Minimising the risk of tanking in tournaments with a preliminary round-robin group stage

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Abstract

Multi-stage tournaments consisting of a round-robin group stage followed by a knock-out phase are ubiquitous in sports. However, as has been verified recently, this format is incentive incompatible if at least two teams from a group advance to the knock-out stage where the brackets are predetermined. A framework is proposed to quantify the risk of tanking in these types of tournaments. Our model is applied to the 2022 FIFA World Cup in order to uncover how its design could have been improved by changing the set of groups to be finished before their pairs, a component that has received no attention in the previous literature. Using the suggested approach, tournament organisers are able to compare all feasible schedules at the time of the draw and choose an optimal sequence of matches with respect to avoiding tanking.

Keywords: OR in sports; FIFA World Cup; simulation; sports scheduling; tanking

MSC class: 90-10, 90B90, 91B14

JEL classification number: C44, C63, Z20

Eben diese Mannigfaltigkeit der Gegenstände entsteht bei der Prüfung der Mittel, je höher man mit dem Standpunkt hinausrichtet; denn je höher die Zwecke liegen, um so größer ist die Zahl der Mittel, welche zu ihrer Erreichung angewendet werden.¹

(Carl von Clausewitz: Vom Kriege)

¹ “The same multiplicity of circumstances is presented also in the examination of the means the higher our point of view, for the higher the object is situated, the greater must be the number of means employed to reach it.” (Source: Carl von Clausewitz: On War, Book 2, Chapter 5 [Criticism]. Translated by Colonel James John Graham, London, N. Trübner, 1873. http://clauswitz.com/readings/OnWar1873/T0C.htm)
1 Introduction

Several sports tournaments are organised in a hybrid format: a preliminary stage played in round-robin groups is followed by the knockout phase. Usually, the top $\ell$ teams in each group advance to the knockout stage such that higher-ranked teams face lower-ranked teams in the first knockout round. Group rank is supposed to reflect team abilities, that is, the group winners are on average stronger than the runners-up. Consequently, every team is interested in winning if its opponent in the first knockout round is chosen randomly such as in the UEFA Champions League, the most prestigious European club football competition.

However, in the case of predetermined knockout brackets, almost all real-world tournaments are vulnerable to tanking, the act of deliberately dropping points or losing a game in order to gain an advantage: according to Vong (2017), the necessary and sufficient condition for incentive compatibility is to allow only the top-ranked player to qualify from each group. The reason is that the runner-up in group $i$ can be stronger than the winner due to bad luck, thus, the teams playing in other groups want to face the winner of group $i$ rather than the runner-up.

There are a number of instances when this problem caused serious issues of unfairness. Perhaps the most famous example is the women’s doubles badminton tournament of the 2012 Olympic Games (Kendall and Lenten, 2017, Section 3.3.1). Here, four teams were ejected because of “not using one’s best efforts to win a match” and “conducting oneself in a manner that is clearly abusive or detrimental to the sport”. They were accused of trying to lose in order to get (perceived) easier draws in the knockout stage of the competition.

Analogously, the Indonesian defender Mursyid Effendi deliberately scored an own goal during a soccer game between Thailand and Indonesia at the 1998 AFF championship (Kendall and Lenten, 2017, Section 3.9.2). Both teams already secured a place in the semifinals but the group winner would have to play against the host Vietnam in another city, and the runner-up would have to play against Singapore without travelling, which was seen as the better option. The Fédération Internationale de Football Association (FIFA) fined both teams for “violating the spirit of the game” and banned the Indonesian player for life from international football.

Naturally, an organiser ought to take many factors other than incentive (in)compatibility into account when designing a tournament such as time constraints and the number of matches. Nonetheless, it is important to mitigate the threat of tanking if it can be achieved by a minimal change in the competition. The current paper will study that issue and show how an appropriate rescheduling of some matches to another time frame on the same day can improve fairness.

Our main contributions can be summarised as follows:

- We develop a framework to quantify the risk of tanking in hybrid contests with a predetermined knockout bracket, a format used in the majority of international sports tournaments such as the FIFA World Cup, the UEFA European Championship, the IHF World Handball Championship, or the FIBA Basketball World Cup.

- We uncover that, besides the well-known role of the sequence of group matches in promoting attractiveness and competitiveness, the order of the last round in two groups can also not be neglected in this setting.
We propose changes to the format of the 2022 FIFA World Cup that would have reduced its inherent unfairness.

To conclude, the proposed method can be used by tournament designers to evaluate alternative schedules at the time of the draw and choose an option that reduces the probability of a match with misaligned incentives to the extent possible.

The remainder of the study is organised as follows. Section 2 provides a concise literature overview. The methodology is presented in Section 3, and the results for the 2022 FIFA World Cup are provided in Section 4. Finally, Section 5 concludes.

2 Related literature

Since tanking is felt as being against the spirit of the game, it is a standard topic of academic research. Kendall and Lenten (2017) discuss a number of examples from various sports. In particular, the traditional player draft used to ensure competitive balance in major North American and Australian sports creates perverse incentives to lose after a team is eliminated from the playoff (Fornwagner, 2019; Price et al., 2010; Taylor and Trogdon, 2002). Many solutions have been proposed to mitigate this problem (Banchio and Munro, 2021; Gold, 2010; Kazachkov and Vardi, 2020; Lenten, 2016; Lenten et al., 2018).

Inspired by the women’s doubles badminton tournament of the 2012 Olympics, Pauly (2014) suggests a mathematical model of strategic manipulation in complex sports competitions. An impossibility theorem is proved to demonstrate that strategy-proofness cannot hold under some reasonable constraints. As already mentioned in the Introduction, Vong (2017) gives the necessary and sufficient condition for incentive compatibility in multistage tournaments: only the group winner can qualify for the next stage.

Tanking can emerge not only because an advantage is gained in expected terms but also unintentionally, due to misaligned tournament rules. Dagaev and Sonin (2018) reveal how incentive compatibility should be guaranteed in qualification systems composed of one round-robin and several knockout tournaments. Neglecting this result has led to problems in the UEFA Champions League qualification (Csató, 2019) and in the UEFA Champions League seeding (Csató, 2020b), as well as in the qualification for the 2020 UEFA European Championship (Csató, 2021b; Haugen and Krumer, 2021). Further tournament designs allow for the possibility that a team can be strictly better off by losing, too (Csató, 2018, 2020a,c, 2022c).

However, all these studies consider strategy-proofness as a binary concept and do not attempt to measure the degree of its violation. Csató (2022d) presents the first method to quantify incentive incompatibility through the example of the European Qualifiers for the 2022 FIFA World Cup.

A recent line of literature deals with the issue of how the order of matches influences the probability of collusion, match-fixing, and tanking in sports tournaments. Guyon (2020) calculates the risk of collusion as a function of the schedule in groups of three teams, which will be used in the 2026 FIFA World Cup. Stronka (2020) introduces the so-called unanimity pair matching method. This matches the winners of two adjacent groups if they unanimously express their preference for playing with each other. The novel policy can substantially reduce the temptation to lose in the FIFA World Cup. Chater et al. (2021) develop a general method to assess the competitiveness of matches played in the last round of the FIFA World Cup group stage. The choice of teams playing each other is found to be crucial to see exciting and fair games even in the last round. We will adopt
their thoroughly checked simulation model in Section 3. Csató et al. (2022) determine the probability of stakeless matches (with one team or both teams being indifferent as the outcome does not affect their rank) in the UEFA Champions League group stage under alternative schedules.

Instead of the sequence of games, Csató (2022b) studies the effect of tie-breaking rules on the likelihood of situations where a team has few incentives to exert full effort. Finally, Guyon (2022) proposes a radical reform in the knockout format of sports tournaments to solve most of these problems: the teams performing best during the group stage can choose their opponents.

Since we recommend modifying the kick-off time for certain matches, it is worth noting that this may affect attendance as a share of the capacity of the stadiums (Krumer, 2020).

3 Methodology

This section presents a framework that allows quantifying the risk of tanking. Even though our simulation model is customised for the FIFA World Cup in Section 3.1, the approach outlined in Section 3.2 can be applied in other sports competitions, taking the limitations detailed in Section 3.3 into account.

3.1 The simulation model

The FIFA World Cup takes place every four years and is organised in the current format since 1998. Hence, the scarce historical data cannot be directly used to evaluate the threat of tanking. However, they provide a solid basis to simulate the outcomes of the games. Thus, an arbitrary number of fictional but reasonable tournaments can be generated as usual in the tournament design literature (Csató, 2021a; Lasek and Gagolewski, 2018; Ley et al., 2019; Scarf et al., 2009).

The prediction model for individual games is a fundamental element of any simulation method. Poisson models, first suggested by Maher (1982), are perhaps the most popular to generate football match results. According to the underlying assumption, the number of goals scored by both teams follows a Poisson distribution. In particular, team \( i \) scores \( k \) goals against team \( j \) with a probability of

\[
P_{ij}(k) = \frac{\left( \lambda_{ij}^{(f)} \right)^k}{k!} \exp \left( -\lambda_{ij}^{(f)} \right),
\]

where \( \lambda_{ij}^{(f)} \) is the expected number of goals scored in this match played on field \( f \).

We adopt the model of Chater et al. (2021), which is fitted on the basis of all (192) matches played in the first two rounds of the World Cup group stage between 1998 and 2018. The last round of games is not taken into account because other factors than team performance may play a role in determining the result. Chater et al. (2021) have compared this approach to some alternatives and concluded that its parameters can be clearly interpreted, is not worse than other exact-score models, and is competitive with an ordered logistic regression to predict wins, draws, and losses.

Therefore,

\[
\lambda_{ij} = \alpha \frac{R_i}{R_i + R_j},
\] (1)
where \( R_i \) and \( R_j \) are the strengths of teams \( i \) and \( j \), respectively, while parameter \( \alpha \) equals the average number of goals scored in the sample.

A team’s strength is based on a single variable, its Elo rating. Although FIFA adopted the Elo method of calculation after the 2018 World Cup for its own World Ranking (FIFA, 2018), the formula does not take into account two crucial aspects, home advantage and the margin of victory. Furthermore, the FIFA World Ranking suffered from severe shortcomings before 2018 (Cea et al., 2020; Csató, 2021b; Kaminski, 2022; Lasek et al., 2016). On the other hand, the World Football Elo Ratings seems to be a reliable measure of teams’ abilities (Gásquez and Royuela, 2016; Hvattum and Arntzen, 2010; Lasek et al., 2013), and is a widely used benchmark in the tournament design literature (Csató, 2022a,b,d,e; Stronka, 2020).

Since the raw Elo indices fluctuate between 1400 and 2200 in the FIFA World Cup, Chater et al. (2021) adjust the performance differences by a linear transformation of the original Elo rating \( E_i \):

\[
R_i = 1 + \exp (\beta) \cdot \frac{E_i - E_{\min}}{E_{\max} - E_{\min}},
\]

which is finally plugged into (1). Here \( E_{\min} = 1471 \) (the minimal Elo rating in the sample) and \( E_{\max} = 2142 \) (the maximal Elo rating in the sample).

The model contains two parameters, \( \alpha \) in formula (1) and \( \beta \) in formula (2). The estimations of Chater et al. (2021, Table 5) are adopted, namely, \( \alpha = 2.5156 \), which equals the average number of goals per match in the sample, and \( \beta = 3.7581 \). Chater et al. (2021) calculate a number of statistics from the chosen Poisson model in order to compare them with the sample data. These checks suggest that the simulation framework provides a good approximation of the actual score-generating process.

Finally, the strengths of the teams playing in the 2022 FIFA World Cup should be obtained. The Elo rating is a dynamic measure, updated for both teams after they play a match. Consequently, the Elo ratings move between the draw, the announcement of the schedule, the beginning of the tournament, as well as during the tournament. Since we think the appropriate time to determine the schedule coincides with the draw of the groups that took place on 1 April 2022, the Elo ratings of 31 March 2022 are used to measure team abilities, see Table 1.\(^2\)

Even though this simulation model of Chater et al. (2021), is not necessarily the best available option even for the FIFA World Cup, the exact prediction method is not an essential part of our proposal. The tournament organiser is free to choose any exact-score generating model according to its preferences, and repeat the process described in Section 3.2.

### 3.2 Quantifying the threat of tanking

The 2022 FIFA World Cup contains eight groups labelled from A to H. The top two teams from each group advance to the Round of 16, where the group winner of group \( i \) plays against the runner-up of the pair of group \( i \), denoted by \( i^* \). The groups are paired in alphabetical order: A–B, C–D, E–F, G–H. The last rounds of these pairs of groups are played on the same day but at different times. Therefore, if group \( i \) is finished, all teams in group \( i^* \) know before the two matches played in the last round their opponents in the

\(^2\) Csató (2022a) used the same Elo ratings to analyse the 2022 FIFA World Cup draw but the Elo of Argentina contained a typo: it was assumed to be 2018 instead of the correct 2108.
Table 1: Groups and teams in the 2022 FIFA World Cup

| Country     | Group A | Country     | Group B |
|-------------|---------|-------------|---------|
| Qatar       | 1663    | England     | 2039    |
| Netherlands | 1938    | United States | 1822   |
| Senegal     | 1729    | Iran        | 1820    |
| Ecuador     | 1840    | Wales       | 1841    |
| Senegal     | 1729    | Iran        | 1820    |
| Ecuador     | 1840    | Wales       | 1841    |

| Group C                                      | Group D                                      |
|----------------------------------------------|----------------------------------------------|
| Argentina                                   | France                                       |
| 2108                                         | 2116                                         |
| Mexico                                      | Denmark                                      |
| 1848                                         | 1936                                         |
| Poland                                      | Australia                                    |
| 1799                                         | 1677                                         |
| Saudi Arabia                                | Tunisia                                      |
| 1634                                         | 1612                                         |

| Group E                                      | Group F                                      |
|----------------------------------------------|----------------------------------------------|
| Spain                                       | Belgium                                      |
| 2039                                         | 2069                                         |
| Germany                                     | Croatia                                      |
| 1966                                         | 1855                                         |
| Japan                                       | Morocco                                      |
| 1796                                         | 1738                                         |
| Costa Rica                                  | Canada                                       |
| 1743                                         | 1798                                         |

| Group G                                      | Group H                                      |
|----------------------------------------------|----------------------------------------------|
| Brazil                                      | Portugal                                     |
| 2155                                         | 1984                                         |
| Switzerland                                 | Uruguay                                      |
| 1920                                         | 1923                                         |
| Serbia                                      | South Korea                                  |
| 1845                                         | 1800                                         |
| Cameroon                                    | Ghana                                        |
| 1631                                         | 1541                                         |

The rating of the host Qatar is increased by 100, the fixed value of home advantage in the World Football Elo Ratings, see http://eloratings.net/about.
The column Elo shows the strength of the teams according to the World Football Elo Ratings as of 31 March 2022, see https://www.international-football.net/elo-ratings-table?year=2022&month=03&day=31.

Round of 16 as the group winner (the runner-up of group $i$) or the runner-up (the winner of group $i$).

This creates an incentive for tanking in group $i^*$ if the winner of group $i$ is perceived to be weaker than the runner-up of group $i$. Because the Elo ratings are common knowledge, the risk of tanking is assumed to emerge in group $i^*$ if the winner of group $i$ has a lower Elo than the runner-up of group $i$. Thus, a simulation run consists of the following steps:

1. All matches in groups $i$ and $i^*$ are played such that the teams exert full effort, that is, the outcomes are generated according to the simulation model described in Section 3.1;

2. Final rankings in groups $i$ and $i^*$ are determined;

3. Variable $k$ is set as $k = 1$;

4. If the winner of group $i$ has a lower Elo than the runner-up of group $i$, then the score of the team that plays against the winner of group $i^*$ in the last round is increased by $k$ in this particular match;
5. The final ranking in group $i^*$ is recomputed since the original group winner conceded $k$ additional goals in its last match;

6. A tanking opportunity with $k$ goals is registered in group $i^*$ if the original winner of group $i^*$ is the runner-up under the changed results.

Otherwise, $k$ is increased by one and the process returns to Step 4.

The reason behind the modification of game outcomes is that the winner of group $i^*$ will be better off by allowing its opponent to score more goals if it will become the runner-up due to this manipulation. The simulation run is finished without finding a tanking opportunity if $k > 10$, that is, a successful tanking by the original winner of group $i^*$ is impossible or requires that more than 10 additional goals are scored by its opponent in the last round.

The cost of a tanking opportunity for the organiser is likely not uniform. First, the temptation to tank in group $i^*$ is stronger if the difference between the Elo ratings of the winner ($E_1$) and the runner-up ($E_2$) in group $i$ is smaller. Second, tanking is easier to implement if $k$, the number of goals that need to be conceded, is smaller. Hence, not only the number of tanking opportunities is counted, but they are also be weighted according to the following formula:

$$WT = (E_2 - E_1)/(100 \times k).$$

The ranking criteria follow the official rule (FIFA, 2022, Article 12): (1) higher number of points obtained in all group matches; (2) superior goal difference in all group matches; (3) higher number of goals scored in all group matches; (4) higher number of points obtained in the group matches between the teams concerned; (5) superior goal difference resulting from the group matches between the teams concerned; (6) higher number of goals scored in the group matches between the teams concerned; (7) drawing of lots. The fair play points based on yellow and red cards are not considered despite this criterion being applied before drawing of lots in the FIFA World Cup.

The matches played in the last round of the group stage, used to determine the team against which the tanking strategy is applied, are presented in Table 2.

The simulation process is repeated 1 million times.

### 3.3 Limitations

Besides the standard caveats of using simulation models, the identification of tanking remains imperfect because of the following reasons:

- The teams do not focus only on their opponent in the Round of 16 but on the difficulty of the whole knockout bracket (e.g., a team may intend to avoid playing Brazil before the final even if it implies a stronger opponent in the Round of 16);

- Elo rating is not necessarily a good indicator of preferences in the Round of 16 (e.g., a European team might want to avoid playing against another European team in the knockout stage);

- Tanking is assumed to be a unilateral action from the original winner of group $i^*$, however, the other competitors for the top two positions in group $i^*$ can also take the possible manipulation of this team into account;
Table 2: Matches played in the last round of the 2022 FIFA World Cup

| Group   | Team 1     | Team 2     |
|---------|------------|------------|
| Group A | Qatar      | Netherlands|
|         | Senegal    | Ecuador    |
| Group B | England    | Wales      |
|         | United States | Iran   |
| Group C | Argentina  | Poland     |
|         | Mexico     | Saudi Arabia|
| Group D | France     | Tunisia    |
|         | Denmark    | Australia  |
| Group E | Spain      | Japan      |
|         | Germany    | Costa Rica |
| Group F | Belgium    | Croatia    |
|         | Morocco    | Canada     |
| Group G | Brazil     | Cameroon   |
|         | Switzerland | Serbia     |
| Group H | Portugal   | South Korea|
|         | Uruguay    | Ghana      |

- Tanking strategies may be applied even if the opponents in the Round of 16 are not certainly known (e.g. a team may be tempted to avoid Brazil even if it is only a likely runner-up);

- The group winner might be already known after two rounds are played (but, according to Stronka (2020, p. 9), such a situation has a low probability).

Nonetheless, in our opinion, these compromises should be accepted in order to get a tractable model of tanking.

4 Analysing the design of the 2022 FIFA World Cup

Due to the shortcomings of the model presented in Section 3.3, the probability of tanking derived from the simulations may be inaccurate and has limited meaning on its own. However, the results are appropriate to compare alternative tournament designs since any model within reason can be taken to that end (Appleton, 1995). Such a comparative study requires the identification of options available for the organiser. The reasons behind the choice of the schedule are not communicated by FIFA, hence, we are not sure that the sequence of matches in a given group can be easily modified. Furthermore, this question has been extensively discussed in the literature (Chater et al., 2021; Guyon, 2020; Stronka, 2020).

On the other hand, the order of the last rounds in a group and its pair seems to be a natural decision variable: compared to the current schedule, it requires only moving some matches to an earlier/later kick-off time on the same day. Therefore, it is assumed that FIFA could determine whether Group A (C/E/G) is finished before Group B (D/F/H) or vice versa as the regulation of the World Cup does not specify this aspect of the tournament schedule (FIFA, 2022, Article 9.4).
Figure 1: The number of tanking opportunities in the 2022 FIFA World Cup (out of $10^6$ simulation runs, log scale)

Figure 1 shows the number of tanking opportunities identified out of 1 million simulation runs for the four pairs of groups as a function of the number of goals that the winner of the group finished later should concede to get a more favourable opponent in the Round of 16 compared to the full effort case. Unsurprisingly, a successful manipulation mainly requires few goals to concede, which makes it easy to implement in practice. There are no great differences between the pairs of groups since the draw procedure aims to produce groups at roughly the same competitive level (Csató, 2022a). Our policy tool, the choice of kick-off time in the last round, is not a silver bullet: it is impossible to reduce the threat of tanking by orders of magnitude. However, even a slight decrease is
of great value because it has essentially no price regarding all other characteristics of the tournament.

The threat of tanking is quantified in Table 3 without accounting for its hardness (the number of goals that need to be conceded) and benefits (the difference between the Elo ratings of the winner and the runner-up in the other group). The recommendation is able to reduce the probability of tanking by more than 0.6 but less than 4.5 percentage points in absolute terms. In relative terms, the reduction is between 2% and 17%. The schedule of the 2022 FIFA World Cup is optimal only for one pair of groups from this perspective.

However, as we have argued in Section 3.2, a weighted measure of tanking probably reflects better the seriousness of the problem. This is reported in Table 4. Now our proposal is more effective, an optimal order of two groups can decrease the mean of weighted tanking $WT$ by 10 to 51%. The latter occurs for the pair of Groups G and H, where the first group contains Brazil, which has a robust advantage in Elo rating over the other three teams. Therefore, it would be a great mistake to finish Group G before Group H: if Brazil would only be the runner-up due to bad luck, then strong incentives exist to avoid winning Group H. The danger can be eliminated by finishing Group H before Group G as has been done in the 2022 FIFA World Cup. To a certain extent, the same argument holds in the relation of Groups E and F, where Belgium is clearly the favourite in Group F but Spain is not much stronger than Germany in Group E. The format of the 2022 FIFA World Cup is not optimal with respect to our weighted tanking measure for Groups E and F, as well as for Groups C and D.

To conclude, the structure of the 2022 FIFA World Cup has seemingly been chosen without considering the risk of tanking in the last round of group matches. It is suggested to optimise the design of future tournaments for this factor in the relatively general framework provided above.
5 Conclusions

The current paper has investigated hybrid sports tournaments consisting of a group stage followed by a knockout phase. If the knockout brackets are predetermined, then misaligned incentives may arise in the groups that are finished later as illustrated by several historical examples. Therefore, it is crucial to determine a schedule for the group matches which minimises the risk of tanking. For this purpose, we have proposed an optimisation model based on simulating game results and identifying the situations where deliberately conceding some goals can be beneficial for a team.

Our framework has been applied to the 2022 FIFA World Cup. The findings uncover that the design of this tournament could have been improved by changing the set of groups to be finished before their pairs. Admittedly, the suggested reform is not a strong tool in mitigating incentive incompatibility compared to adding further draw constraints in the European Qualifiers for the 2022 FIFA World Cup (Csató, 2022d). However, it is worth considering because the attractiveness and competitiveness of the matches played in the last round can be increased without influencing any other aspect of the competition.

Hopefully, our work will inspire future research to quantify the degree of violating incentive compatibility and further desired properties of tournament designs. Such a project can explore the inevitable trade-offs between various aims of the organiser and, ultimately, contribute to increasing the fairness of sports tournaments and making the matches more exciting.

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