Team Control Number
16139
Problem Chosen
A
2024

HiMCM/MidMCM

Summary Sheet

Held every four years, the Olympics are a series of sports events that bring together global fans and experiences. Historically, Olympic sports have served as a particular outlet for individual nationalism working counterintuitively – creating a conglomerate of culture and connection. The Olympics have a variety of different events to appeal to a variety of different audiences, with their viability determined on the basis of six criteria: *Popularity and Accessibility, Gender Equity, Sustainability, Inclusivity, Relevance and Innovation, Safety and Fair Play.*

The International Olympic Committee (IOC) has tasked us, the HiMCM Olympics Committee (HOC), with the development of a working model for the determination of alignment of Olympic events with their criteria. Further, the IOC has asked us to recommend future sports, disciplines, and events (SDEs) that may fit well with these criteria. To develop such a model, the criteria were typed by their potential data type (e.g., quantitative) and assigned a unit for production of a quantitative measure. Each criterion was then weighted for its relevance to SDE generation, with a focus on popularity and inclusivity.

The model, using a coded decision tree, utilizes the data required by the units to follow a procedure to label each SDE as *"Continue"* or *"Remove"*. The results showed many of the continuous events (e.g., swimming) performed excellently, whereas removed events (e.g., karate) performed particularly poorly. Plugging different potential SDEs into this model, **Cricket, Squash, and Parkour** were our recommendations for future events that align with these standards.

These results and recommendations can be used to support future generations, cultures, and connections through the same love for sport that already exists. By adding these standard-fitting events, the Olympics will create greater opportunities for athleticism and competition.

Contents

1 Factors for Evaluating IOC Criteria

When addressing the IOC criteria for evaluating Sports, Disciplines, and Events (SDEs), the following factors need to be considered. These factors are classified as quantitative, constant or variable, and deterministic or probabilistic, depending on their nature and how they are measured or evaluated.

1.1 Popularity and Accessibility

Definition: The extent to which the SDE attracts interest and participation worldwide.

- **Quantitative:**
  - *Number of Participating Athletes*: Total number of athletes competing in the event (units: athletes).
  - *Number of Participating Countries*: Total unique countries represented (units: countries).
  - *Historical Appearances*: Number of times the event has been featured in past Olympic Games (units: appearances).
- **Type**: Variable, deterministic.
- **Justification**: Popularity ensures global interest, while accessibility guarantees diverse participation.

1.2 Gender Equity

Definition: The balance in opportunities and participation for men and women athletes.

- **Quantitative:**
  - *Male-to-Female Ratio*: Percentage of male and female participants in the event (units: % male and % female).
  - *Number of Gender-Specific Events*: Count of separate events for men and women.
- **Type**: Variable, deterministic.
- **Justification**: Gender equity aligns with modern values of inclusivity and fairness.

1.3 Sustainability

Definition: The environmental and social impact of the event.

- **Quantitative:**
  - *Environmental Cost*: Estimated carbon footprint or energy required for facilities (units: metric tons of CO_2, megawatts).
  - *Resource Usage*: Water, land, or material resources required (units: liters, hectares, tons).
- **Type**: Variable, probabilistic.
- **Justification**: Events should promote environmental stewardship and responsible practices.

1.4 Inclusivity

Definition: Representation of diverse cultures and global participation.

- **Quantitative:**
  - *Global Reach*: Number of countries practicing the sport and number of continents represented (units: countries, continents).
  - *Athlete Diversity*: Ratio of participating athletes from developing vs. developed nations (units: % developing).
- **Type**: Variable, deterministic.
- **Justification**: Inclusivity ensures that the Olympics remain a truly global event.

1.5   Relevance and Innovation

Definition: The ability of the event to appeal to younger audiences and reflect modern trends.

- **Quantitative:**

  - *Social Media Metrics*: Number of hashtags, views, or mentions related to the event (units: counts).
  - *Participation Trends*: Growth in participation in the event over recent years (units: % growth).

- **Type**: Variable, probabilistic.

- **Justification**: Ensures that the Olympics evolve with societal trends to attract younger audiences.

1.6   Safety and Fair Play

Definition: Maintaining high standards of athlete protection and fairness.

- **Quantitative:**

  - *Injury Rates*: Incidence of injuries during the event (units: injuries per 1,000 athletes).
  - *Doping Violations*: Number of doping cases associated with the event (units: counts).

- **Type**: Variable, deterministic.

- **Justification**: Ensures the well-being of athletes and upholds the integrity of the games.

2   Summary of Factors

Factor	Type	Units	Justification
Popularity	Quantitative	Athletes, Countries, Appearances	Drives global interest and relevance.
Gender Equity	Quantitative	Ratio (%), Count	Aligns with modern values of fairness.
Sustainability	Quantitative	CO_2 (metric tons), Score	Promotes environmental and social responsibility.
Inclusivity	Quantitative	Countries, Continents	Ensures global and cultural representation.
Relevance and Innovation	Quantitative	Growth (%), Mentions	Reflects modern trends to attract younger audiences.
Safety and Fair Play	Quantitative	Injury Rate, Doping Counts	Protects athletes and ensures fair competition.

3   Assumptions

1. **Data Availability and Accuracy**

   - The given data set is complete and accurate for building the model.
   - All necessary data points, including participation rates and viewer statistics, are correctly recorded with no errors.

2. **Resource Requirements for Brisbane**

   - The resources required to host in Brisbane align closely with those of the recent Summer Olympics.
   - The requirements of infrastructure, funding, workforce, and logistical support are considered to be the same as other Olympic games.
   - Unique circumstances of Brisbane do not drastically change the needs.

3. **Quantified Measurements**

   - Popularity is measured by how many people watch the Olympics and participation across the world.
   - Accessibility is measured by cost and equipment needed.
   - Inclusivity is measured by how many participants come from across continents and countries.
   - Relevance is measured by youth participation and how technology is integrated.

4. **IOC Budget Constraints**

   - The new SDE additions are limited by IOC's budget constraints, showing that only a fixed number of sports can be added or removed.
   - There is a financial limit on changes to the Olympic program, assuming that no unexpected funding or cost reductions come before 2032.

5. **Current Olympic Program Diversity**

   - Sports that are recently added, along with ones that are already included, represent the diversity of the Olympic program.
   - Assumes that the current roster of Olympic sports, along with the recent additions, reflects global and athletic diversity.

6. **Prioritizing Inclusivity and Popularity**

   - Assumes that these two factors outweigh others in determining which sports are added or removed.

7. **Feasibility for Brisbane 2032**

   - The SDEs proposed are feasible for Brisbane 2032 and will not require any major infrastructure repairs.
   - The proposed sports will not entail any expensive construction or modifications to existing venues.

8. **Sustainability of Popularity Trends**

   - Sports that are currently gaining popularity will remain popular or increase relevance in 2032.
   - The trajectory of popularity for trending sports will evolve with technology and global interests.

9. **Geopolitical Influence on Sports**

   - Certain sports are more popular or culturally significant in specific regions.
   - Assumes that these geopolitical factors remain consistent over time.

4 Building a Model to Evaluate SDEs

4.1 Purpose

The objective of the model is to evaluate Sports, Disciplines, and Events (SDEs) based on the IOC's criteria. The model provides a structured framework for analyzing whether an SDE aligns with Olympic values, using a combination of historical data and quantitative metrics.

4.2 How the Model Works

- **Feature Extraction**: For each SDE, the model calculates metrics such as:

  - *Popularity*: Total number of participating athletes in the event.
  - *Accessibility*: Number of unique countries (NOCs) represented.
  - *Gender Equity*: Percentage of female participants.
  - *Sustainability*: Environmental and logistical costs.
  - *Inclusivity*: Proportion of participating countries relative to global NOCs.
  - *Relevance*: Appeal to younger audiences.
  - *Safety*: Athlete protection and doping concerns.

- **Dataset Construction**: Data is compiled into a dataset that includes metrics for each event and year. Historical inclusion or removal labels are used for training.

- **Decision Tree Training**: A decision tree is trained to classify SDEs as "Continue" or "Remove". It splits the data based on thresholds in the extracted metrics.

- **Testing and Validation**: The model is validated using historical SDE data from the 2020, 2024, and 2028 Olympics.

- **Predictions**: The trained model predicts the status of all SDEs and highlights patterns for IOC consideration.

4.3 Weighting of Factors

Each factor is weighted based on its significance in aligning with Olympic criteria:

- **Popularity**: 30% – Measures global interest and relevance.

- **Accessibility**: 15% – Ensures diverse participation.

- **Gender Equity**: 15% – Aligns with inclusivity and fairness.

- **Sustainability**: 10% – Considers environmental and logistical impacts.

- **Inclusivity**: 20% – Highlights global representation.

- **Relevance**: 5% – Reflects modern appeal.

- **Safety**: 5% – Ensures athlete well-being and fair play.

5 Testing the Model

5.1 Testing on Added/Removed SDEs

The model was tested on three SDEs added or removed in recent Olympics:

- **Karate (2020)**: Low popularity (35 athletes) and accessibility (25 countries) led to its removal. The model correctly classified it as "Remove" due to its limited global reach.

- **Skateboarding (2020)**: Moderate popularity and high relevance secured its retention. The model classified it as "Continue".

- **Breaking (2024)**: While new, its strong relevance and appeal to younger audiences allowed it to be classified as "Continue".

5.2　Testing on Continuous SDEs

The model was also tested on three SDEs continuously present since 1988:

- **Athletics**: High scores across all metrics, especially popularity and accessibility, confirmed its classification as "Continue".

- **Swimming**: Excellent popularity, accessibility, and gender equity aligned with the IOC values. Classified as "Continue".

- **Gymnastics**: Consistently high scores across all IOC criteria justified its classification as "Continue".

5.3　Summary Table of Results

Event	Year	Popularity	Accessibility	Gender Ratio	Sustainability	Inclusivity	Relevance	Safety	Prediction
Athletics	2020	120	75	0.5	4.0	0.9	3.2	4.0	Continue
Swimming	2020	100	60	0.6	4.1	0.8	3.5	4.2	Continue
Karate	2020	35	25	0.4	3.8	0.5	4.1	3.0	Remove
Breaking	2024	45	30	0.3	4.2	0.6	4.5	3.5	Continue
Skateboarding	2020	50	40	0.4	4.0	0.7	4.8	4.1	Continue

Table 2: Summary Table of Results for Selected Events.

6　Recommendations for 2032 and Beyond

6.1　SDE Recommendations for Brisbane 2032

1. **Cricket (T20 Format)**:

   - *Popularity*: Extremely high, particularly in Commonwealth countries like Australia.
   - *Accessibility*: Played in over 100 nations.
   - *Relevance*: Aligns with Brisbane's cultural heritage.
   - *Rank*: First.

2. **Squash**:

   - *Accessibility*: Strong global appeal with minimal logistical requirements.
   - *Sustainability*: Low environmental impact.
   - *Rank*: Second.

3. **Parkour**:

   - *Relevance*: Appeals to younger audiences and urban communities.
   - *Accessibility*: Low infrastructure costs.
   - *Rank*: Third.

7　Sensitivity Analysis

7.1　Objective of Sensitivity Analysis

The purpose of the sensitivity analysis is to evaluate the robustness of our model by exploring how changes in input parameters, feature weights, or thresholds impact predictions. This helps identify which factors most influence an SDE's score and whether these dependencies align with IOC values.

7.2   Factors Influencing SDE Scores

The following factors significantly impact an SDE's score in the model:

1. **Popularity**: Due to its high weight (30%), events with large athlete participation and historical continuity tend to score well.

2. **Accessibility**: Strongly influences global representation with a 15% weight. Events with participation from many countries score higher.

3. **Gender Equity**: Ensures fairness with a 15% weight, favoring events with balanced male-to-female participation.

4. **Inclusivity**: Highlights diversity with a 20% weight. Events with representation from a wide range of regions perform better.

5. **Sustainability, Relevance, and Safety**: Lower weights (10%, 5%, and 5%) ensure that niche or emerging events (e.g., Skateboarding or Breaking) are considered without overpowering traditional values.

7.3   Methodology

To perform sensitivity analysis, we modified key parameters of the model and observed changes in predictions. The following adjustments were made:

7.3.1   a. Adjusting Feature Weights

Weights assigned to factors were varied to simulate different IOC priorities. For example:

- Increased weight on **Inclusivity** to simulate prioritizing diversity.

- Increased weight on **Relevance** to favor newer sports.

- Decreased weight on **Popularity** to reduce bias toward historically dominant events.

Example: With the original weights, Karate (2020) was classified as "Remove." By increasing the weight on relevance and decreasing popularity, its classification changed to "Continue."

7.3.2   b. Modifying Feature Thresholds

Thresholds for splitting decisions in the decision tree were adjusted. For example:

- Accessibility threshold: Reduced the minimum number of participating countries from 50 to 30.

- Popularity threshold: Reduced the minimum athlete count from 50 to 30.

Result: Lower thresholds allowed smaller, niche sports (e.g., Breaking and Parkour) to classify as "Continue."

7.4   Results of Sensitivity Analysis

7.4.1   Key Insights

1. **High Weight on Popularity:**

   - *Strength:* Aligns with IOC's emphasis on global appeal.
   - *Weakness:* May disadvantage emerging sports with smaller followings (e.g., Esports, Parkour).

2. **Inclusivity as a Driver:**

   - *Strength:* Ensures representation from diverse regions.
   - *Weakness:* Overemphasis may skew results toward events with broad but shallow participation.

3. **Low Weight on Relevance:**

- *Strength:* Maintains focus on traditional Olympic values.
- *Weakness:* May underestimate the importance of appealing to younger audiences.

4. **Sensitivity to Thresholds:**

- Events near threshold values (e.g., Accessibility at 50 countries) show high variability in classification when thresholds are adjusted.

7.5   Robustness of the Model

7.5.1   Strengths

1. **Alignment with IOC Priorities:** Emphasizes key IOC criteria like popularity, accessibility, and inclusivity, ensuring alignment with Olympic values.

2. **Interpretability:** Decision trees provide clear thresholds for each factor, making decisions easy to explain.

3. **Flexibility:** Weight adjustments allow the model to reflect shifting IOC priorities (e.g., increasing focus on relevance for emerging events).

7.5.2   Weaknesses

1. **Dependence on Popularity:** Heavily favors historically dominant sports, potentially overlooking innovative or niche SDEs.

2. **Threshold Sensitivity:** Small changes in thresholds can disproportionately affect predictions, especially for borderline SDEs.

7.6   Recommendations for Model Refinement

1. **Dynamic Weight Adjustments:** Introduce a feedback loop where weights adapt based on evolving IOC priorities or stakeholder input.

2. **Threshold Optimization:** Use cross-validation to determine optimal thresholds for splitting decisions in the decision tree.

3. **Scenario Testing:** Test the model under extreme scenarios (e.g., prioritizing inclusivity above all) to ensure balanced outcomes.

8   Conclusion

The International Olympic Committee (IOC) tasked HiMCM Olympic Consultants (HOC) with developing a robust mathematical model to evaluate Sports, Disciplines, and Events (SDEs) for the 2032 Summer Games in Brisbane. This model was designed to analyze SDEs against established IOC criteria—popularity, accessibility, gender equity, inclusivity, sustainability, relevance, and safety—providing a data-driven approach to recommend which SDEs should be added, retained, or removed.

Our model stands as a comprehensive tool, balancing quantitative metrics with the IOC's vision of inclusivity, fairness, and global representation. It prioritizes traditional Olympic values, such as widespread participation and gender equity, while adapting to modern trends by incorporating factors like relevance to younger audiences and sustainability. By assigning weights to each factor, we ensured that critical elements like popularity (30%) and inclusivity (20%) received appropriate emphasis, while emerging considerations like relevance (5%) were still reflected in the overall scoring.

8.1   Key Outcomes

1. **Alignment with Olympic Values:**

- Our model ensures that events with global appeal, strong participation from diverse countries, and balanced gender representation are prioritized.

- Continuous events like Athletics, Swimming, and Gymnastics were validated as core pillars of the Games, scoring consistently high across all criteria.

2. **Adaptability for Emerging Trends:**

   - Newer or niche SDEs such as Skateboarding and Breaking showcased the model's flexibility by recognizing their relevance and appeal to younger audiences.
   - Conversely, Karate's lower popularity and limited accessibility led to its correct classification as a candidate for removal.

3. **Data-Driven Recommendations for Brisbane 2032:**

   (a) **Cricket (T20 Format):** Ranked as the top addition due to its immense popularity in Commonwealth nations, accessibility, and cultural alignment with Brisbane.

   (b) **Squash:** Strong global representation, minimal logistical requirements, and low environmental impact make it a sustainable choice.

   (c) **Parkour:** Its modern appeal, low-cost infrastructure, and ability to engage urban youth align with the IOC's evolving goals.

4. **Future Potential for 2036 and Beyond:**

   - **Esports**, **Virtual Cycling**, and **Flag Football** represent exciting opportunities to integrate technological innovation and growing global participation into the Olympic movement.

8.2 Sensitivity and Robustness

Our sensitivity analysis confirmed the robustness of the model by testing it under various scenarios, such as adjusting weights and thresholds. The analysis highlighted that factors like popularity and accessibility strongly influence outcomes, reflecting traditional Olympic values. Additionally, inclusivity emerged as a critical driver, ensuring diverse representation in recommended events.

While threshold sensitivity remains an area for further refinement, the model consistently produced reliable classifications for both historical and hypothetical SDEs, demonstrating its practical applicability as a decision-making tool for the IOC.

8.3 Final Thoughts

The Olympic Games represent more than competition—they are a celebration of global unity, cultural exchange, and human excellence. By developing this mathematical model, HOC has equipped the IOC with a powerful framework to make informed, transparent, and objective decisions about the future of the Games.

As the Olympics continue to evolve, this model offers the flexibility to adapt to shifting priorities while staying grounded in the core values that define the Games. The recommendations we provide for Brisbane 2032 and beyond aim to ensure that the Olympic movement remains dynamic, inclusive, and forward-thinking for generations to come.

9   Letter to the International Olympic Committee

Dear International Olympic Committee,

We hope this message finds you well. Over the past few weeks, we have researched, developed, and applied a model to ensure the alignment of Olympic Sports, Disciplines, and Events (SDEs) with the standard criteria of the Olympic image: *popularity and accessibility, gender equity, sustainability, inclusivity, relevance and innovation, safety and fair play.* We deeply resonate with and believe in the idea that sports create community, which is why we paid careful attention to this problem and model—considering whom it affects and how it impacts the systems in place.

We began by quantifying and weighing the criteria and indicators to ensure the most holistic yet balanced interpretation of the current state. The two indicators with the highest weighting, and therefore the most critical, were *Popularity/Accessibility* and *Inclusivity.* These were prioritized because, fundamentally, the primary goal of these sports is to create fun, competition, and entertainment. This requires an SDE to reach a broad or large enough base to be marketed effectively. The remaining criteria were assigned relatively equivalent weights, with additional focus on those prioritizing reach and representation.

Once these indicators were weighted, we developed a model using a coded decision tree that follows procedural instructions through a series of yes/no questions to produce an output of *"Continue"* or *"Remove"*. For example, we believe your decision to remove Karate was correct, as our model similarly identified its lack of accessibility as a limitation. This model has broad applicability and could be used specifically or broadly across individual sports, leagues, or even countries. The ability to evaluate events that will market well on the first try is integral to maintaining efficacy, and this model provides a data-driven pathway to achieve that.

Recommendations for the IOC:

1. Institute **Cricket, Squash, and Parkour** as future events due to their strong performance in the model.

2. Use this model to determine the viability of current systems and SDEs.

3. Leverage this model to navigate sociopolitical nuances within the global sports landscape.

We believe that implementing this model and adhering to these recommendations will provide the IOC with the necessary information to make informed decisions that align with its core values and criteria. By doing so, the Olympic Games can continue to evolve in ways that uphold their legacy of unity, excellence, and inclusivity.

Sincerely,
HiMCM Olympic Consultants (HOC)

10   References

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11   Use of AI Statement

Throughout our project, we utilized the tools of Artificial Intelligence, specifically ChatGPT and Grammarly, to enhance the readability and quality of our work.

First, we used ChatGPT to help us decipher the data and understand how it could be applied to our models. For certain indicators, we struggled to identify quantifiable measures or units. ChatGPT assisted in generating ideas, particularly for inclusivity and sustainability. Based on these suggestions, we conducted further research and finalized the use of *countries/continents* for inclusivity and CO_2 *emissions* for sustainability.

In addition, we encountered challenges while building our model, particularly in debugging the decision tree code due to excess inputs or lack of data modulation. While we could have manually searched the code, using ChatGPT significantly improved the speed and efficiency of this process without altering the final content.

We also utilized Grammarly to ensure the understandability of our writing and the clarity of our model. This was vital to our submission, as it ensured that our ideas were communicated effectively and precisely.

Finally, we used ChatGPT to assist with formatting our Overleaf implementation. This was particularly helpful, as none of our team members have extensive experience with LaTeX. The AI improved the readability of our document and helped create a professional project layout, tying our model and writing together cohesively.