring widespread participation.
2. Gender Equality - Equal Participation Opportunities: Whether the sport offers equal competition opportunities for male and female athletes. - Gender Event Distribution: Whether the event setup reflects gender balance, ensuring both men and women have similar competitive experiences.
3. Sustainability - Environmental Impact: The sport's compliance with environmental standards, including its impact on resources, carbon emissions, and other factors. - Social Responsibility: Whether the sport promotes social responsibility, such as sustainable development and public welfare.
4. Inclusiveness - Cultural Representation: Whether the sport reflects cultural diversity and represents multiple cultures around the world. - Globalization Level: Whether the sport is practiced widely in at least 75 countries across four continents, demonstrating global inclusiveness.
5. Relevance and Innovation - Appeal to Young Audiences: Whether the sport attracts young viewers and includes contemporary elements. - Reflects Modern Trends: Whether the sport aligns with current cultural or societal trends. - Technological and Innovative Integration: Whether the sport incorporates elements of technology, such as innovative combinations of virtual and physical components.
6. Safety and Fair Competition - Athlete Protection: Whether the sport ensures the safety of athletes and minimizes the risk of injuries. - Fair Competition and Anti-Doping Standards: Whether the sport adheres to standards of fair competition and has comprehensive anti-doping rules and monitoring mechanisms.

By comprehensively evaluating these aspects, the Olympic Games can select events that better reflect contemporary Olympic values, embrace global trends, and meet audience interests and expectations.

2. OpenAI ChatGPT (Nov 16, 2024 version, ChatGPT-4o)

Query1: Can you find papers online about indicators for evaluating sports projects?

Output: Establishing a scientific and reasonable indicator system is crucial when evaluating sports projects. Here are some studies on evaluation indicators for sports projects for your reference:

1. Research on the Comprehensive Benefit Indicator System and Quantitative Analysis Methods of Sports Events: This study explores the basic principles and basis for evaluating the benefits of sports events, constructing a suitable indicator system and method for comprehensive benefit evaluation.
2. Performance Evaluation of Public Sports Services: Indicator System Construction and Scoring Calculation Methods: This study builds an indicator system for evaluating the performance of public sports services, covering aspects such as service efficiency, public satisfaction, and service investment, and explores scoring methods.
3. Performance Evaluation Indicator System for Sports Venue PPP Projects: This research proposes a "3E+P" theoretical framework for evaluating the performance of PPP sports venue projects and constructs a performance evaluation indicator framework for such projects in China.
4. Construction and Empirical Study of a Global City Sports Industry Development Evaluation Indicator System: This study uses the Delphi method to survey experts in the sports industry, building an evaluation indicator system for the development of the global sports industry.
5. Research on the Construction of a Performance Evaluation Indicator System for Sports Events Based on the Balanced Scorecard (BSC): This study introduces the balanced scorecard (BSC) into sports event performance evaluation, proposing a system that encompasses financial, customer, internal processes, learning and growth, social, and environmental dimensions.

These studies provide a theoretical basis and practical reference for constructing an evaluation indicator system for sports projects. You can delve deeper into relevant literature based on your specific needs.

3. OpenAI ChatGPT (Nov 18, 2024 version, ChatGPT-4o)

Query1: What is the general process for using LSTM for time series prediction?

Output: When using LSTM for time series prediction, especially for multiple projects and indicators, the modeling and prediction process typically follows these steps:

1. Data Preparation - Data Format Adjustment: Ensure your data is arranged chronologically. Data for each project's indicators across different years can be treated as a time series. Format the data as a 3D matrix suitable for LSTM, usually [number of samples, time steps, number of features]. - Normalization: LSTM is sensitive to data scales, so

you should standardize each indicator using common methods like Z-score normalization (zero mean, unit variance) or Min-Max scaling.

2. Constructing the LSTM Model - Input Format: Each time step input includes past data points to predict future values. For example, if predicting values for upcoming years, use past years' data as input. - Target Output: The target output is future data. For example, predicting data for 2028, 2032, 2036 would require your model to predict these years based on past inputs. - Basic Model Structure: - Input Layer: Shape as (time steps, number of features). - LSTM Layers: One or more layers to capture temporal dependencies. - Output Layer: Depending on prediction targets, can be a single or multiple predicted values.

3. Data Splitting - Training and Testing Sets: Split the data into training and testing sets. Usually, recent data serves as the testing set, while earlier data forms the training set.

4. LSTM Model Training - Train using the training set. Select appropriate loss functions (e.g., Mean Squared Error) and optimizers (e.g., Adam). - Adjust hyperparameters such as the number of LSTM units, time steps, and learning rate to find the best model.

5. Predicting Future Data - Once trained, input historical data to predict future values. - When predicting multiple future periods, consider using a step-by-step approach, where each prediction becomes input for subsequent predictions.

6. Evaluating Model Performance - Evaluate accuracy using metrics such as RMSE (Root Mean Square Error) and MAE (Mean Absolute Error). - Adjust the model structure, add layers, or refine inputs if results are unsatisfactory.

7. Model Optimization - Hyperparameter Tuning: Use methods like cross-validation or grid search. - Handling Seasonality: Add seasonal features during data preprocessing or use multi-step LSTM training.