IMMC: Global Sports League

South Korea | Korean Minjok Leadership Academy

Your team is invited to select a sport you are passionate about, develop a model that produces a fair and effective schedule for the GSL, and test how well your scheduling model adapts to changes in the league.

Problem Analysis

Your team is invited to select a sport you are passionate about, develop a model that produces a fair and effective schedule for the GSL, and test how well your scheduling model adapts to changes in the league.

Task 1.	Task 2.	Task 3.	Task 4.
Determine which sport and countries to be included in GSL	Develop an algorithm that takes multiple factors into account	According to the outline, Generate a schedule for GSL	Generalize the model for multiple sports. Add countries.

Overview

Assumptions and Justifications

1. Population under 15 represents the number of potential consumers
2. Spectators will make use of country's available infrastructure
3. EPI Scores will from 2024 will remain constant through 2025
4. Sporting event is held at the city with the largest population

Variables

Parameter	Symbol	Usage
Gini Coefficient	GC	Sports Selection
Expected Score	E_A	Matchmaking
Probability	p	Matchmaking
Shannon Entropy	H	Matchmaking
Arrival Plan	AP	Scheduling

Key Factors for Sports Selection

Possible Sports Pool

Team sports that have been a part of the Olympics

Factor 1.

Competitive Equity (Weighed)

Fosters high engagement, low entry barriers, and ensure long-term sustainability

Factor 2.

Global Popularity

Large fanbase makes the league popular and therefore more sustainable

Selected Sports

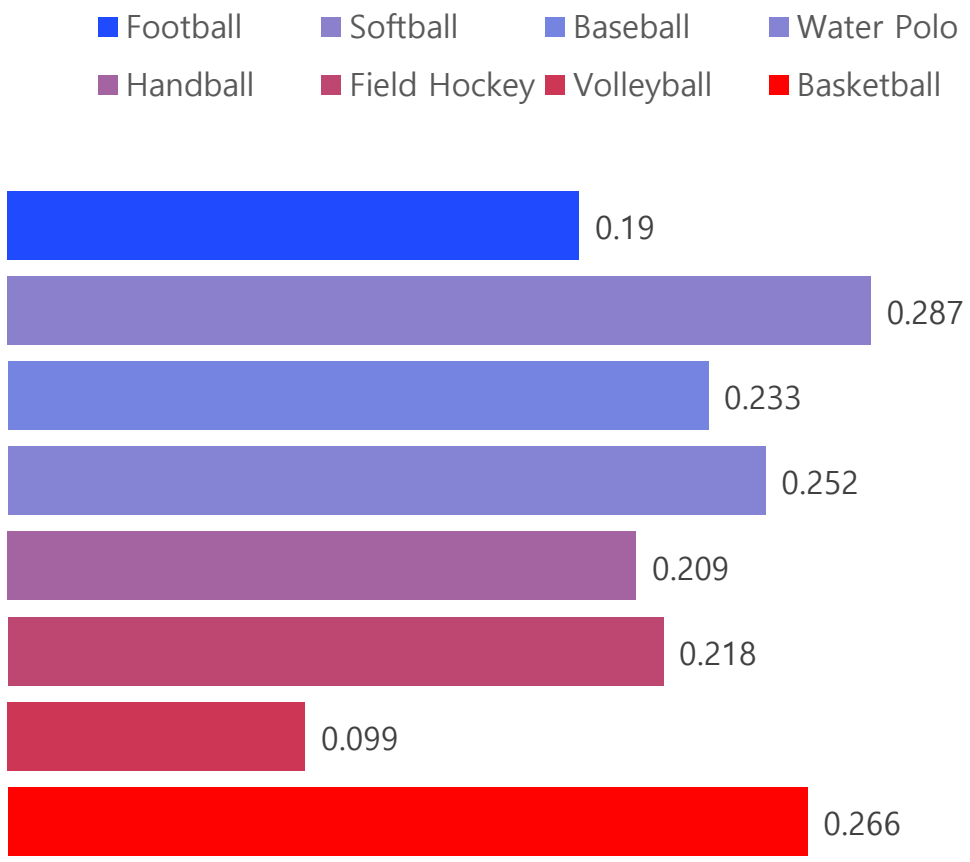
Competitive Equity

Competitive Equity Measured
by **Gini Coefficient**

$$GC = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N}|x_i - x_j|}{2N^2\bar{x}}$$

x_i and x_j are each team's winning probability
$\bar{x}$ is average winning percentage

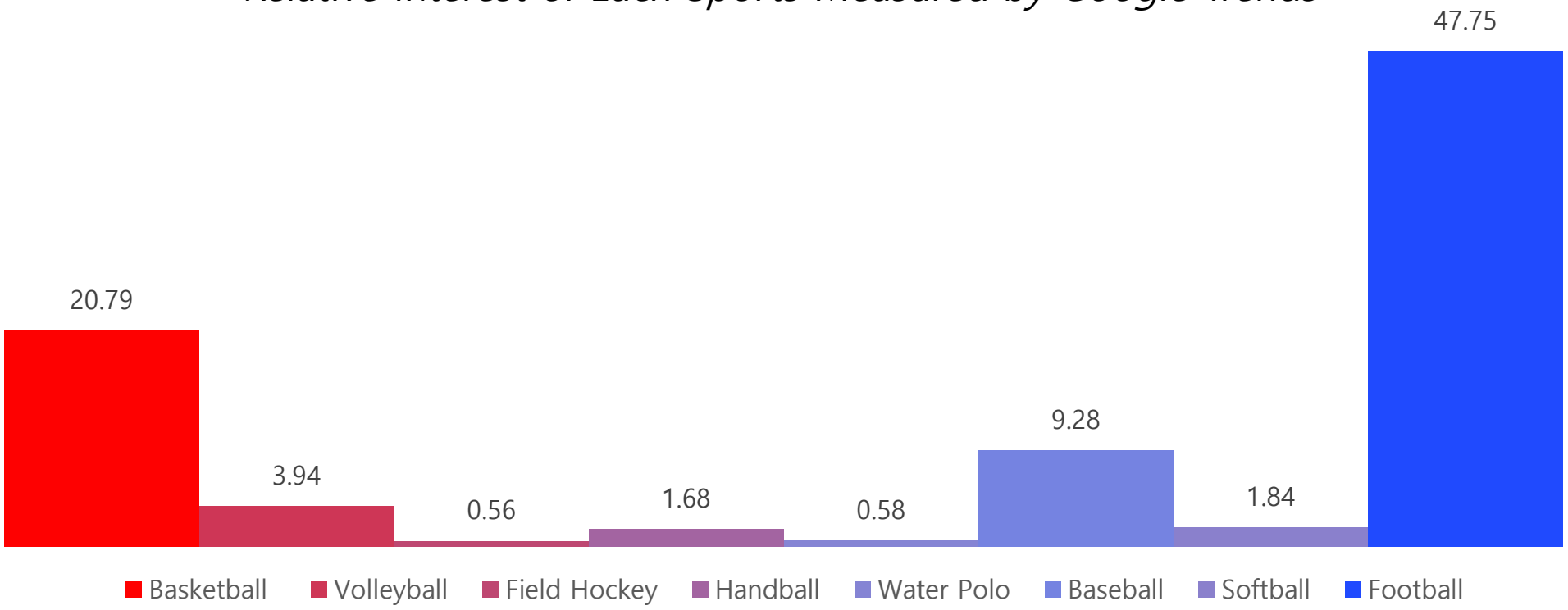
Lower Gini Coefficient → Better Equity



Competitive Equity

Global Popularity Measured by **Google Trends**

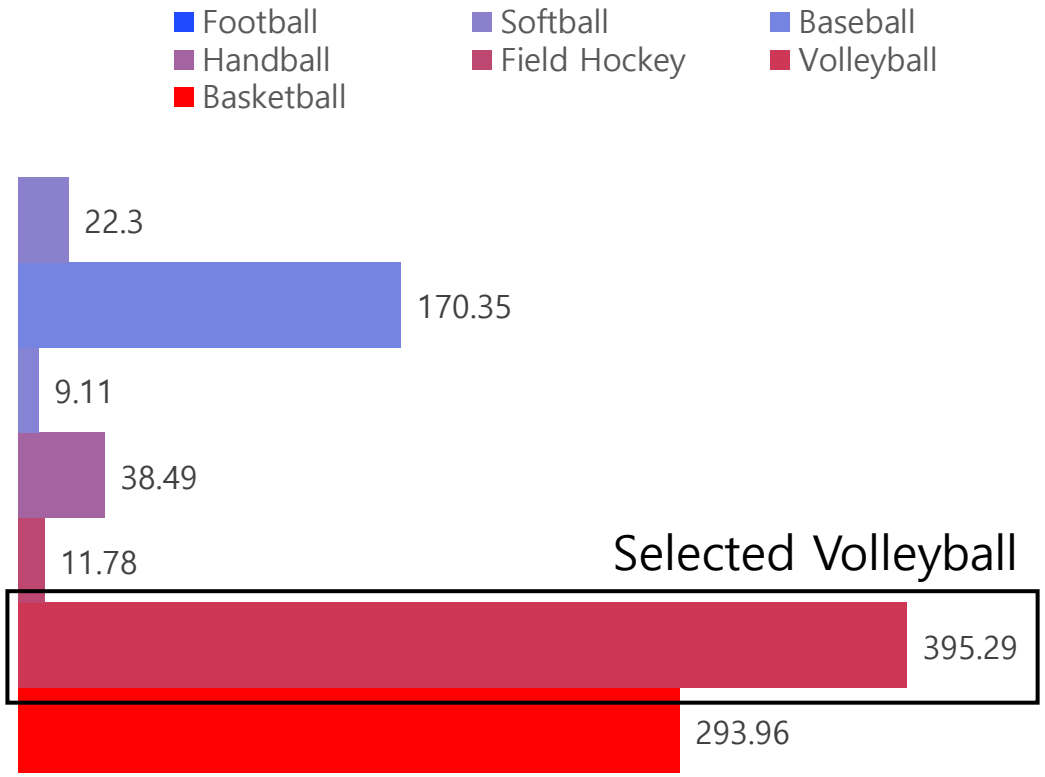
Relative Interest of Each Sports Measured by Google Trends



Sports Compatibility Score (SCS)

$$SCS = \frac{S_p}{GC^2}$$

When Calculated, Football had the highest SCS score of 1369. However, because the World Cup already exists in Football, we excluded it as our candidate for the GSL.



Team Selection

KEY Selection Criteria (Filter)

Stadium Infrastructure

Geographical Representation

Ranking Score (40%) → Competitive level (FIVB rankings)
Social Score (40%) → Future audience (population under 15)
Environmental Sustainability Score (20%) → EPI (Environmental Performance Index)
All data was scaled to **0-1 range (Min-Max Normalization)*

Sports Potential Profile (SPP)

$$SPP = 0.4S_{Ranking} + 0.4S_{Social} + 0.2S_{Environmental}$$

Name	SPP	Name	SPP	Name	SPP	Name	SPP	Name	SPP
France	0.6139	Brazil	0.5177	Cameroon	0.4800	Canada	0.4369	Iran	0.3953
Poland	0.6041	Germany	0.4992	Argentina	0.4760	Ivory Coast	0.4356	Pakistan	0.3927
USA	0.5743	Italy	0.4957	Egypt	0.4664	Netherlands	0.4088	Australia*	0.3328
Slovenia	0.5454	Japan	0.4919	Angola	0.4598	Cuba	0.4086	New Zealand*	0.2130

Countries with was not in Top 20 ranked by SPP, but was selected through geographical representation*

Entropy Based Interactive Matchmaking (E-BIMM)

"The Most Efficient Matchmaking by Gaining the Most Information per Match"

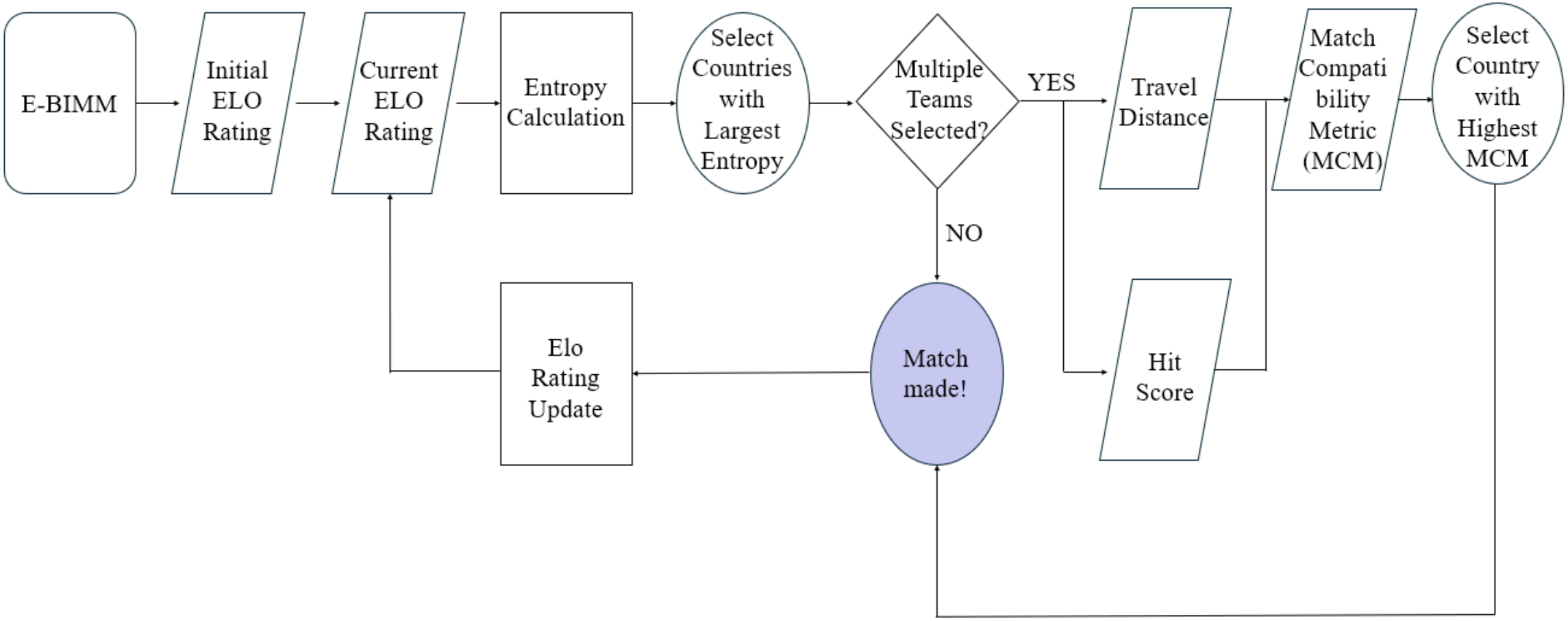
Probability of Winning Based on ELO Rating

$$p_w = \frac{1}{1 + 10^{\frac{R_B - R_A}{200}}}$$

Information Entropy

$$\mathrm{H} = -\sum_i p_i \log_2 p_i$$

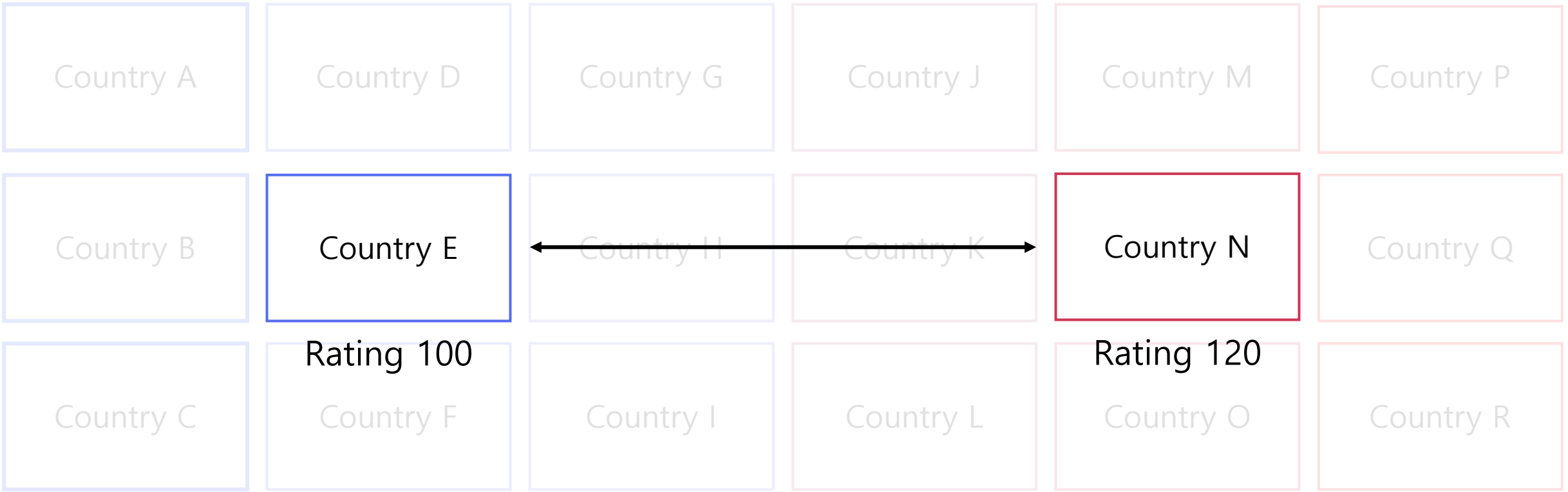
Modelling Layout



Priority Mechanism

Country A	Country D	Country G	Country J	Country M	Country P
Country B	Country E	Country H	Country K	Country N	Country Q
Country C	Country F	Country I	Country L	Country O	Country R

Priority Mechanism



Priority Mechanism

Country A | Country D | Country G | Country J | Country M | Country P

Country B | Country E | Country H | Country K | Country N | Country Q

Country C | Country F | Country I | Country L | Country O | Country R

WIN!!

$$p_{w,E} = \frac{1}{1 + 10^{\frac{R_N - R_E}{200}}}$$

Rating 100

Rating 120

$$p_{L,E} = \frac{1}{1 + 10^{\frac{R_E - R_N}{200}}}$$

LOSE!!

Priority Mechanism

Country A | Country D | Country G | Country J | Country M | Country P

Country B | Country E | Country H | Country K | Country N | Country Q

Country C | Country F | Country I | Country L | Country O | Country R

$$\mathrm{H} = -\sum_{i} p_i \log_2 p_i$$

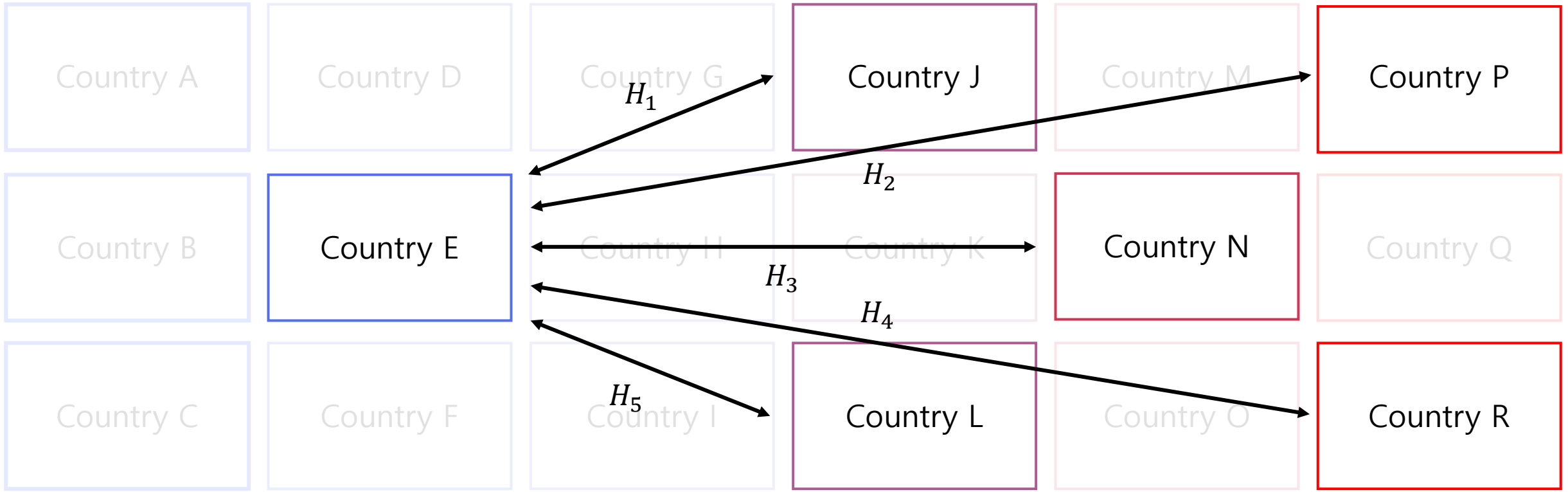
Entropy

Amount of Information We Can Get

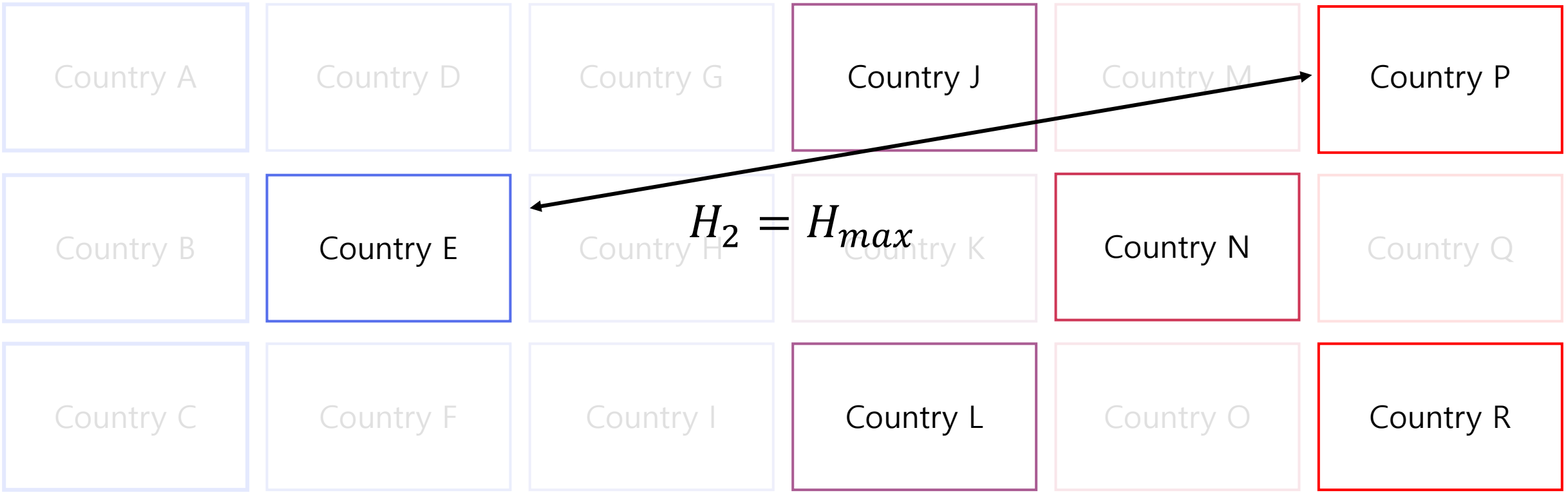
Rating 100

Rating 120

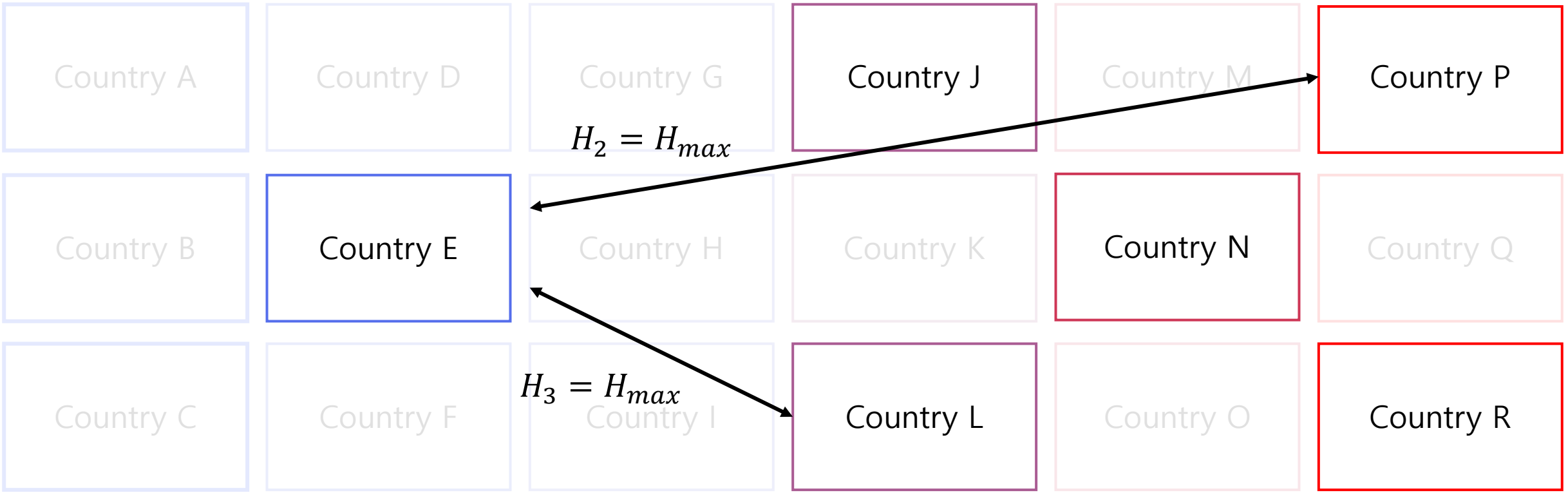
Priority Mechanism



Priority Mechanism



What If?


Country A
Country D
Country G
Country J
Country M
Country P
$H_2 = H_{max}$
Country B
Country E
Country H
Country K
Country N
Country Q
$H_3 = H_{max}$
Country C
Country F
Country I
Country L
Country O
Country R

Match Compatibility Metric (MCM)

Candidate Pool

Two Countries with the Same H-value

Factor 1.

Travel Time (*0.7 Weighed)

Fosters high engagement, low entry barriers, and ensure long-term sustainability

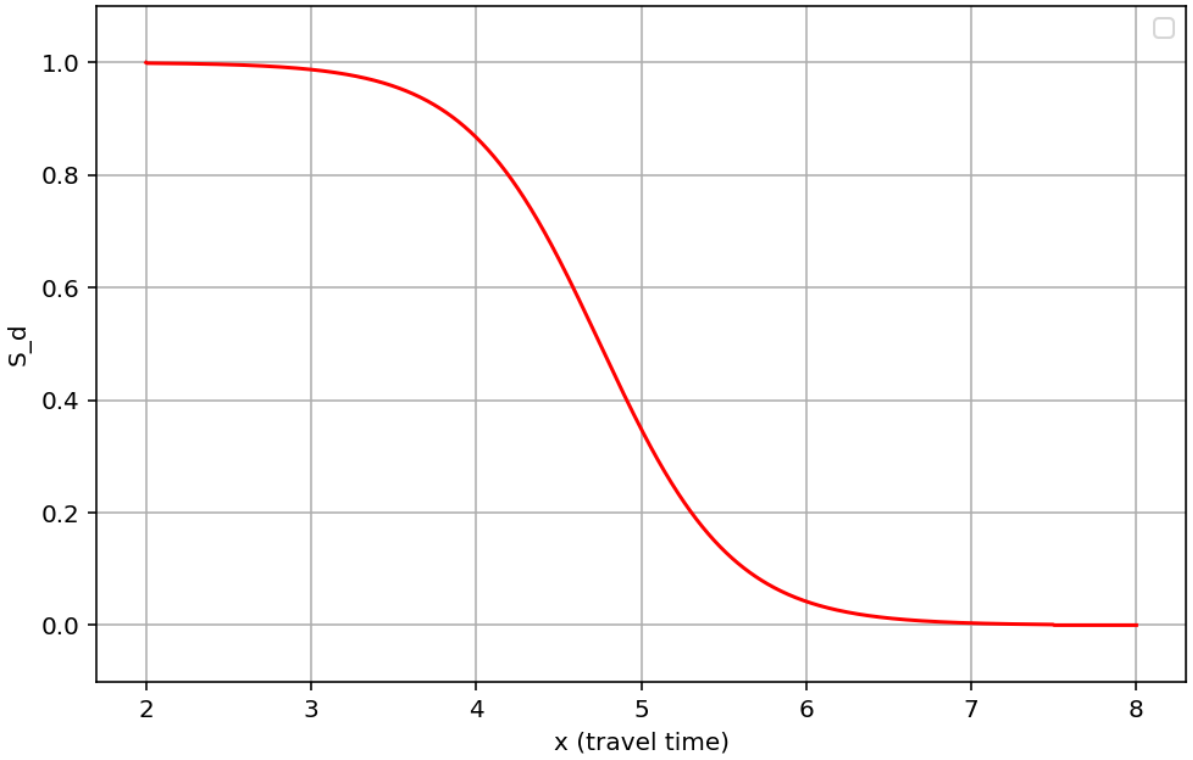
Factor 2.

Hit Score (*0.3 Weighed)

Large fanbase makes the league popular and therefore more sustainable

$$MCM = 0.7S_d + 0.3S_H$$

Travel Time in MCM



Travel Time Calculated by Assuming...

Travel with Boeing 737
Travel Between Match Cities

Used the following Function to Model

$$S_d = \begin{cases} 1 \ (x \leq 2) \\ \dfrac{1}{1 + e^{2.5(x-4.75)}} \ (2 < x < 7.5) \\ 0 \ (x \geq 7.5) \end{cases}$$

Hit Score in MCM

Considered the **Average of ELO Rating of Two Teams** Since a Match with Better Teams will Attract More Viewers

Considered **Traditional Derby/Rivarly** Since a Match Between these Teams Attract More Viewers

$$\overline{Elo_{avg}} = \frac{Elo_i + Elo_j}{2}$$

$$\overline{Elo_{norm}} = \frac{\overline{Elo_{avg}} - Elo_{min}}{Elo_{max} - Elo_{min}}$$

$$R(i,j) = \begin{cases} 1\ (If\ i\ and\ j\ has\ a\ rivalry) \\ 0\ (else) \end{cases}$$

$$S_H(i,j) = 0.8\overline{Elo_{avg}} + 0.2R(i,j)$$

Game Scheduling

Arrival Plan (AP)	Ensures athlete recovery from travel fatigue and jet lag
Game Time Calculation Method (GTCM)	Sets fair match times for home viewers and away TV audience

Arrival Plan (AP)

Travel time

extra 1 day per hour beyond 6-hour time zone difference

$$AP_{(\text{day})} = \frac{T_{travel}}{24} + 1 + \max(\Delta t - 6, 0)$$

Basic 1-day rest

A **threshold model** for AP calculation

What are the symptoms of jet lag?

The following are the most common symptoms of jet lag. However, each individual may experience symptoms differently. Symptoms may include:

- general fatigue
- sleepiness during the day
- difficulty with normal sleeping patterns
- impaired mental ability and memory
- irritability
- headaches
- gastrointestinal discomforts, including stomach cramps, diarrhea, or constipation
- reduced physical activity

OHSU-Brain Institute

Research shows that human body requires one day recovery per each time zone crossed, particularly when the time zone difference is significant (usually 6 hours).

Game Time Calculation Method (GTCM)

Home Team (A) :
Optimal for live audience, staff availability

$$10 \leq T_A \leq 22$$

Away Team (B) :
Suitable for TV viewers after work hours

$$17 \leq T_B \leq 26$$

$$T_B = T_A + \Delta t$$

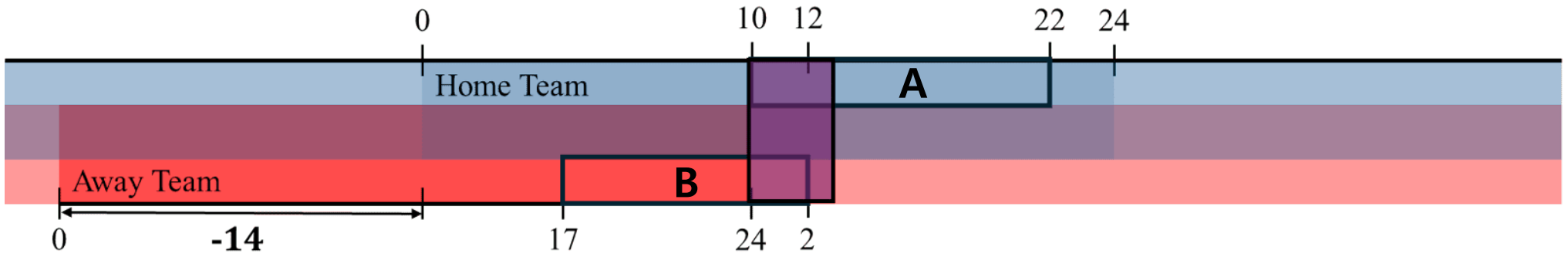
Goal: calculate the range of appropriate game time in terms of A-time(home team)

In case of conflict, **home team's needs are prioritized**
: because they reflect operational necessity, not just viewer preference.

Game Time Calculation Method (GTCM)

Full Watch Condition

If the away TV audience watches the game *from the beginning*
→ able to watch it *at least 2 hours*. (won't likely watch if they can only see the first 30min.)



Scheduling Diagram (Full Watch)

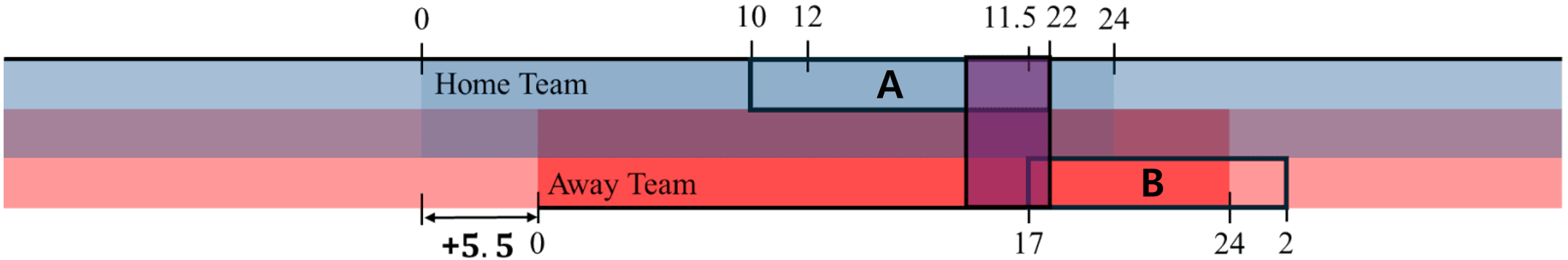
* In the diagram, time difference isn't considered. (the time on the diagram is marked in terms of each country's time zone)
* Every equation is written in A team's perspective.

$$17 - \Delta t \leq T_A \leq 26 - 2 - \Delta t \quad \text{(Condition 1)}$$

Game Time Calculation Method (GTCM)

Late Join Condition

If the away TV audience begin to watch *at least 30min before the end*
→ can watch after the game starts.



Scheduling Diagram (Full Watch)

$$T_A + 2.5 + \Delta t \leq 26 \Rightarrow T_A \leq 23.5 - \Delta t \text{ (Condition 2)}$$

Game Time Calculation Method (GTCM)

$$17 - \Delta t \le T_A \le 26 - 2 - \Delta t \quad (1) \qquad T_A + 2.5 + \Delta t \le 26 \Rightarrow T_A \le 23.5 - \Delta t \quad (2)$$

Final Game Time

$$T_A \in [\max(10, 17 - \Delta t), \min(22, 23.5 - \Delta t)$$

$T_A \in [T_{A\cdot start}, T_{A\cdot end}]$
$T_B \in [T_{B\cdot start}, T_{B\cdot end}]$

Final Generalized Formula

$$T_A \in [\max(T_{A\cdot start}, T_{B\cdot start} - \Delta t), \min(T_{A\cdot end}, T_{B\cdot end} - 2.5 - \Delta t)$$

Simulation Methodology

1 Player's Condition

Geography: Used Haversine formula to measure the distance.
Arrival Plan: Considers flight hours and time zone difference in two countries.

$$d = 2R\,arcsin\left(\sqrt{\left[\,sin^2((\varphi_2-\varphi_1)/2) + cos\,\varphi_1 \cdot cos\,\varphi_2 \cdot sin^2((\lambda_2-\lambda_1)/2)\,\right]}\right)$$

φ: latitude λ: $longitude$ R: $Earth's\ radius$

$Haversine\ Formula$

Simulation Methodology

2 Rationality & Reality

Elo Rating
- Update follows previous E-BIMM method.
- We initialized Elo Rating rationally with real world data. (Men's Volleyball Nations League(2018~2024), Summer Olympic(2016, 2020, 2024))

Match Simulation
- Match outcome is simulated based on win probability of each pair.
- Each round consists of home and away games. (Twenty games per round)

$Expected\ win\ probability\ of\ team\ A \quad E_A = \frac{1}{1 + 10^{(\frac{R_A + RB}{200})}}$

Simulation Methodology

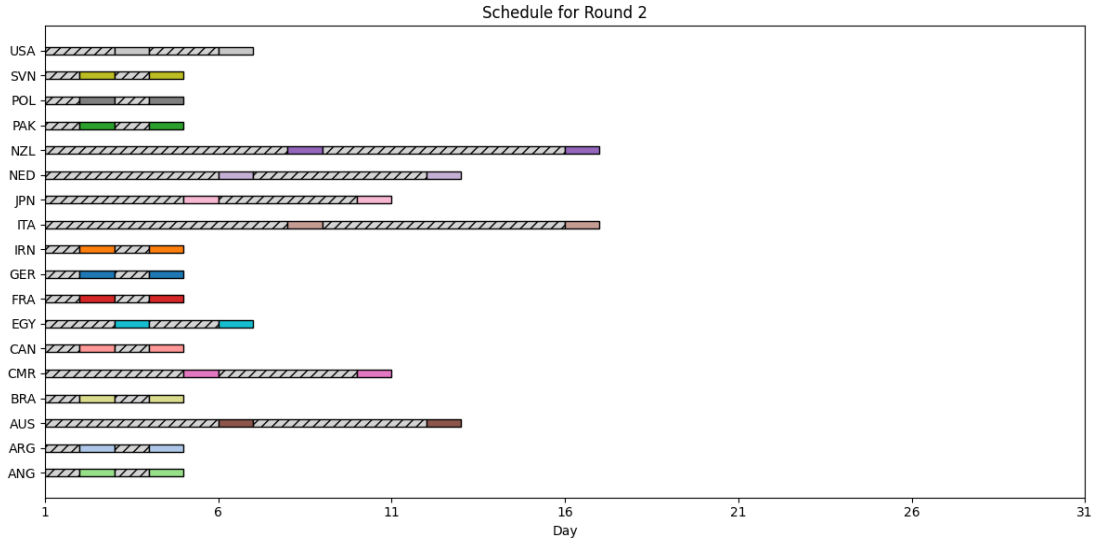
3 Scheduling & Visualization

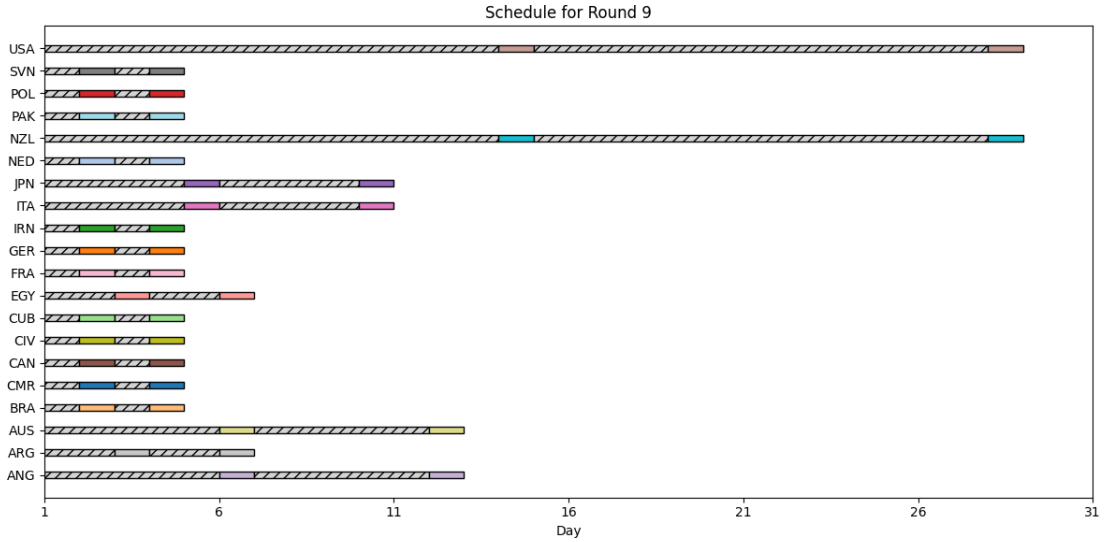
Scheduling
- Each round begins on the 1st of the month.
- Bring AP calculation into scheduling.

Visualization Method
- Visualized using Gnatt chart format.
- X-axis represents timeline and Y-axis represents each country with unique color.

Simulation Methodology

3 Scheduling & Visualization





Examples of schedule visualization (Round2, Round9)

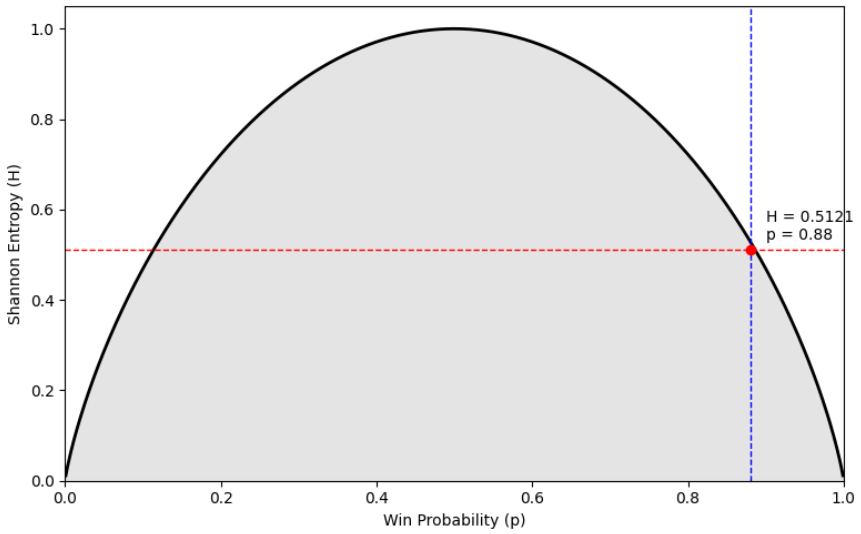
Results

IMMC specified league should span 8 to 9 months. We compared 8 rounds scenario and 9 rounds scenario.

For N=8, the average Shannon Entropy was 0.5812.
For N=9, the average Shannon Entropy was 0.5121.

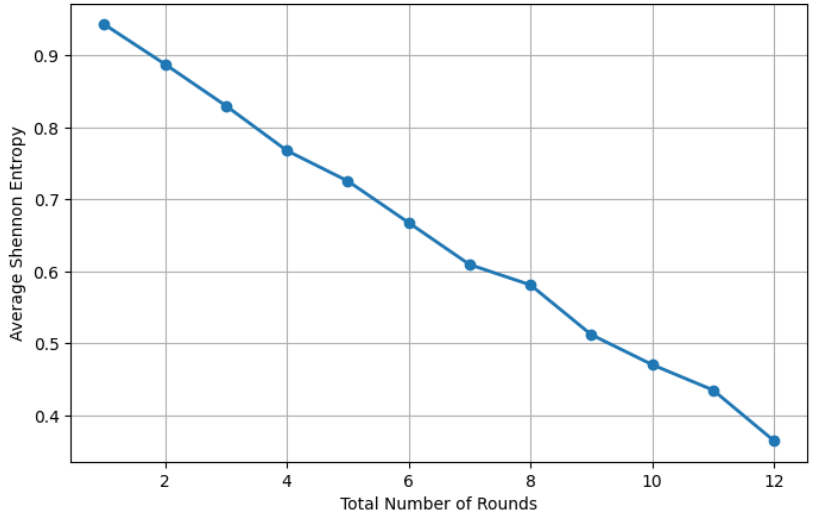
With 9 rounds, GSL could yield reliable results, saving 200 games compared to traditional round-robin league.

Sensitivity Analysis



As Shannon Entropy decreases,

One-sided win probability increases at diminished rate.



Decrement appears linear function w.r.t total number of rounds.

After certain round, there is negligible change in win rate.

Team Addition

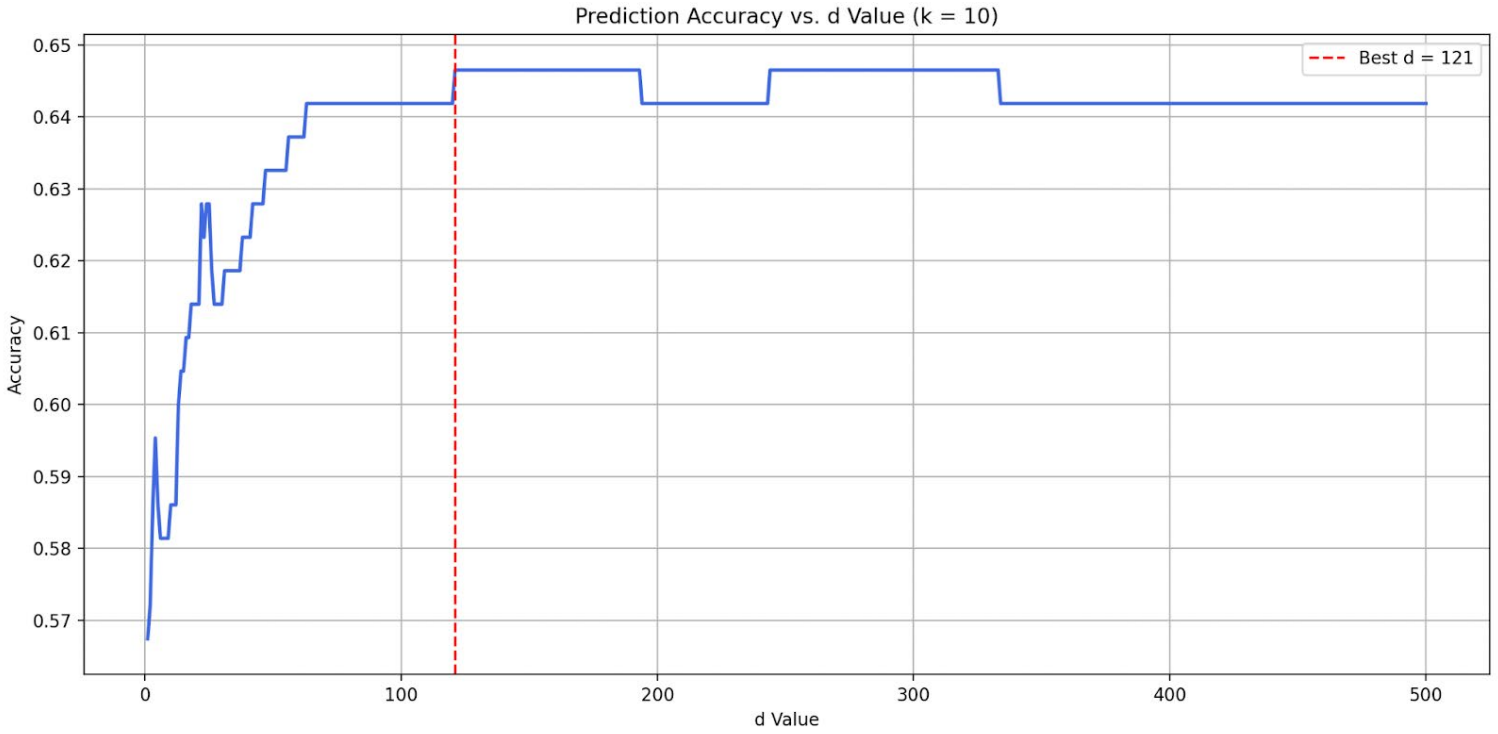
By using SPP Index, we added 4 countries...

Name	SPP	Name	SPP
Belgium	0.3928	Serbia	0.3838
Dominican Republic	0.3917	Czech Republic	0.3766

Since the minimum requirement of 2 teams per continent was already met,

***geographical representation was not** considered.*

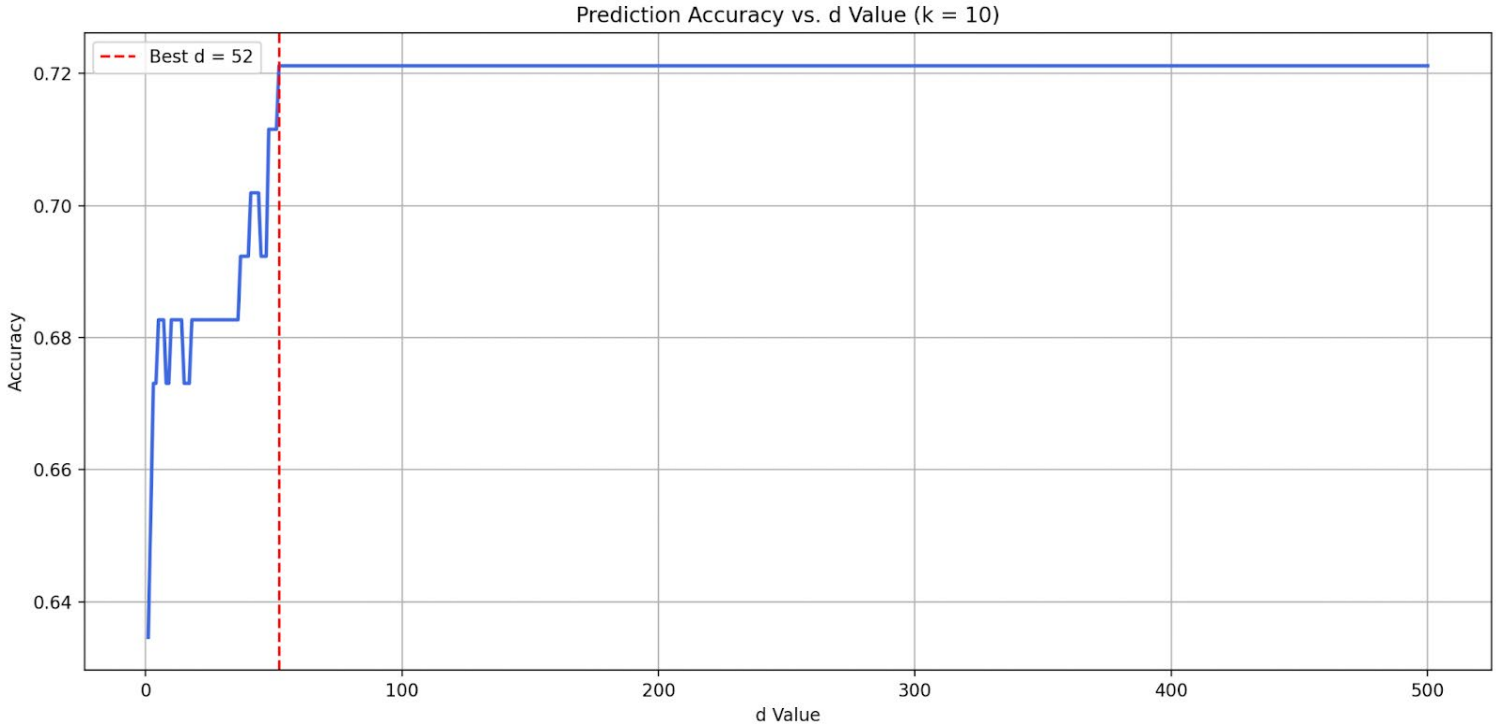
Model Applied in Football



Data: 2010-2022 FIFA World Cup (knockout –stage matches weighted 1.2x).

*Result: Optimal d=121 → **64.65% prediction accuracy** (excluding draws).*

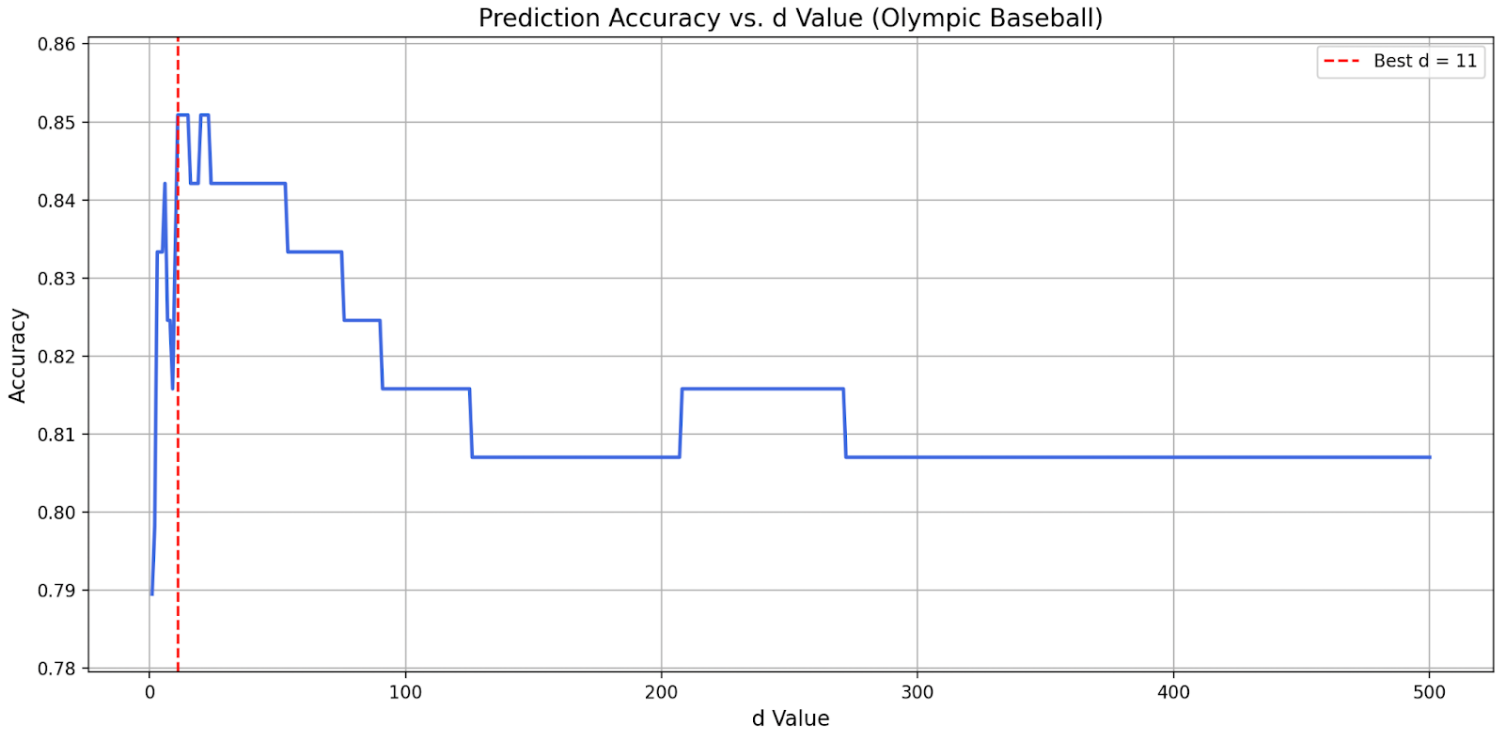
Model Applied in Basketball



Data: 2016-2024 Olympics + 2006-2023 FIBA World Cup (FIBA matches weighted 1.25x)

*Result: Optimal d=52 → **72.12% prediction accuracy***

Model Applied in Baseball



Data: 2020-2020 Olympic matches

*Result: Optimal d=11 → **85.09% prediction accuracy** (highest performance).*

Conclusion

Strengths

- Innovative Matchmaking Model
- Comprehensive Metric Integration
- Holistic Sport & Country Selection
- Realistic Scheduling Components
- Scalability & Adaptability
- Simulation & Visualization:

Weaknesses

- Complexity in Implementation
- Dependence on Assumptions
- Limited Validation of Viewer Interest
- Lack of Stakeholder Perspective
- Static Skill Assumption in Simulation

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