Analyzing the Fairness and Efficiency of Tournament Formats: A Simulation Study of Dominant, Counter, and Kryptonite Team Dynamics

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***Abstract*— This paper presents a simulation-based analysis of how different tournament formats affect fairness, efficiency, and team dynamics. We model 16-team competitions under four structures: Single Elimination (SE), Double Elimination (DE), a Group Stage feeding into an SE playoff, and a Swiss Stage also culminating in SE playoffs. Teams are represented by strategic archetypes: 'Dominant' (D) teams with consistently high win rates, 'Counter' (CT) teams that specialize in defeating D, and 'Kryptonite' (KR) teams that are strong against D but weak against general opponents. Simulations use predefined win-rate matrices and assume random seeding. Key metrics include overall win rates, qualification chances, and sensitivity to early matchups. SE is efficient but highly luck-dependent. DE improves fairness by offering recovery paths, though at the cost of match volume. Hybrid formats like Swiss-to-Playoff, balance fairness and resilience to early upsets, but further reduce efficiency. KR teams are particularly vulnerable in SE due to the risk of early exit despite strategic value. Findings highlight important trade-offs between fairness and efficiency, offering practical guidance for tournament organizers choosing structures aligned with competitive goals and diverse team compositions.**

Keywords*— *tournament formats; simulation modeling; team archetypes; fairness; efficiency; single elimination; double elimination; swiss system

I. Introduction

Tournaments are an integral part of various competitions, from traditional sports to modern esports, with the primary goal of objectively identifying the best participant or team. Ideally, a tournament format should be able to reflect the true strength (skill) ranking of its participants as much as possible, while minimizing the influence of random elements that can obscure the final outcome. Beyond fairness, another crucial consideration is efficiency in execution—conducting the minimum number of matches possible without significantly compromising the accuracy of results.

However, the reality of competition is often more complex than mere linear skill differences. The dynamics of "dominant" teams that consistently outperform most opponents, "counter" teams that have specific strategies to defeat dominant teams, and 'kryptonite' teams that excel specifically against top-tier opponents through specialized strategies, while struggling against conventional teams, add a layer of complexity in assessing the effectiveness of a tournament format. These unique interactions among these three types of teams can significantly affect match outcome probabilities and, consequently, the accuracy of the final rankings produced by a tournament.

This paper aims to conduct an in-depth analysis of the fairness and efficiency aspects of various popular tournament formats. Using a simulation study approach, this research will specifically investigate how the interaction dynamics between dominant, counter, and kryptonite teams affect the performance of these formats. Through this analysis, it is hoped to provide new insights into designing competition systems that are not only fair and efficient but also able to accommodate the complexity of strategic interactions among participants, thereby producing rankings that are more representative of true strength.

II. Theoretical Background

A. Probability Theory

Probability theory is a branch of mathematics concerned with the analysis of random phenomena. In the discrete setting, it deals with experiments or processes that produce outcomes from a finite or countably infinite sample space.

A Bernoulli trial is a random experiment with exactly two possible outcomes, typically labeled as "success" and "failure," with fixed probabilities p and $1 - p$, respectively. A sequence of independent Bernoulli trials forms the basis of many discrete probability models.

The expected value (or expectation) of a discrete random variable X, denoted $\mathbf{E}[X]$, is defined as the weighted average of all possible values that X can take, with weights given by their respective probabilities:

$$\mathbf{E}[X] = \Sigma\, x \cdot P(X = x)$$

The **variance** of a random variable *X*, denoted **Var**(*X*), measures the spread of its values around the mean and is defined as:

$$\mathbf{Var}(X) = \mathbf{E}[(X - \mathbf{E}[X])^2]$$

The Law of Large Numbers states that, as the number of independent trials of a random variable increases, the sample average converges to the expected value. This principle is a fundamental basis for Monte Carlo Simulation.

Monte Carlo Simulation is a computational technique that utilizes repeated random sampling to obtain numerical results and estimate the behavior of complex systems, particularly those with inherent randomness or where analytical solutions are intractable. It relies on the LLN to ensure that as the number of simulations increases, the average of the results provides an increasingly accurate approximation of the true expected value or distribution of the system being modeled. This technique is broadly applicable to simulating stochastic processes.

A probability distribution on a finite sample space assigns a probability p_k to each outcome *k*, such that:

$$\Sigma\, p_k = 1$$

Discrete distributions often used in probabilistic modeling include the binomial distribution, geometric distribution, and discrete uniform distribution, depending on the structure of the random process being modeled.

When simulating or analyzing random events, assumptions such as independence (the outcome of one trial does not influence another) and identically distributed trials are commonly used to simplify analysis and ensure statistical reliability.

B. Graph Theory

Graph theory is a field of discrete mathematics concerned with the study of graphs, which are mathematical structures used to model pairwise relations between objects. A directed graph (or digraph) is defined as a pair G = (V,E), where V is a set of vertices (or nodes) and E ⊆ V×V is a set of ordered pairs of vertices called directed edges.

In a directed graph, an edge (u,v) ∈ E indicates a directed connection from vertex u to vertex v. If each edge carries a numerical value or weight (such as a win probability), the graph is said to be a weighted directed graph.

A complete graph is a simple graph in which every distinct pair of vertices is connected by an edge. The specific nature of this connection depends on whether the graph is undirected or directed.

1. Complete Undirected Graph:

   A complete undirected graph is a simple undirected graph. In a complete undirected graph, every distinct pair of vertices u, v ∈ V is connected by exactly one edge {u,v} ∈ E. This means that for any two distinct vertices, there is an undirected edge between them.

Formally, a simple undirected graph G = (V, E) is a complete undirected graph if for any two distinct vertices u, v ∈ V, the edge {u,v} is an element of E. Equivalently, the set of edges E is {{u,v} | u, v ∈ V, u ≠ v}. A complete undirected graph on n = |V| vertices is denoted by K_n and has |E| = n(n-1)/2 edges.

2. Complete Directed Graph (or Complete Symmetric Digraph):

   A complete directed graph (also known as a complete symmetric digraph or a tournament where every pair has edges in both directions) is a simple directed graph. In a complete directed graph, for every distinct pair of vertices u, v ∈ V, *both* the directed edge (u,v) and the directed edge (v,u) are present in E.

Formally, a simple directed graph G = (V, E) is a complete directed graph if for any two distinct vertices u, v ∈ V, both (u,v) ∈ E and (v,u) ∈ E. A complete directed graph on n = |V| vertices has |E| = n(n-1) edges.

An important representation of graphs is the adjacency matrix. For a graph with n vertices, the adjacency matrix is an n x n matrix A, where the entry A[i][j] denotes the presence (and possibly weight) of a directed edge from vertex i to vertex j. For unweighted graphs, this entry is typically 1 (if an edge exists) or 0 (otherwise). For weighted graphs, it may store a real number representing edge weight.

Graph theory provides tools for analyzing connectivity, reachability, and structure within systems of interacting elements. In the context of discrete modeling, it is particularly useful for representing competitions, dependencies, and flows between components.

C. Combinatorics

Combinatorics is the area of mathematics concerned with counting, arrangement, and combination of discrete objects. Two fundamental principles in combinatorics are the rule of product and the rule of sum, which are used to compute the total number of outcomes in compound events.

A permutation is an ordered arrangement of a set of distinct elements. The number of permutations of *n* distinct elements is given by *n factorial*, written as:

$$n! = n \times (n - 1) \times (n - 2) \times \ldots \times 1$$

This represents the number of ways to arrange *n* teams in a tournament bracket, for example.

A combination is a selection of items from a set where order does not matter. The number of combinations of *r* items selected from a set of *n* elements is given by the binomial coefficient, written as:

$$C(n, r) = n! \,/\, (r! \times (n - r)!)$$

This is used when choosing subsets of items, such as selecting a group of teams or matches from a larger set.

Combinatorics also includes the study of partitions, subsets, and other counting techniques that are essential for analyzing the number of possible configurations in discrete structures.

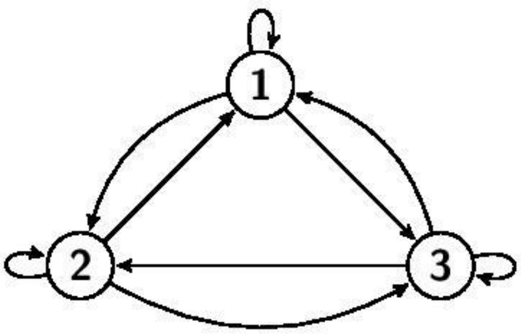
III. Methodology

A. Simulation Method

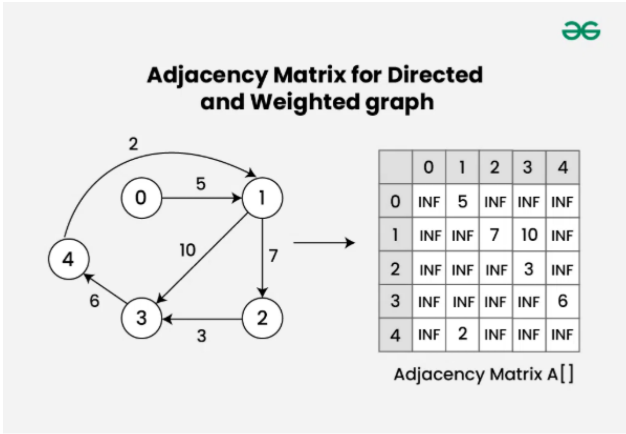
To analyze the fairness and efficiency of different tournament formats under the influence of dominant, counter, and kryptonite team dynamics, a Monte Carlo simulation approach was adopted. Specifically, one million tournament iterations were run virtually for each format under consideration. Each match within a simulated tournament was resolved as a random event, modeled as a Bernoulli trial where win probabilities were determined based on the relative strengths and types (dominant, counter, kryptonite) of the interacting teams. The aggregated results from these one million simulations were then used to calculate key metrics, including fairness, defined as the probability of the true Xth-best player achieving an Xth-place tournament finish., and efficiency, measured by the **number** of matches. The large number of simulations ensures, by the Law of Large Numbers, that these estimated metrics closely approximate their true probabilistic values for each tournament format.

B. Predetermined Win Rate

Win rates for team X against team Y is all predetermined to control unexpected factors and to make the results more apparent and obvious. These predetermined win rates can be represented in an adjacency matrix, because these predetermined win rates can be represented by a complete weighted directed graph.



Source: https://commons.wikimedia.org/wiki/File:Complete_Directed_Graph.jpg



Source: https://www.geeksforgeeks.org/dsa/adjacency-matrix-of-directed-graph/

C. Single Elimination Simulation

Simulations for a 16-team single-elimination tournament format were conducted using custom C code. The study focused on the performance of two specific teams (hereafter "Focal Team A" and "Focal Team B"), with Team A possessing a generally higher average win rate than Team B. These teams have unique, predefined win probabilities when playing against each other, and different (standardized) win probabilities against the other 14 "standard" teams. Match outcomes were determined by Bernoulli trials.

The initial seeding for the tournament, guided by average win rates, was specifically manipulated to place Focal Team A and Focal Team B into four distinct relative bracket positions to analyze the impact on their tournament outcomes, particularly their final win rates:

1. **Direct R1 Matchup:** Focal Team A and Focal Team B were seeded to compete directly against each other in the first round.
2. **Same Quarter, Different Eighth:** The focal teams were seeded into the same quarter-final bracket segment but in different eighth-final segments, allowing a potential meeting in the second round (quarter-final). (e.g., Team A as the top seed of the quarter, Team B as the top seed of an adjacent eighth).
3. **Same Half, Different Quarter:** The focal teams were seeded into the same half of the bracket but in different quarter-final segments, allowing a potential meeting in the third round (semi-final).
4. **Opposite Halves:** The focal teams were seeded into opposite halves of the bracket (e.g., Team A as the overall 1st seed, Team B as the top seed of the other half), ensuring they could only meet in the final match.

In each scenario, after placing the two focal teams according to the scenario's logic (which is informed by their relative average win rates), the remaining 14 standard teams were randomly assigned to the other initial bracket positions using a shuffle algorithm. One million simulation runs were performed for each scenario. Key metrics collected were the tournament win rates of Focal Team A and Focal Team B, which include the 1st and 2nd place percentage of both Team A and Team B. The pseudo-random number generator was initialized once per program execution.

D. Double Elimination Simulation

A 16-team double-elimination tournament format was simulated using custom C code. The analysis centered on two focal teams: "Focal Team A" (with a generally higher average win rate) and "Focal Team B." These teams had unique win probabilities against each other and standardized probabilities against the other 14 "standard" teams. Matches were resolved as Bernoulli trials. The simulation adhered to standard double-elimination rules, including a Winners Bracket, Losers Bracket, and potential Grand Final reset.

Initial tournament seeding, based on average win rates, was systematically structured to position Focal Team A and Focal Team B into four relative configurations within the Winners Bracket to examine the effect on their final tournament win rates:

1. **Direct R1 Matchup (Winners Bracket):** Focal Team A (e.g., as 1st overall seed) and Focal Team B (e.g., as 16th overall seed) meet in the first round of the Winners Bracket.
2. **Same Quarter, Different Eighth (Winners Bracket Context):** The focal teams were assigned into the Winners Bracket such that if both won their first match, they would meet in the second Winners Bracket round (e.g., Team A as 1st seed, Team B as 8th or 9th seed, meeting in the Winners Quarter-Final for their segment).
3. **Same Half, Different Quarter (Winners Bracket Context):** The focal teams were assigned into the same half of the initial Winners Bracket but in different quarter segments (e.g., Team A as 1st seed, Team B as 4th or 5th seed), potentially meeting in the Winners Semi-Final.
4. **Opposite Halves (Winners Bracket Context):** The focal teams were assigned into opposite halves of the initial Winners Bracket (e.g., Team A as 1st seed, Team B as 2nd seed), ensuring they could only meet in the Winners Final or later in the Grand Final.

Following the placement of the focal teams for each scenario (driven by the scenario logic and their relative average win rates), the remaining 14 standard teams were randomly assigned to the other initial seed positions. Each scenario was simulated one million times. Key metrics included the 1st and 2nd place percentage of both Team A and Team B. The pseudo-random number generator was initialized once.

E. Hybrid Group Stage + Playoff Tournament Simulation

This format involved a 16-team tournament simulated in C code, beginning with a group stage followed by a distinct single-elimination playoff structure. The analysis focused on two focal teams ("Focal Team A" with a higher average win rate, and "Focal Team B"), which had unique win probabilities against each other and standardized probabilities against the other 14 "standard" teams. Match outcomes were determined by Bernoulli trials.

1. Group Stage:

- The 16 teams were initially divided into two 8-team groups (Group A and Group B).
- Standard teams were randomly assigned to these groups. The placement of Focal Team A and Focal Team B into these groups was varied by scenario (see below).
- Within each 8-team group, a full internal double-elimination tournament was simulated. This determined, for each group, a:
    - Winner of Upper Bracket Final (W_UBF_A, W_UBF_B)
    - Loser of Upper Bracket Final (L_UBF_A, L_UBF_B)
    - Winner of Lower Bracket Final (W_LBF_A, W_LBF_B)
      These six teams (three from each group) advanced to the playoff stage.

3. Playoff Stage (Single Elimination):

The six qualified teams entered a specific 5-match single-elimination playoff bracket to determine the two Grand Finalists:

- **Path to Grand Finalist 1:**
    1. Match P1: Loser of Group B Upper Bracket Final (L_UBF_B) vs. Winner of Group A Lower Bracket Final (W_LBF_A).
    2. Match P2: Winner of P1 vs. Winner of Group A Upper Bracket Final (W_UBF_A). The winner of P2 became Grand Finalist 1.
- **Path to Grand Finalist 2:**
    1. Match P3: Loser of Group A Upper Bracket Final (LUBF_A) vs. Winner of Group B Lower Bracket Final (WLBF_B).
    2. Match P4: Winner of P3 vs. Winner of Group B Upper Bracket Final (WUBF_B). The winner of P4 became Grand Finalist 2.
- **Grand Final:** Grand Finalist 1 vs. Grand Finalist 2.

4. Seeding Scenarios for Focal Teams:

The initial assignment of Focal Team A and Focal Team B into the two groups was varied across scenarios, with their seeding *within* their assigned group determined by their average win rates:

- **Scenario 1:** Focal Team A and Focal Team B both assigned to Group A, and faces immediately on the Upper Bracket Quarterfinal.
- **Scenario 2:** Focal Team A and Focal Team B both assigned to Group A, and in the same half group,

therefore possibly matching each other on Upper Bracket Semifinal or Lower Bracket.

- **Scenario 3:** Focal Team A and Focal Team B assigned to Group A, but in different half-groups, therefore possibly matching each other on Upper Bracket Final or Lower Bracket.
- **Scenario 4:** Focal Team A assigned to Group A, meanwhile Focal Team B assigned to Group B (cannot meet on the Group Stage)

After placing the focal teams according to the scenario, the remaining standard teams were randomly distributed to fill the groups. One million simulation runs were performed for each scenario. Key metrics collected were the 1st and 2nd place percentage of both Team A and Team B. The pseudo-random number generator was initialized once.

F. Hybrid Swiss Stage + Playoff Tournament Simulation

This 16-team hybrid tournament format, simulated in C code, began with a 5-round Swiss stage followed by an 8-team single-elimination playoff. The analysis focused on two designated teams ("Focal Team A" with a higher average win rate, and "Focal Team B"), with unique win probabilities against each other and standardized probabilities against other teams. Matches were resolved as Bernoulli trials.

1. Swiss Stage:

- All 16 teams entered the Swiss stage. Round 1 pairings were random; subsequent rounds paired teams with identical win-loss records (randomly among eligible opponents within the same record tier).
- Qualification for playoffs required 3 wins; 3 losses led to elimination. The stage concluded when 8 teams qualified.

2. Playoff Stage:

- The 8 Swiss stage qualifiers advanced to a single-elimination playoff. Playoff seeding for these 8 teams was random.

Focal Team Analysis and Scenarios:

The primary analysis for this format investigated the impact of direct encounters (or lack thereof) between Focal Team A and Focal Team B during the Swiss stage. Both focal teams were part of the initial 16-team pool. Simulations were conducted and subsequently analyzed based on two distinct conditions reflecting their Swiss stage interaction:

- **Scenario 1 (No Swiss Encounter):** This scenario exclusively analyzed simulation runs where Focal Team A and Focal Team B *did not* play against each other at any point during the 5-round Swiss stage.
- **Scenario 2 (Single Swiss Encounter):** This scenario exclusively analyzed simulation runs where Focal Team A and Focal Team B played against each other *exactly once* during the 5-round Swiss stage.

For simulations falling into each of these two scenarios, the following metrics were separately calculated for both Focal Team A and Focal Team B:

- Their percentage of qualifying for the playoff stage.
- Their percentage of finishing in 1st place in the overall tournament.
- Their percentage of finishing in 2nd place in the overall tournament.

A large number of total simulations (e.g., one million or more) were performed to ensure a sufficient sample of runs could be categorized into each of these two specific scenarios for robust analysis. The pseudo-random number generator was initialized once per program execution.

One million simulation runs of the entire hybrid tournament were performed. The primary metrics collected were the tournament win rates of Focal Team A and Focal Team B. The pseudo-random number generator was initialized once per program execution.

IV. Results and Discussion

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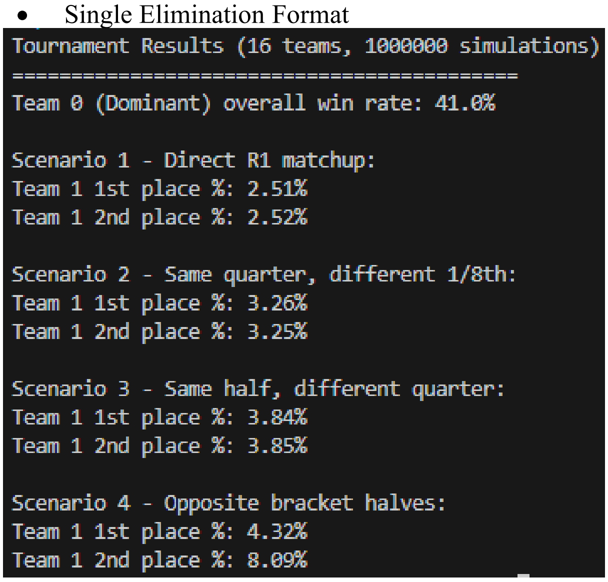
A. Dominant Team Dynamics

- Single Elimination Format



```
Tournament Results (16 teams, 1000000 simulations)
==========================================
Team 0 (Dominant) overall win rate: 41.0%

Scenario 1 - Direct R1 matchup:
Team 1 1st place %: 2.51%
Team 1 2nd place %: 2.52%

Scenario 2 - Same quarter, different 1/8th:
Team 1 1st place %: 3.26%
Team 1 2nd place %: 3.25%

Scenario 3 - Same half, different quarter:
Team 1 1st place %: 3.84%
Team 1 2nd place %: 3.85%

Scenario 4 - Opposite bracket halves:
Team 1 1st place %: 4.32%
Team 1 2nd place %: 8.09%
```

With single elimination format the whole tournament, it can be seen that unlucky situations such as meeting the dominant team directly or even being in the same half bracket with the dominant team results in a big win rate difference, with Scenario 4 (opposite bracket halves) providing Team 1 with a 2nd place percentage (8.09%) that is more than twice the amount achieved in Scenario 3 (same half, different quarter, at 3.84%), and more than thrice the 2nd place percentage on Scenario 1 (2.51%).

Looking from an efficiency standpoint, this is the most efficient format with just 15 matches to decide the winner of the tournament.

- Double Elimination Format

```
Double Elimination Results (16 teams, 1000000 runs)
============================================
Team 0 (Dominant) win rate: 55.5%

Scenario 1 - Direct matchup (1v16):
Team 1 1st place %: 2.19%
Team 1 2nd place %: 3.03%

Scenario 2 - Same quarter, different 1/8th (1v9 area):
Team 1 1st place %: 2.68%
Team 1 2nd place %: 3.83%

Scenario 3 - Same half, different quarter (1v4 area):
Team 1 1st place %: 3.00%
Team 1 2nd place %: 5.20%

Scenario 4 - Opposite halves (1v2):
Team 1 1st place %: 3.16%
Team 1 2nd place %: 7.19%
```

For double elimination format, it has a significant improvement on fairness of the format compared to single elimination, with the normal team facing the dominant team on the first round having around 42.14% the 2nd place percentage of the normal teams that is on a different half bracket of the dominant team (3.03 / 7.19), compared to only 31.14% for the single elimination format (2.52 / 8.09). Other than that, the dominant team also has a higher tournament 1st place win rate, making this format

Looking from an efficiency standpoint, this is twice or more matches than the single elimination format, needing 30 or 31 matches, depending on the grand final outcome. This result shows that double elimination formats have increased fairness with efficiency as the trade-off.

- Hybrid Format - Group Stage with Double Elimination Format and Playoff with Single Elimination Format

```
Tournament Results (16 teams, 1000000 simulations per scenario)
================================================================
Team 0 (Dominant) 1st place %: 49.8%

Scenario 1 - Direct R1 Group Matchup
Team 1 1st place %: 2.17%
Team 1 2nd place %: 2.56%

Scenario 2 - Same Group, might meet in Group UB SF:
Team 1 1st place %: 2.66%
Team 1 2nd place %: 3.27%

Scenario 3 - Same Group, might meet in Group UB Final:
Team 1 1st place %: 3.36%
Team 1 2nd place %: 5.85%

Scenario 4 - SN and D on Different Groups:
Team 1 1st place %: 3.68%
Team 1 2nd place %: 6.85%
```

This hybrid approach takes some of the fairness from the double elimination format while also incorporating the efficiency from single elimination format. The normal team facing the dominant team on the first round has around 37.37% the 2nd place percentage of the normal teams that is on a different half bracket of the dominant team (2.56 / 6.85), which around the middle of both the double elimination format (42.14%) and single elimination format (31.14%), with the exact middle point being 36.64%.

However, the match amount for this hybrid format leans more towards the double elimination format than single elimination format, with 27 matches, much closer to 30/31 compared to 15.

- Hybrid Format – Swiss Stage to a Playoff with Single Elimination Format

```
Tournament Results (16 teams, 1000000 total sims, 1000000 valid playoff runs)
======================================================================
Team 0 (Dominant) overall win rate (of valid playoffs): 48.08%

Scenario SW1 - SN does NOT meet D in Swiss:
  (Based on 758100 Swiss stages)
  Team 1 (SN) qualified for playoffs: 45.32%
  Team 1 (SN) 1st place (when SN qual): 7.33%
  Team 1 (SN) 1st place (overall for this scenario): 3.32%
  Team 1 (SN) 2nd place (when SN qual): 12.46%
  Team 1 (SN) 2nd place (overall for this scenario): 5.65%

Scenario SW2 - SN meets D ONCE in Swiss:
  (Based on 241900 Swiss stages)
  Team 1 (SN) qualified for playoffs: 48.87%
  Team 1 (SN) 1st place (when SN qual): 7.40%
  Team 1 (SN) 1st place (overall for this scenario): 3.62%
  Team 1 (SN) 2nd place (when SN qual): 12.40%
  Team 1 (SN) 2nd place (overall for this scenario): 6.06%
```

This hybrid approach uses Swiss Stage for qualifiers to Playoffs, which improves fairness very drastically for qualifiers, making only 2 scenarios possible, one where the normal team only faces the dominant team once in the Swiss Stage (worst case) and one where the normal team never faces the dominant team on the Swiss Stage (best case). It is very fair because of the forgiving nature of Swiss Stage, allowing 3 losses before getting eliminated, therefore lessening the impact of losses by bad luck like facing the dominant team.

But from an efficiency standpoint, it is the worse, needing 38-42 matches to conclude the tournament, trading-off the advantage from the format’s best fairness.

B. Counter Team Dynamics

- Single Elimination Format

```
Tournament Results (10000000 sims, 16 teams)
=============================================
DOM_TEAM (ID 0) overall avg win: 26.57%
CNT_TEAM (ID 1) overall avg win: 9.02%

S1 - D vs CT R1:
DOM 1st: 10.23%
CNT 1st: 10.01%
CNT 2nd: 10.00%

S2 - D & CT meet R2:
DOM 1st: 25.62%
CNT 1st: 9.25%
CNT 2nd: 9.22%

S3 - D & CT meet R3:
DOM 1st: 33.29%
CNT 1st: 8.65%
CNT 2nd: 8.65%

S4 - D & CT meet R4 (Final):
DOM 1st: 37.14%
CNT 1st: 8.18%
CNT 2nd: 4.33%
```

In a pure Single Elimination setup with a hard counter, the Dominant Team (D) saw its overall win rate drop to 26.57%, while the Counter Team (CT) achieved a 9.02% win rate. The data clearly showed that CT's prospects were best when facing D in Round 1 (10.00% win, 10.01% 2nd), a scenario where D's win rate was at its nadir (10.26%). Conversely, if D and CT met in the final, D's win rate rose to 37.12%, and CT's win chance fell to 8.18%. This indicates a clear advantage for CT in an early engagement, with draw luck moderately influencing CT's success. The format remained highly efficient with 15 matches.

- Double Elimination Format

```
--- Tournament Results (Double Elimination, 1000000 Sims) ---
Overall Averages:
Team 0 (Dominant) win rate: 36.57%
Team 1 (Counter)  win rate: 10.16%

Scenario 1 - Direct WB R1 (D vs CT):
Team D wins: 20.31%
 Team CT wins: 10.87%
 Team CT 2nd: 10.23%

Scenario 2 - Same WB R1 Quarter (D & CT meet WB R2):
Team D wins: 35.36%
 Team CT wins: 10.31%
 Team CT 2nd: 9.24%

Scenario 3 - Same WB Half, Diff Quarter (D & CT meet WB R3):
Team D wins: 43.66%
 Team CT wins: 9.89%
 Team CT 2nd: 7.69%

Scenario 4 - Opposite WB Halves (D & CT meet WB Final/GF):
Team D wins: 46.96%
 Team CT wins: 9.60%
 Team CT 2nd: 5.06%
```

Under Double Elimination format, the Dominant Team (D) had an overall win rate of 36.57%, with the Counter Team (CT) winning 10.16% of tournaments. Similar to Single Elimination, CT benefited from an early encounter in the Winners Bracket (WB). Meeting D in WB R1 gave CT its highest win rate (10.87%) and 2nd place rate (10.23%), while D's chances were lowest (20.31% win). If they met later in the WB, D's win rate increased substantially. While CT's outright win chance was only mildly affected by WB draw timing (S1 vs S4 ratio ~1.13), its top-2 finish prospects were more sensitive, still favoring an earlier clash. This format required 30-31 matches.

- Hybrid Format - Group Stage with Double Elimination Format and Playoff with Single Elimination Format

```
Running tournament simulations (16 teams, Hard Counter, Group DE + SE Playoff, 1000000 sims per scenario)...

Results (16 teams, 4000000 total simulations, Group DE + SE Playoff - HC)
==================================================
Team 0 (D) overall win %: 33.53%
Team 2 (CT) overall win %: 10.16%

Scenario 1 - D vs CT in R1 of group:
  Team D qualified for playoffs %: 43.18%
  D wins tournament %: 18.38%
  Team CT qualified for playoffs %: 57.61%
  CT wins tournament %: 11.53%
  CT 2nd place in tournament %: 10.58%

Scenario 2 - D, CT Same Group, diff R1 matches, can meet in UB SF:
  Team D qualified for playoffs %: 68.11%
  D wins tournament %: 32.15%
  Team CT qualified for playoffs %: 48.50%
  CT wins tournament %: 10.75%
  CT 2nd place in tournament %: 9.53%

Scenario 3 - D, CT Same Group, different group halfs, can meet in UB Finals:
  Team D qualified for playoffs %: 80.63%
  D wins tournament %: 40.75%
  Team CT qualified for playoffs %: 39.45%
  CT wins tournament %: 9.51%
  CT 2nd place in tournament %: 6.29%

Scenario 4 - D, CT Different Groups:
  Team D qualified for playoffs %: 84.48%
  D wins tournament %: 42.86%
  Team CT qualified for playoffs %: 37.51%
  CT wins tournament %: 8.86%
  CT 2nd place in tournament %: 5.61%
```

This hybrid structure resulted in a 33.53% overall win rate for the Dominant Team (D) and 10.16% for the Counter Team (CT). An early meeting in the group stage (R1) was most favorable for CT, yielding its highest win (11.53%) and 2nd place (10.58%) percentages, while D's tournament win rate was at its lowest (18.38%). If D and CT were in different groups, meaning a potential later playoff clash, D's win rate climbed to 42.86%, and CT's dropped. CT's win probability was notably higher (1.3x) with an early group encounter versus being in separate groups. The tournament used 27 matches.

- Hybrid Format – Swiss Stage to a Playoff with Single Elimination Format

```
Running simulations (16 teams, Swiss stage, Hard Counter, 10000000 total sims)...

Team D overall win rate: 38.76%
Team CT overall win rate: 9.25%

Scenario 1 - SN does NOT meet D in Swiss:
(Based on 7578457 Swiss stages)
Team CT qualified for playoffs: 53.15%
Team CT 1st place (when SN qual): 8.66%
Team CT 1st place (overall for this scenario): 9.28%
Team CT 2nd place (when SN qual): 6.22%
Team CT 2nd place (overall for this scenario): 6.66%
Team D qualified for playoffs: 91.06%
Team D 1st place (when SN qual): 38.91%
Team D 1st place (overall for this scenario): 38.82%
Team D 2nd place (when SN qual): 12.72%
Team D 2nd place (overall for this scenario): 12.94%

Scenario 2 - SN meets D ONCE in Swiss:
(Based on 2343532 Swiss stages)
Team CT qualified for playoffs: 52.82%
Team CT 1st place (when SN qual): 8.38%
Team CT 1st place (overall for this scenario): 9.15%
Team CT 2nd place (when SN qual): 6.10%
Team CT 2nd place (overall for this scenario): 6.64%
Team D qualified for playoffs: 90.56%
Team D 1st place (when SN qual): 38.83%
Team D 1st place (overall for this scenario): 38.66%
Team D 2nd place (when SN qual): 12.55%
Team D 2nd place (overall for this scenario): 12.84%
```

The Swiss Stage leading to a Single Elimination Playoff saw the Dominant Team (D) win 38.76% of tournaments and the Counter Team (CT) win 9.25%. A key finding here was the Swiss stage's remarkable ability to neutralize the impact of an early D-CT meeting. CT's overall tournament win rates (around 9.2%) and 2nd place rates (around 6.6%) were almost identical whether they met D once in Swiss or not at all. This format demonstrated exceptional fairness concerning the Swiss draw for CT, effectively postponing the true D-CT showdown to the playoffs. This fairness, however, came with the highest match count of 38-42 games.

C. Krypotnite Dynamic

- Single Elimination Format

```
Tournament Results (SE, 1000000 sims, 16 teams, Kryptonite)
========================================
D_ID (ID 0) overall avg win: 28.48%
KR_ID (ID 1) overall avg win: 4.45%

S1 - D vs KR R1:
D 1st: 10.23%
KR 1st: 5.11%
KR 16th: 20.03%

S2 - D & KR meet R2:
D 1st: 28.70%
KR 1st: 4.61%
KR 16th: 60.01%

S3 - D & KR meet R3:
D 1st: 35.94%
KR 1st: 4.20%
KR 16th: 60.01%

S4 - D & KR meet R4 (Final):
D 1st: 39.03%
KR 1st: 3.89%
KR 16th: 59.94%
```

In a pure Single Elimination format with the Kryptonite dynamic, the Dominant Team (D) achieved an overall average win rate of 28.48%, while the Kryptonite Team (KR) had a low overall win rate of 4.45%.

A Round 1 matchup between D and KR was crucial for KR. In this scenario (S1), KR had its highest tournament win percentage (5.11%), and importantly, its chance of finishing 16th (last place) was dramatically lower (20.03%) compared to scenarios where they met later. If KR did not meet D in Round 1 (S2, S3, S4), its win percentage dropped (to 3.89%-4.61%), and its 16th place percentage skyrocketed to around 60%. This starkly illustrates that for KR, an early encounter with D was highly beneficial, not just for a slim chance at winning, but critically for avoiding an immediate exit, as KR struggled against normal teams. D's win rate was lowest (10.23%) if it met KR in R1. The format's 15-match efficiency remains, but for KR, the draw against D in R1 was paramount for survival.

- Double Elimination Format

```
--- Tournament Results (Double Elimination, 1000000 Sims, Kryptonite) ---
Overall Averages:
Team 0 (Dominant) win rate: 40.21%
Team 1 (Kryptonite)  win rate: 4.44%

Scenario 1 - Direct WB R1 (D vs KR):
Team D wins: 21.70%
Team KR wins: 4.83%
Team KR 16th place %: 11.94%

Scenario 2 - Same WB R1 Quarter (D & KR meet WB R2):
Team D wins: 39.95%
Team KR wins: 4.48%
Team KR 16th place %: 31.20%

Scenario 3 - Same WB Half, Diff Quarter (D & KR meet WB R3):
Team D wins: 48.16%
Team KR wins: 4.32%
Team KR 16th place %: 36.05%

Scenario 4 - Opposite WB Halves (D & KR meet WB Final/GF):
Team D wins: 51.01%
Team KR wins: 4.12%
Team KR 16th place %: 36.01%
```

With a Double Elimination structure, D's overall win rate was 40.21%, and KR's was 4.44%.

An early Winners Bracket (WB) Round 1 clash between D and KR (Scenario 1) yielded KR's best tournament win rate (4.83%). Significantly, this scenario also resulted in KR's lowest chance of finishing 16th overall (11.94%). As the potential WB meeting with D was delayed (S2, S3, S4), KR's win rate slightly decreased (to 4.12% in S4), but its 16th place percentage substantially increased, reaching 36.01% in S3 and S4. This suggests that even with a loser's bracket, KR benefited from facing D early to capitalize on its specific strength and to avoid being picked off by normal teams before getting that chance. D's win rate was lowest (21.70%) when meeting KR in WB R1 and highest (51.01%) when meeting in the WB Final/GF. The 30-31 match format provides more play, but KR's strategy hinges on that early D encounter.

- Hybrid Format - Group Stage with Double Elimination Format and Playoff with Single Elimination Format

```
Results (16 teams, 4000000 total simulations, Group DE + SE Playoff - Kryptonite)
==================================================
Team 0 (D) overall win %: 36.44%
Team 2 (KR) overall win %: 4.57%

Scenario 1 - D vs KR in R1 of group:
  Team D qualified for playoffs %: 40.30%
  D wins tournament %: 18.99%
  Team KR qualified for playoffs %: 47.35%
  KR wins tournament %: 5.54%
  KR last place in group %: 52.65%

Scenario 2 - D, KR Same Group, diff R1 matches, can meet in UB SF:
  Team D qualified for playoffs %: 69.22%
  D wins tournament %: 36.02%
  Team KR qualified for playoffs %: 36.39%
  KR wins tournament %: 5.02%
  KR last place in group %: 63.61%

Scenario 3 - D, KR Same Group, different group halfs, can meet in UB Finals:
  Team D qualified for playoffs %: 81.54%
  D wins tournament %: 44.69%
  Team KR qualified for playoffs %: 25.67%
  KR wins tournament %: 4.13%
  KR last place in group %: 74.33%

Scenario 4 - D, KR Different Groups:
  Team D qualified for playoffs %: 84.45%
  D wins tournament %: 46.06%
  Team KR qualified for playoffs %: 23.66%
  KR wins tournament %: 3.60%
  KR last place in group %: 76.34%
```

This hybrid format saw D achieve an overall win rate of 36.44%, with KR at 4.57%.

If D and KR met in Round 1 of their group (Scenario 1), KR had its highest tournament win percentage (5.54%). Crucially, its chance of finishing last in the group (and thus not making playoffs) was at its lowest (52.65%) in this scenario. If the group stage meeting was later, or if they were in different groups (S2, S3, S4), KR's tournament win percentage decreased (to 3.60% in S4), and its likelihood of finishing last in the group rose dramatically, up to 76.34% if in different groups. This again highlights that for KR, whose primary strength is against D, an early group match against D was vital not only for a chance to win the tournament but, more pressingly, to survive the group stage by potentially eliminating its main target or getting a strong start. D's tournament win rate was lowest (18.99%) when meeting KR in R1 of the group. This format used 27 matches.

- Hybrid Format – Swiss Stage to a Playoff with Single Elimination Format

```
Team D overall win rate: 42.34%
Team KR overall win rate: 3.75%

Scenario 1 - SN does NOT meet D in Swiss:
(Based on 7573229 Swiss stages)
Team KR qualified for playoffs: 35.74%
Team KR 1st place (when SN qual): 3.43%
Team KR 1st place (overall for this scenario): 3.76%
Team KR 16th place (failed Swiss, when SN qual): 67.30%
Team KR 16th place (failed Swiss, overall for this scenario): 64.26%
Team D qualified for playoffs: 91.00%
Team D 1st place (when SN qual): 42.34%
Team D 1st place (overall for this scenario): 42.39%
Team D 2nd place (when SN qual): 11.82%
Team D 2nd place (overall for this scenario): 11.99%

Scenario 2 - SN meets D ONCE in Swiss:
(Based on 2350755 Swiss stages)
Team KR qualified for playoffs: 35.20%
Team KR 1st place (when SN qual): 3.28%
Team KR 1st place (overall for this scenario): 3.70%
Team KR 16th place (failed Swiss, when SN qual): 68.65%
Team KR 16th place (failed Swiss, overall for this scenario): 64.80%
Team D qualified for playoffs: 90.69%
Team D 1st place (when SN qual): 42.28%
Team D 1st place (overall for this scenario): 42.30%
Team D 2nd place (when SN qual): 11.74%
Team D 2nd place (overall for this scenario): 11.93%
```

In this hybrid system, team D overall win rate was 42.34%, and KR was 3.75%.

Whether KR met D once in the Swiss stage (S2) or not at all (S1) had a minimal impact on KR's already low overall tournament win percentage (3.70% vs. 3.76%). However, KR's chance of failing to qualify from the Swiss stage (equivalent to a "16th place" finish here) was very high in both scenarios: 64.26% if not meeting D, and 64.80% if meeting D once. KR's playoff qualification rate was also similar (around 35%). This suggests the forgiving nature of Swiss and KR's general weakness against normal teams meant that even taking out D (if it happened) didn't guarantee progression, as multiple wins are needed. D's tournament win rate was almost identical in both Swiss scenarios (around 42.3%). While this format is fair, KR's specific weakness profile meant it struggled to advance regardless of the D encounter in Swiss, making this the least effective format for KR to leverage its unique strength. This format was the least efficient with 38-42 matches.

V. Conclusion

This experimental comparative analysis has successfully demonstrated the profound and nuanced impact of tournament format selection on competitive outcomes, fairness, and operational efficiency across various team dynamics. The study delineates between two primary categories: "single format tournaments," such as pure Single Elimination (SE) or Double Elimination (DE), and "hybrid formats," which typically incorporate a qualifier stage (like Swiss or DE Groups) leading to playoffs. These hybrid structures generally enhance fairness by providing more matches and opportunities for teams to prove their mettle before elimination, but usually at the cost of reduced efficiency due to an increased match load.

The findings confirm that SE, while most efficient, is highly susceptible to draw luck, where an early encounter with a Dominant (D) team is detrimental for "normal" teams but often strategically vital for "Hard Counter" (CT) or

"Kryptonite" (KR) teams. DE significantly improves fairness through its second-chance mechanism, bolstering D's consistency and offering more pathways for CTs, albeit with a greater match load. Hybrid formats offer varied balances: Group DE followed by SE playoffs provides an intermediate solution, while the Swiss Stage followed by SE playoffs shows the highest qualifier fairness, largely neutralizing the impact of early D encounters against CT/KR and unlucky SN teams facing D. during the Swiss phase itself, though it is the most resource-intensive. The distinct needs of each team archetype were highlighted: D teams thrive in more forgiving formats; normal teams benefit from avoiding D early; CTs often gain by confronting D sooner; and KR teams are critically dependent on an immediate D matchup for any chance of success, struggling otherwise due to general weakness.

Practically, the optimal format choice is contingent upon an organizer's specific goals, balancing the desire for competitive integrity and fairness against logistical constraints and desired tournament length. Therefore, while a Swiss system might be ideal for maximizing fairness in qualification, its length may be unideal. Conversely, SE's speed comes with more randomness. It is important to note that this analysis assumed purely random seeding for almost all scenarios. The results consistently underscore the importance of deliberate format selection.

Future studies could expand on these findings by integrating various seeding methodologies, which could further enhance fairness and potentially alter the observed dynamics by more systematically controlling early-round matchups. Overall, this research emphasizes that the architecture of a tournament is a critical factor in shaping its narrative, the perceived justice of its outcomes, and the strategic considerations for all participating teams.

VI. Appendix

Programs for simulations:
https://github.com/Berdzhart/TournamentFormatAnalysis

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PERNYATAAN

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