Manipulation unraveled: a new framework to analyze the impact of tournament design on manipulation opportunities

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Abstract

Manipulation in sports competitions is widespread, but knowledge about how tournament design creates opportunities for manipulation is limited and scattered. Therefore, the goal of this study is to first identify manipulation opportunities caused by the way tournaments are designed. Secondly, we analyze which tournament designs are most vulnerable and most robust towards each opportunity. Based on a thorough review of a broad range of literature, a framework is developed to categorize manipulation opportunities. The proposed framework consists of two dimensions: whether benefits are guaranteed, and whether cooperation is needed. If the possibility of manipulation cannot be avoided, we present remedies from the literature that mitigate these opportunities. Finally, we present a flowchart that shows the impact of tournament design on the occurrence of manipulation opportunities. This framework provides valuable insights for managers and practitioners who wish to limit manipulation in sports tournaments.

Keywords: competition format, framework, incentive compatibility, manipulation, tournament design

1 Introduction

Every sport needs rules. Where the (sporting) rules of the game describe how an individual sport game is played, the tournament design refers to the rules that determine how the tournament – a series of games between a number of competitors, competing for one or more overall prizes – is organized. The most defining features of any tournament design are the qualification rules (including promotion and relegation), format, seeding and draw, schedule, ranking and prize allocation.[1] Qualification rules designate how players can qualify for a sports tournament. The format of a tournament determines the set of matches that need to be played, based on how opponents are matched against each other. In the popular double round robin, for example, each player faces each other player twice. The time (and location) in which these matches are played is designated by the schedule. In knockout tournaments, where a player is eliminated after one loss, seeding is typically used to avoid that strong players are eliminated in earlier stages against even stronger opponents. In contrast, subject to some constraints, a draw allocates players randomly. Ranking rules define how players are compared to each other. Lastly, the prize allocation states how the prizes are distributed over the participants. Ideally, the tournament design should be such that players cannot benefit from losing instead of winning a game[2], and have an incentive to "give it their best". If a player does not exert full effort because not winning is deemed more advantageous, it is said that the player *manipulates*. A tournament in which incentives for manipulation may arise is called *incentive incompatible*.[3, 2, 4] In contrast, a tournament that eliminates any incentive for manipulation is called *strategy-proof*.

The history of manipulation is probably as old as organized sport itself. Huggins[5] describes a case from the 98th Olympic games, 388 BC, of a boxer named Eupolus bribing three of his opponents. Since then, sixteen intimidating Zane statues were erected, financed with the money collected from fines imposed upon bribery-corrupted persons and cities. These statues reminded the athletes to always give it their best. The Olympic committee of today still

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requires athletes to follow this principle: "*Participants in the Olympic Games must not, by any manner whatsoever, manipulate the course or result of a competition, or any part thereof, in a manner contrary to sporting ethics, infringe the principle of fair play or show unsporting conduct*"[Article 10][6]. This principle is not only central in the Olympics, but in every sports event.

A player might manipulate for a variety of reasons. In a review of Vanwersch et al.[7] on the causes and consequences of fraud in sports, a distinction is made between betting-related and non-betting-related manipulation. In the case of the former, financial gains related to betting activities motivate the player to deliberately withhold effort. In the case of the latter, however, the manipulation is often linked to sporting and competitive outcomes.[8, 9] The motivation of performing well in a tournament may of course be related to financial benefits.[10, 8] However, because the financial reward only follows the sporting accomplishment, the motivation to initiate manipulation in case of non-betting related manipulation is assumed to be of competitive nature. Interestingly, it was found that incentives for non-betting-related manipulation almost always result from the way the tournament was designed.[7] Hence, for league managers, redesigning tournaments to make them strategy-proof can be a more efficient and effective way to reduce manipulations compared to fair play campaigns. Nonetheless, the literature in the field of sport management has mainly focused on the individual and organizational drivers for engaging in match-fixing.[11, 7, 12] Notwithstanding the need to increase moral [13] and to develop preventive measures against manipulation of sports competitions[14], certain forms of manipulating competition can most simply be reduced by taking away the potential sporting benefits that can be gained by manipulating.

Devriesere et al.[1] give a thorough overview of tournament design choices and their impact on fairness, however, they do not discuss manipulation. Still, research about non-betting related manipulation, from here on simply called manipulation, in sports tournaments has seen a growing interest in the last decade. The review paper of Kendall and Lenten[15] gives an extensive overview of sports rules that cause obscure incentives and unintended consequences. They structure their review based on the type of sports, discussing for each type several rules that led to undesirable consequences. Csató[4] presents various examples and theoretical results about the *incentive compatibility* and *fairness* of tournament designs. A recent review of Medcalfe[16] discusses how tournament design affects the behavior of players; manipulation is briefly touched upon. In contrast to Kendall and Lenten[15], the goal of our study is to focus on tournament design in general instead of rules specific to certain sports. Moreover, instead of focusing on a small subset of manipulation opportunities as in the works of Csató[4] and Medcalfe[16], we construct a framework such that we can identify and analyze a wide variety of manipulation opportunities. To the best of our knowledge, no unifying framework categorizing manipulation opportunities has been developed yet.

Although not restricted to Olympic sports, the framework is particularly relevant for sports federations, the International Olympic Committee (IOC), and the Organizing Committees responsible for structuring the Olympic Games. Each Olympic competition functions as a tournament, with formats often determined by federations in collaboration with the IOC and host organizers.

The rest of this paper is organized as follows. First, the scope and methodology are briefly discussed. Next, we introduce some background literature that will be relevant in identifying manipulation opportunities. In the following two sections, the proposed framework is presented. We will use the existing literature to present examples, as well as to indicate which tournament designs are most robust and most vulnerable toward each opportunity. From this comprehensive analysis, we deduce and present several managerial insights. Finally, the last section gives the limitations of this work and concludes.

2 Scope and Methodology

We focus on sports tournaments where players compete in pairs. In such tournaments, a confrontation between two players is called a game or a match. Hence, we exclude races and jury sports. Moreover, although a clear link is present between a draft mechanism and manipulation, we also exclude it here. The reason for this is that it is more related to organizational processes to allocate players to teams than to the design of a tournament. In addition, we explicitly delineate the scope of this review by excluding economics literature on tournaments unrelated to sports. The reason for this is that many of the problems inherent to the field of economics such as procurement, contest theory and mechanism design are already described in large literature reviews. Moreover, there is often no clear cut connection between these abstract mechanism design problems and the particular formats of sports competitions.

To identify relevant literature, we used the two databases Google Scholar and Web of Science. We did not put any restrictions on the time frame. The following search string was used in both databases: ("incentive compatible" OR "strategy-proof" OR "manipulation" OR "match-fixing") AND ("sports" OR "tournament" OR "competition" OR "design" OR "format" OR "schedule"). These keywords were identified as yielding promising directions during the exploratory searches. Once an initial set of articles was found, we filtered the articles based on whether the dis-

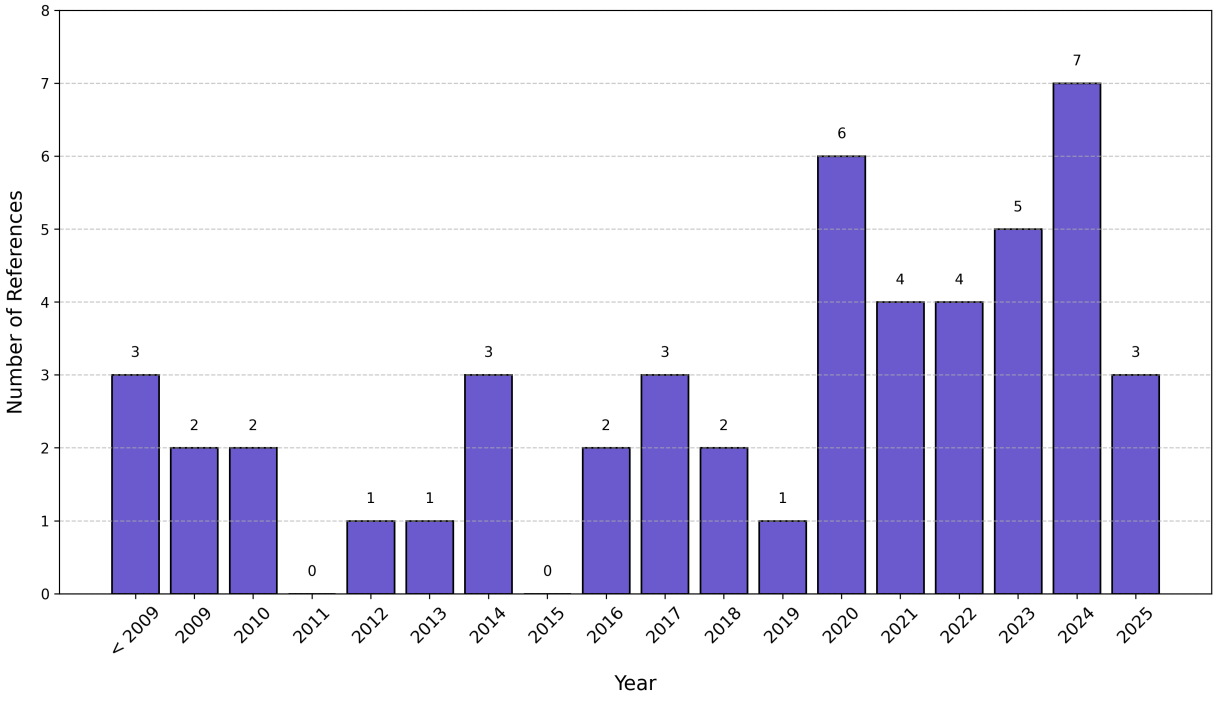

Figure 1: Number of academic works that deal with both tournament design and manipulation opportunities by year (n=49).

cussed manipulation opportunity was caused or influenced by, directly or indirectly, a tournament design choice. Furthermore, we omit those contributions that are not in line with our scope.

Next, the snowball sampling method [17] was used to find further relevant articles. This involves searching the reference list of the selected articles and is a well known method to accompany database searches, as it confirms saturation and ensures comprehensiveness.[18, 19] A first search was performed on 20th September 2024, while a second search was made on 10th March 2025.

Figure 1 shows the number of included academic works that deal with both manipulation opportunities and tournament design. These articles are marked in the reference list by an asterisk (*). As can be seen from the plot, research in this field began sparking interest from 2009 on and has seen a significant increase in the last five years.

These articles illustrate the impact of specific tournament design choices on opportunities for manipulation, thereby establishing the foundation of our proposed framework (Figure 3) and flowchart (Figure 4). Before delving into these contributions, the following section provides an overview of the relevant background literature, focusing on three key topics: tournament formats, perceived match importance, and the measurement of strategy-proofness. The terminology and definitions introduced in this section are frequently referenced throughout the discussion of each manipulation opportunity.

3 Related literature

3.1 Tournament formats

The format of the tournament designates which games are to be played throughout the tournament. At the heart of tournament design lie two basic formats: round robin and knockout tournaments. While in a round robin tournament, each team plays a fixed number of games, knockout tournaments are characterized by the fact that teams may be eliminated from the tournament after losing, and hence the number of games they play depends on their results.

In a k-round robin (kRR), each participant faces all other participants k times. Since a 1RR is typically called a "single round robin" and a 2RR is called a "double round robin", we will use the notations SRR and DRR, respectively, for these tournament formats. In case $k \geqslant 2$, the kRR usually can be split up into k *phases* (also called *legs*), such that in each phase, each opponent faces each other opponent once.

In an incomplete round robin tournament (iRR), the number of teams is higher than the number of games played

by a team plus one. They each play the same number of games, but they only face a subset of their opponents.[20] The so-called Swiss tournament is an incomplete round robin tournament, where each team's opponents are determined as the tournament proceeds. Indeed, the pairs of teams that are matched together depend on their results in the previous matches. A typical approach is to pair players with similar historical results. The Swiss system is often used in chess.[21, 22, 23, 24]

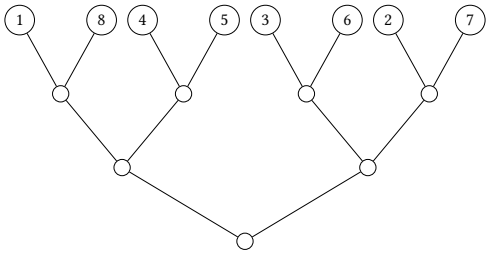

Figure 2: SKO with standard seeding

In a single knockout tournament (SKO), teams only have one chance to advance to the next round. A SKO of n teams can be represented by a binary tree with n leaf nodes and one root node. It is common to label the teams with a number from 1 to n representing the strength of the team (1 being the strongest team and n the weakest). Seeding is often used to avoid that the strongest contestants face each other already in the beginning of the competition. [1]

In a double knockout (DKO) tournament, one loss is allowed in the tournament [25, 26]. This format is organized as two separate SKOs: the first SKO is called the main tournament, while the second SKO is called the consolation tournament. If a participant loses in the main tournament, it moves to the consolation tournament. A loss in the consolation tournament leads to the exit of the participant. If the winner of the main tournament loses the final match against the winner of the consolation tournament, a rematch is played between these two participants. Another possibility is the knockout tournament with repechage. In this case, the winner of the main tournament is the winner of the tournament as a whole, while the bronze medal is given to the winner of the consolation (repechage) tournament.

More complicated formats can be built with these two basic formats. In a multistage tournament, the tournament is divided into multiple stages. If the number of teams is large, the first stages of the tournament are typically organized as group stages. Each team is distributed into one of the groups. Each group then plays a sub-tournament, with the best teams (typically two) of each group advancing to the next stage.

3.2 Perceived match importance

When considering the vulnerability of matches towards manipulation, it is useful to classify a match based on how important that match is to both players. A match $i - j$ is said to be important for i with respect to some prize X (e.g. qualifying for the playoffs) if its result in that match could make the difference between winning and losing X. If i is already sure it will get prize X, no matter the result of the match, i is indifferent and does not deem the match to be important with respect to X. The same result applies if i has no chance anymore of obtaining X. Then, a match can be classified into three categories: either the match is important to both players, to exactly one of the players, or to none of the players. Csató et al.[27] call these matches *competitive*, *weakly stakeless* and *strongly stakeless*, respectively. Moreover, Csató and Gyimesi[28] classify stakeless matches based on their expected outcome. Such matches are considered more detrimental when the indifferent team is more likely to win by playing honestly, as opposed to when it is likely to lose regardless of its incentives. In contrast, Chater et al.[29] do not distinguish between strongly and weakly stakeless matches, but simply call a match stakeless if at least one of the players is indifferent. However, they do make a distinction in competitive games based on whether the targets of both players are compatible or not. A competitive game for which there exists a set of outcomes that ensures that both teams receive X is said to be *collusive*. Since weakly stakeless matches contain an asymmetry in the evaluation of the importance of the match, they are said to be *asymmetric*.[30] A match in which at least one of the players its position is fixed is called *irrelevant* in Faella and Sauro.[31] The authors prove that, unfortunately, the occurrence of irrelevant matches in conventional round robin tournaments cannot be avoided if the number of players is at least six.

Although we will not discuss betting-related manipulation opportunities, we note that teams that have no sporting incentive to exert effort are at higher risk to be approached by bookmakers.[32] Therefore, although strongly stakeless matches might not be undesirable from a non-betting related perspective, they should be avoided as much as possible.

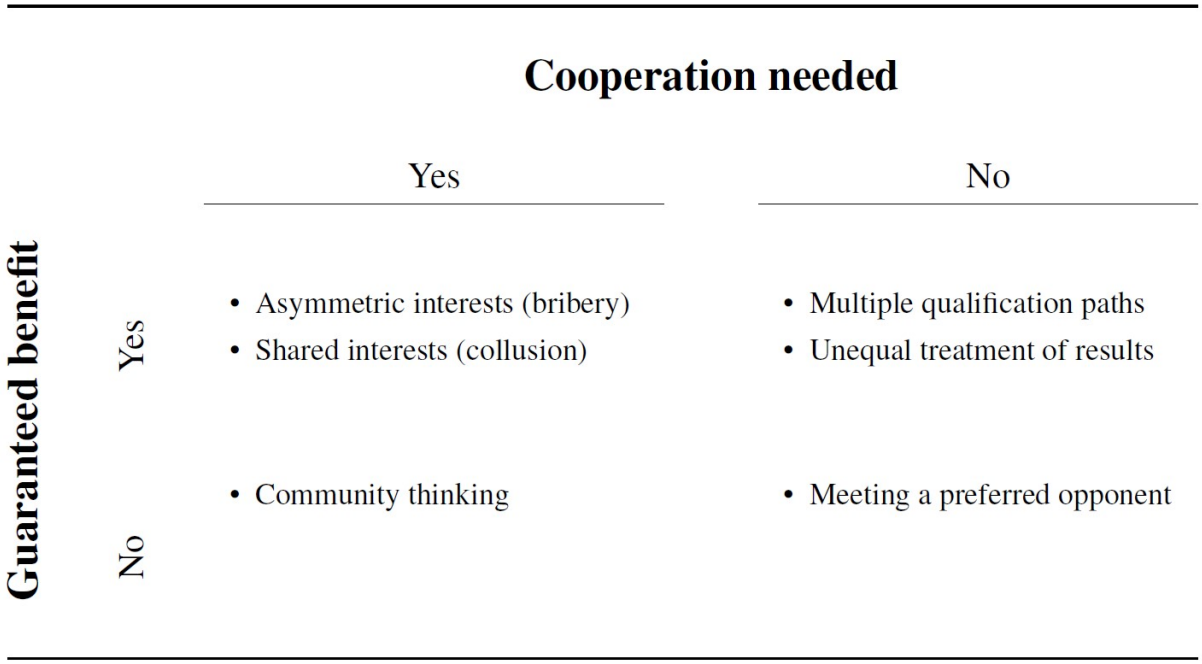

Figure 3: Framework to categorize manipulation opportunities

3.3 Measuring strategy-proofness

Strategy-proofness is often introduced as a binary concept: either a tournament allows for manipulation opportunities or it does not.[33] Therefore, strategy-proofness can be established by showing that a particular design avoids the occurrence of manipulation opportunities altogether. On the contrary, any counterexample is sufficient to refute that a design is strategy-proof. The counterexample might be a situation that happened in the past [15] or a hypothetical scenario.[34, 35, 2] A drawback of using strategy-proofness in this way is that it does not say *how* vulnerable a tournament design is.

Vong[3] notes that *"devising a method to quantify incentive compatibility would allow for the study of trade-offs between incentive compatibility and other potentially desirable factors"*. Similarly, Arlegi and Dimitrov[36] suggest that it would be interesting to have a class of "almost fair" competitions designs: designs that are generally strategy-proof and are unfair only over a limited set of extreme cases. Csató[33] claims that this research gap can be filled by measuring the "strategy-proofness" of tournament designs by Monte Carlo simulation, a well-established methodology where a tournament is repeatedly simulated by randomly sampling match outcomes from an underlying statistical distribution.[37, 38, 39, 40, 41, 42, 29, 27] By averaging or counting the results over all simulation runs, meaningful insights can be derived about the dynamics of the tournament design. The vulnerability of different tournament designs can be compared by counting, for example, the average number of manipulation opportunities in each design. This is done, for example, by Stronka[43] and Csató[44], who both use simulation to estimate the probability of manipulation in small RR tournaments. Moreover, comparing the odds of winning that result from such models with betting odds can give an indication of potential manipulation (see e.g. Forrest and McHale[45] for match-fixing monitoring in football and tennis).

4 The framework

Figure 3 presents our framework that categorizes manipulation opportunities, established by carefully scrutinizing the literature. All of the identified manipulation opportunities can be categorized based along two dimensions: a) whether cooperation between players is needed for successful manipulation and b) whether the manipulation yields a guaranteed or expected benefit. In some cases, manipulation is possible regardless of the reaction or intention of the opponent, while in other cases, the manipulation can only succeed if – tacit or explicit – arrangements are made with the opponent before or during the match. A guaranteed benefit is a benefit that is certain if the manipulation is successful. In contrast, with an expected benefit the initiator only increases the probability of reaching its target.

The target is typically some goal that goes beyond winning an individual match, such as winning the tournament. In the next section, we discuss the manipulation opportunities along these two dimensions.

5 Opportunities for manipulation

5.1 Asymmetric interests

5.1.1 Guaranteed benefit-Cooperation needed

In some cases, the stake of winning a match for one team substantially outweighs the costs of losing it for the other. This creates an opportunity for bribing the opponent to lose on purpose and/or the referee to make biased decisions.[46] For instance, Speer[47] estimates that relegation from the English Premier League costs between £180.5-210 million over the next seven years after relegation. Indeed, there have been many cases of bribery that were motivated by the desire to avoid relegation, see Table 1 in the work of Maennig.[48] In case of a match between a middle ranked and a team on the verge of promotion or relegation, there is an asymmetry in the evaluation of the stake.[30] The team that suffers little or no sporting consequences of a loss has an increased incentive to cooperate. Indeed, the risk of successful bribery is aggravated in weakly stakeless matches, where winning the match is important for one team but is deemed relatively unimportant for the other. However, this type of manipulation is not necessarily accompanied by bribery. Indeed, a recent study examining the motives behind manipulation in Belgian amateur football and tennis competitions revealed that, in cases where a team intentionally lost a game to benefit its opponent's sporting objectives, the majority of the losing teams reported deriving no tangible benefit from their actions. In fact, they frequently cited friendship as the primary motivating factor.[49] In any case, cooperation is needed for this type of manipulation. Moreover, because of the explicit agreement between all parties involved, the target can often be guaranteed.

In round robin tournaments, asymmetries can arise in a wide variety of circumstances. Elaad et al.[50] found that in games where one team is in immediate danger of relegation, and the other team is not affected by the result, the team in danger is more likely to obtain the desired result in countries with a high perceived level of corruption. Moreover, Hill[51] collected a database of matches that were known to be fixed and found that most of the fixing indeed happened in the last quarter of the season, where (weakly) stakeless games typically occur more frequently.[39] Caruso[30] uses game-theory to explain how asymmetric interests can lead to manipulation opportunities. The resulting model is applied to the case of UEFA and FIFA football championships, where the reward for reaching the subsequent stage is much bigger than that for winning a single game in the group stage. In order to reduce the level of asymmetry, Caruso[30] proposes a wider reliance on performance bonuses in individual matches. Likewise, Hill[51] proposes to reward teams more intensely for individual games, such that middle-ranked teams are not indifferent between winning or losing near the end of the season.

The tournament's schedule may also have an impact on the occurrence of weakly stakeless games. Recently, a simulation study by Csató et al.[27] looked at all possible schedules for the last two matchdays of the UEFA Champions League group stage. The schedules that minimized the number of weakly stakeless games where found to be characterized by the strongest team playing home against one of the middle teams in the last round.

Furthermore, tie-breaking rules can impact the competitiveness of the tournament. Csató[52] found that giving priority to goal difference over head-to-head results reduces the probability of a team being sure of its final position before the end of the tournament.

Incomplete round robin tournaments are also prone to asymmetric interests. For instance, in Japanese sumo-wrestling tournaments, 15 games are played per contestant. The eighth win results in a gain of approximately 11 ranking points compared to only three points for any other win. The game-theoretic model of Duggan and Levitt[53] predict that in the last matchday between two players with win-loss records 7-7 and 8-6, the former might be able to successfully bribe the latter. Dietl et al.[54] update the study of Duggan and Levitt to take into account changes since January 2000. The results reinforce that the structure of promotion in rankings in iRR tournaments gives incentives for match-fixing. However, based on a simulation study of the old and new UEFA Champions League formats, Gyimesi[55] finds evidence that the iRR format, with a single ranking table, might be more robust than the format in which teams are partitioned into groups, where each group is organized as a DRR with its own ranking table.

In a Swiss tournament, matches are scheduled round per round, instead of all at once for the whole tournament. This is called dynamic scheduling, and is often used to pair players with a similar rating or strength, based on the argument that such games are more exciting and close. A recent application for dynamic scheduling in e-sports tournaments can be found in.[23] Glickman[56] also applies dynamic scheduling by pairing players round per round such that the probability that the best player advances to the next round is maximized. Similarly, one could use

information obtained from prior rounds to avoid scheduling weakly stakeless matches as much as possible in the next round. We emphasize, however, that dynamic scheduling involves additional challenges, including fairness and transparency issues.[21, 22] Moreover, in sports where opponents need to travel between venues for each game (unlike chess and esports), dynamic scheduling can create logistical complexities.

In principle, single knockout tournaments avoid asymmetries from occurring, since a loss directly eliminates the player. However, if other interests than the tournament at hand play a role, asymmetric interests may still exist. In tennis, players choose throughout the year which tournaments to participate in. The performance in each tournament impacts the overall ranking of the player. Only the 104 highest-ranked players qualify for the prestigious Grand Slam tournaments. Participation alone in all four Grand Slam tournaments can account for half of a player's salary.[10] Thus, a notable asymmetry is present in matches between a player who has already qualified and a player who desperately needs a win to qualify. Indeed, evidence of financially motivated bribery was found in male's tennis.[10]

5.2 Shared interests

5.2.1 Guaranteed benefit-Cooperation needed

Teams have a shared interest if there exist a final score which allows both teams to obtain their goal (e.g. qualification). Collusion involves the cooperation of players in order to gain some mutual benefit at the expense of other players; Chater et al.[29] call a game that allows this collusive. Most of the research on collusion has been done for group stages with three or four players, followed by a knockout phase. We will start with the case of four players.

Table 1: Disgrace of Gijón 1982, see Section 3.9.1. in Kendall and Lenten (2017)

Rank	Team	Pld	W	D	L	GD	Pts
1	Austria	2	2	0	0	+3	4
2	Algeria	3	2	0	1	0	4
3	West-Germany	2	1	0	1	+2	2
4	Chile	3	0	0	3	-5	0

The most infamous example of two teams colluding at the expense of a third team is most probably the "disgrace of Gijón", which took place in the match between Austria and West Germany in the 1982 FIFA World Cup. This match was played after the other teams in the group, Algeria and Chile, had completed all their matches. Table 1 shows the standing before the match Austria - West Germany. A win was worth 2 points at that time. According to the tie-breaking criteria of the tournament, if West-Germany would win with a goal difference of at most two goals, both Austria and West-Germany would qualify for the next stage. West-Germany scored a goal after ten minutes. During the rest of game, neither team did any effort to attack. The benefit in this case was guaranteed: a successful cooperation ensured that both teams advance to the next stage. This event provoked a rule change so that the last two games of any group stage are played simultaneously.[15]

Table 2: Possible schedules of the last matchday of a SRR with four teams

S_1	S_2	S_3
$a-d$	$a-c$	$a-b$
$b-c$	$b-d$	$c-d$

It turns out that the schedule can have a significant impact on the occurrence of collusion opportunities. In case of a SRR group stage with four teams a, b, c, and d (decreasing in strength), where the best two teams of each group qualify to the next stage, there are three possible ways to schedule the last matchday, as is shown in Table 2. Using a simulation model for the FIFA World Cup with 32 teams, Chater et al.[29] find that S_2 is the most prone to collusion, although opportunities seem to be rare (5%) because the matches are played simultaneously. However, S_3 has a high probability of stakeless games (67%), since there is a large probability that a and b, being the two strongest players, have won their first two matches and are therefore already sure of qualification. Therefore, even though the exact percentages might be specific to the case of the FIFA World Cup, these results suggest that S_1 is the best option if collusion opportunities are to be minimized.[42, 29]

Collusion opportunities can also arise if a subset of the kth-ranked teams of each group qualify, which is a popular method to populate the knockout bracket if the number of groups is not a power of two. Typically, not all groups finish at the same time. Then, the kth-ranked team of the last group has full information about the result it needs in order to be part of the best kth-ranked teams. Peculiarly, the probability of this collusion opportunity is shown to be maximal with schedule S_1 (Table 2), which is also the schedule that is best at preventing collusion opportunities if there are only two qualifying teams per group.[29] To mitigate collusion if the number of groups is not a power of two, suggested solutions include using imbalanced groups[28], adopting a double-elimination format[57], limiting qualification to at most two teams per group[58], granting one team a bye in the semifinals[58], or structuring each group as an iRR.[59]

Collusion opportunities are also prevalent, however, if the number of teams is three in each group. Suppose the first two games end in a tie. Then, the two teams that only played one game, can agree before the last matchday to tie and score as many goals as required so that they both qualify. Letting the strongest team play in the first two games significantly reduces the probability of collusion.[59, 29, 43] The intuition behind this result is that such a schedule maximizes the probability that the two other teams lose their first match and therefore both have to win their last match in order to qualify, making collusion impossible. Dynamic scheduling has recently been shown to mitigate collusion opportunities even further.[43] For instance, strongly stakeless matches can be avoided by letting the winner of the first round rest on the second matchday, avoiding that a team is already guaranteed to qualify before the last matchday.[60] In order to avoid collusion opportunities completely, however, there should only be one prize.[3]

Lasek et al.[61] describe how two teams can collude in order to improve their positions in the FIFA World Ranking used from 2006 to 2018. Both teams could agree, for instance, to let each win half of their mutual games (and hence lose the other half). This strategy works in general if more points are awarded for a win than are deducted for a loss in the final ranking.

Finally, tie-breaking rules also impact collusion opportunities.[4] Berker[62] performs a simulation study based on the UEFA 2012 European Championship. With head-to-head results as tie-breaker, it was estimated that in 10% of the cases the relative rankings of two teams would be influenced by a match in which neither team had participated. Contrary, if goal difference was the tie-breaking mechanism, such situations occurred in only 0.1% of the cases. Similar results were reported for the 2024 UEFA European Football Championship.[63] As a result, in order to mitigate collusion opportunities, goal difference should be favored over head-to-head results as the main tie-breaking rule.

5.3 Community thinking

5.3.1 Expected benefit-Cooperation needed

In contrast to collusion, where players work together but ultimately act out of self-interest, community thinking refers to players making decisions based on the interest of the community, sometimes even sacrificing their own winning chances. During the badminton semi-finals of the Olympics in 2004, the Chinese player Zhou Ming reportedly lost her match against the Chinese player Zhang Ning, since it was believed by the coaching staff that Zhang would have a greater chance of winning the final. The target of a Chinese player winning the tournament is not guaranteed, however, since Zhang could still lose the final.[64] Hence, we say the benefit of this manipulation opportunity is expected. Similarly, Moul and Nye[65] found evidence that between 1940 and 1978, Soviet chess players agreed to tie intentionally against other Soviet players, this to preserve their energy for playing non-Soviet players.

Another example of community thinking arose in the first edition of the UEFA Women's Nations League, which served as the qualification tournament for the Olympic Games in 2024. Even though England, Scotland, Wales and Northern Ireland are each independent football nations, it is only the United Kingdom (as "Team GB") that is able to participate in the Olympics. In order to give the UK only one chance rather than four to qualify, England was designated as the only of the four nations that can earn a ticket for the Olympics, on behalf of the UK. In the last matchday of the group stage, Scotland played against England. If England won against Scotland, it still had a chance to advance to the next stage of the tournament and clinch a ticket for the Olympics.[66] Indeed, England won with 6-0, suggesting that Scotland acted out of interest of the community.

Finally, we note that in the operations research and computer science literature, much attention has been given to the case where community members sacrifice their own winning chances to the aid of the community favorite already from the beginning of the tournament.[67, 25] When pairwise match results are deterministic and known to all players, it is possible for the players to calculate whether manipulation is beneficial or not.

However, even in this unrealistically simplified case, determining whether successful community thinking is possible or not quickly becomes computationally challenging when the number of matches increases.[67] Therefore, it is sometimes said that the complexity of the problem itself serves as a barrier towards manipulation. In fact, the lack of empirical evidence that such a manipulation can be successful, suggests that the tournament fixing problem

is of limited importance in practice. Hence, in order to mitigate opportunities for community thinking, one should focus on limiting the number of matches between probable community members (e.g. same club or nationality), for example by careful seeding and group composition. Csató[33] shows how draw constraints can be used to that end. To avoid community thinking altogether, one could also restrict the number of participants of each community to one, although it seems unlikely that such a solution would be desirable in practice.

5.4 Multiple qualification paths

5.4.1 Guaranteed benefit-No cooperation needed

Where in some sports (e.g. tennis) the global ranking of players determines qualification, in many sports qualification for a tournament is based entirely on the performance in one or more specific tournaments. We consider the setting with several independent qualification tournaments where some teams participate in more than one tournament. Of course, a team cannot qualify more than once. In case a team satisfies the qualification criteria in multiple tournaments, it qualifies through one of these tournaments, and vacant slots are created for the others. The allocation rule determines how these vacant slots are filled.

Dagaev and Sonin[2] show that opportunities for manipulation arise in such a setting, if one of the following conditions hold: (i) there are multiple round robin tournaments, each with at least one qualification ticket to win, or (ii) one round robin and some knockout tournaments each give access to at least one qualification slot, and the allocation rule does not always favor the round robin tournament.

Table 3: Example of a qualification tournament consisting of a SRR and a SKO

SRR				SKO	
Rank	Team	Pts	Pld	Rank	Team
1	a	13	5	**1**	b
2	c	10	5	*2*	d
3	b	8	4	…	…
4	d	4	4	…	…
…	…	…	…	…	…

In both settings, a manipulation opportunity is present because a player can deliberately let a preferred opponent qualify, such that the qualification rule allocates the player to the vacant spot. To illustrate this principle, we discuss the second setting by means of the example in Table 3, and refer the interested reader to the work of Dagaev and Sonin[2] for an illustration of the first setting. Suppose that players can qualify for tournament T either by finishing in the top 2 of SRR or by winning SKO. In case that the winner of SKO also finishes in the top 2 of SRR, a vacant slot is created. A natural solution would be to allocate the vacant slot for T to the third placed team of SRR. Now, suppose the rule dictates that the vacant slot is instead filled by the runner-up of SKO. Under this rule, d has an incentive to lose against b in its final SRR match, since this means that b would jump to the second place, ensuring that d qualifies for T instead of c.

Such rules occur often in domestic football tournaments, where teams can qualify for an international tournament either through the domestic competition (organized as a kRR) or through the domestic cup (organized as a SKO). Manipulation opportunities were for example present in the 2011/2012 Dutch Eredivisie [4]. Other examples from football that fit the requirements of the second condition are the qualification rules for the UEFA Champions League from 2015-2018[35], the UEFA Euro 2020 qualification tournament [68] and the European Qualifiers for the 2022 FIFA World Cup.[33] Moreover, while Csató and Ilyin[69] present that the new format of the UEFA Champions League, introduced from the 2024/25 season, has eliminated the misaligned incentives of the seeding regime identified by Csató[70], its qualification system again suffers from incentive incompatibility. Interestingly, the authors observe that, despite the different setting, UEFA could have avoided manipulation opportunities by following the recommendations of Dagaev and Sonin[2], which highlights the need for stronger collaboration between sports organizations and the academic community.

On top of illustrating how qualification rules can lead to manipulative behaviour, Csató[33] uses simulation to quantify the risk of manipulation. He finds that the rules that settle the qualification of European countries for the FIFA World Cup 2022 result in a 1.4% probability of manipulation opportunities. On the other hand, Scelles et al.[71] provide empirical evidence that the UEFA Nations League did not compromise the integrity of national men's football team competitions despite the introduction of multiple qualification paths. The authors count the number of games in which a team had an incentive to lose in periods 2014-2016 and 2018-2020, and find only one such case.

Clearly, the benefit in this type of manipulation is guaranteed, as a loss grants immediate qualification to a tournament. A natural solution to this problem is to allocate all vacant slots based on the results of exactly one of the tournaments.

5.5 Unequal treatment of results

5.5.1 Guaranteed benefit-No cooperation needed

In some multi-stage tournaments, teams carry over a part of their results to the next stage. In the 2018 FIFA World Cup qualification tournament matches played against the lowest ranked team of each group were not taken into account when comparing group runners-up. The 2016 UEFA European Under-17 Championship qualification also determines the best runners-up based on their results against the group winners and third-placed teams (but not against the teams ending last), resulting in a situation where two teams benefit more from a tie than from a win.[72] Moreover, in the previous FIFA World Ranking, used between 2006 and 2018, a win would have resulted in a loss of ranking points under some circumstances.[61, 73] In general, Csató[74] shows that multi-stage tournaments where teams are merged into new groups such that only the results against teams that are also in the new group are carried over are not strategy-proof. This is because teams can influence the number of points that are carried over by deliberately losing matches in the last games. Other examples of tournaments that suffer from this issue can be found in handball [74] and cricket.[15] The benefit in this case is also guaranteed: an intentional increase in the number of points a team carries over. In order to avoid these manipulation opportunities, all results from previous stages should be treated equally.[75] Carrying over all points is, for example, robust towards this type of manipulation. However, it might also result in a loss of suspense and excitement in the subsequent round. Moreover, in a qualification tournament where teams are initially distributed over different groups, these groups are potentially unbalanced with respect to the strengths of the teams (and the weakest team of the group in particular). In this case, carrying over all results aggravates the imbalance of the initial stage.

Another possibility is to carry over only half of the points. Csató[74] simulates match outcomes of two handball tournament designs and finds that carrying over half of the points results in more uncertainty about the possible winner. This makes the tournament more exciting and diminishes the effect of the draw or seeding. In European domestic football competitions, carrying over half of the points to the subsequent stage is applied in, for example, Belgium and Romania.[76]

Lastly, the extreme case where none of the points are carried over also avoids this manipulation opportunity. This case, however, fails to reward good performances in the earlier stages.

5.6 Meeting a preferred opponent

5.6.1 Expected benefit-No cooperation needed

In multi-stage tournaments that contain a group stage, a popular way of partitioning the teams into groups is to seed the teams first into pots based on, for example, historical performance, such that pot 1 contains the strongest teams, pot 2 the second strongest teams, etc. Then, a group is formed by assigning teams to groups such that each group contains exactly one team from each pot. In this case, teams have an incentive to be seeded in higher pots, as this, in theory, leads to easier (and thus more preferred) opponents in the group stage. Csató[77] presents two hypothetical cases from major football tournaments where a team would have ended up in a higher pot by throwing a certain match. He also develops a mathematical model that reveals in which cases such opportunities for manipulation occur. A further example is the seeding system of the UEFA Champions League between the 2015/16 and the 2023/24 seasons, where misaligned incentives have been caused by the allocation of vacant slots in Pot 1[70], an issue that has been discussed in the section “Multiple qualification paths”.

If the group stage is followed by a knockout tournament with the two best teams from each group, the best team of each group is typically paired with the second best team of another group. The purpose of pairing teams in this way is to give an incentive to exert full effort in the first stage, since in principle the runner-up is the weaker team. However, based on the results of the UEFA Champions League and UEFA Europa League until 2019-20, Engist et al.[78] conclude that a higher seeding does not lead to a higher probability of qualifying for the knockout stage. In fact, sometimes a lower seed can be more favorable, as is shown in Baumann et al.[79] Indeed, a team may deliberately want to lose in order to end up second and play against the winner of another group, if that winner is perceived to be an easier opponent than the runner-up. Of course, the benefit here is only expected, as playing against a preferred opponent does not mean that a win in the next round is ensured. Furthermore, the winner and runner-up of the same group are often placed in different sides of the bracket. Thus, by deliberately losing, a player may force being placed on the perceived easier side of the bracket. This happened, for example, at the 2012 Olympic badminton scandal.

Eight players from the women doubles competition were disqualified for throwing matches in the group stage, such that they would get easier opponents in the knockout stage.[15] Unfortunately, Pauly[80] and Vong[3] show that a multi-stage tournament can only be robust towards this manipulation if at most one player of each group is allowed to advance to the next stage. However, this solution is often not desirable, as it would lead to the elimination of an excessive number of teams already after the group stage.

Kräkel[81] shows that in order to reduce this risk in multi-stage tournaments, the uncertainty about the opponents in the next round should be maximal. This is achieved when the last matches of every group are played simultaneously and when the final matches of two groups whose top contenders are matched together are played simultaneously as well. While the choice of schedule was found to have a significant impact on collusion opportunities in the group stage of the 2022 FIFA World Cup[29], Csató[44] computes that opportunities for meeting a preferred opponent occur with an estimated probability of 25%, and are barely influenced by the schedule in this format. Therefore, it is concluded that more fundamental reforms are needed to reduce these opportunities. One such approach is to allow group winners to meet a preferred opponent as a reward for winning the group. Stronka[42] proposes a method based on the preferences expressed by the group winners. Group winners are paired if they both indicate that they want to play against each other. Otherwise, a winner is matched with a runner-up from a different group. Intuitively, with this method, it is better to win since this gives the group winner the opportunity to indicate its preferences. Applying this approach to the FIFA World Cup 2018, they show through simulation that their proposed method reduces the temptation to lose significantly. A more radical approach is the "choose-your-opponent" design. First proposed by Hwang[82], this design lets qualified teams choose, based on previous results, who they want to play against. This format has been used, for example, in several Ice Hockey Leagues. An extensive discussion of the choose-your-opponent design is given by Guyon.[83] Together with Hall and Liu[84], incentives to manipulate are shown to shrink significantly.

However, teams sometimes look further in the bracket than the next round. In the case of the 2012 Olympic badminton scandal, the incentives to lose came from the possibility of avoiding a team later than the next round. Therefore, one could schedule all games of the last matchday of each group simultaneously. Although this might be undesirable from a commercial perspective, UEFA follows this policy in the new incomplete round-robin format of its club competitions. Another solution to this issue is to avoid the use of a predetermined bracket, but instead to have a draw after each round. However, in some tournaments this may be challenging due to time constraints, as the brackets are designed to balance the number of rest days for the teams.

There also exist single stage tournament formats where these manipulation opportunities can arise. In case of a Swiss-system tournament, an intentional early loss might lead to weaker, hence preferred, opponents in later rounds. Cseh at al.[24] analyse whether this strategy, which is called the Swiss Gambit (not to be confused with the identically titled sequence of opening moves), can work. According to their experiments, it is a risky gambit rather than a reliable tool to improve the final rank. In contrast to single knockout tournaments, double knockout tournaments do not avoid this type of manipulation opportunity. Indeed, Stanton and Williams[25] show that, under deterministic outcomes, a player might manipulate if it can obtain a more favorable position in the consolation tournament. This type of manipulation may also occur in knockout tournaments with repechage if a player considers their chances of winning the main tournament negligible and finds that deliberately losing at a strategic moment improves their prospects in the consolation tournament. However, further research is needed to quantify the magnitude in which these opportunities occur.

Finally, we note that teams can also have an incentive to meet a preferred opponent not because of sporting but because of monetary rewards. For example, for each of its international football competitions, UEFA ranks the qualified teams based on their performance in the last ten years. A part of the total revenue is distributed according to this ranking, with higher-ranked teams receiving a larger share. Csató[85] presents a case from the English Premier League, in which Arsenal had an incentive to lose against West Ham United. By doing so, West Ham would secure qualification for the Europa League instead of Manchester United. This scenario arose because West Ham had an inferior record than Arsenal, while Manchester United had a superior one. Consequently, a loss would have resulted in Arsenal receiving greater financial rewards than if they had won. Notably, while the monetary benefit was assured, there was no guaranteed sporting benefit.

6 Solutions and implications

Figure 4 shows a flow chart for (multi-stage) round robin and knockout tournaments, identifying which design elements provoke manipulation opportunities. Single knockout tournaments with only one member per community are robust towards all opportunities discussed in this review. Yet, it also has several disadvantages. Half of the players play just one game, which may be undesirable for these players and their fans. It is also not especially effective at

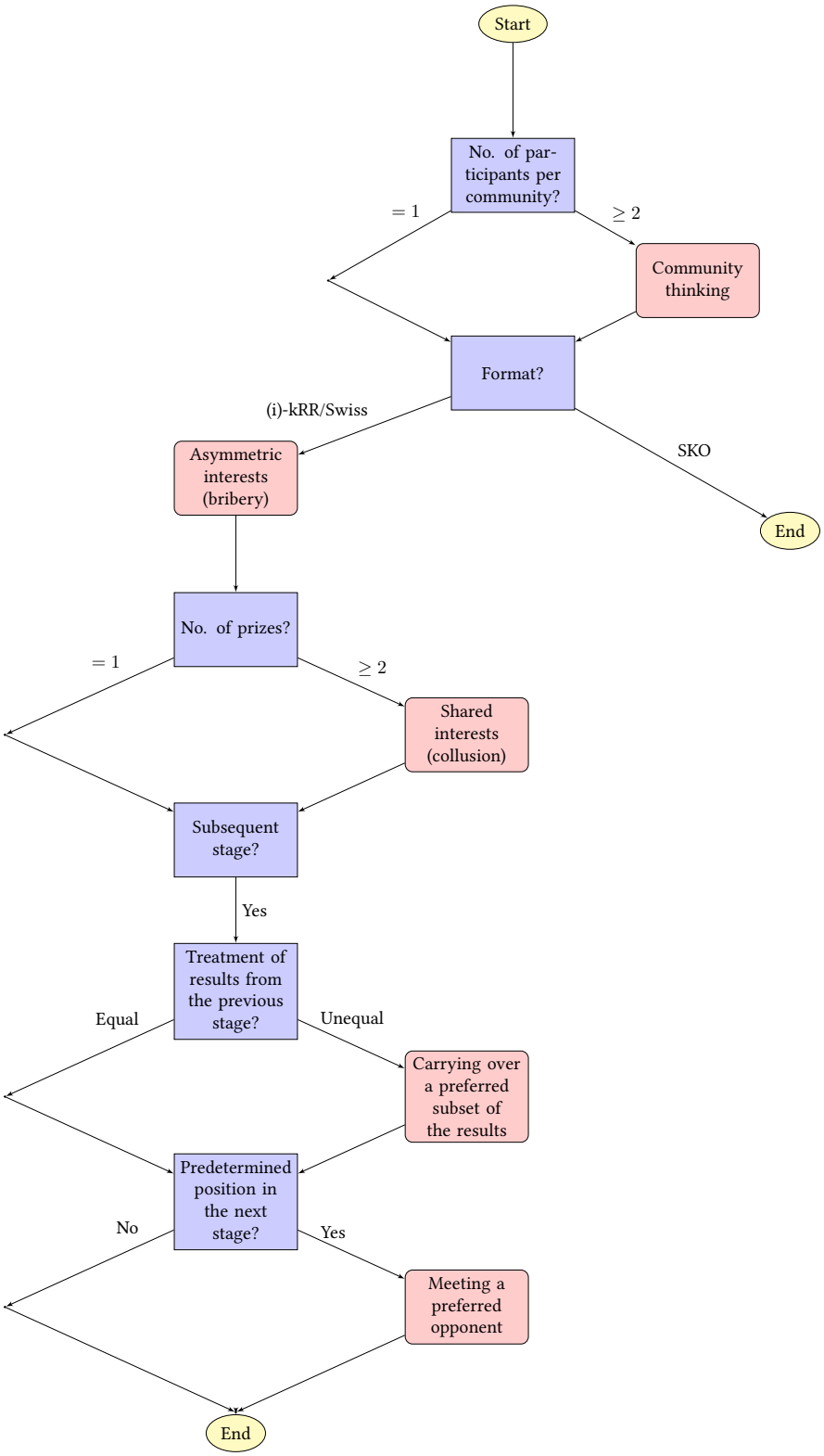

Figure 4: Flowchart manipulation opportunities per stage

identifying the best player (see e.g. Sziklai et al.[26]). On the other hand, round robin tournaments additionally contain the risk of asymmetric and shared interests. If a RR tournament is used in the group stage, collusion can be avoided by letting only the best team qualify from each group (i.e. only one prize per group is present). However,

this results in an early elimination of at least two-thirds of all teams. Lastly, in case of multi-stage RR tournaments, treating all results of previous stages equally combined with not revealing the seeding or group composition of the next stages, further avoids manipulation opportunities.

The previous analysis shows that solutions reducing manipulation opportunities often result in less interesting tournaments from a spectator perspective or sports enjoyment perspective. Hence, league managers need to make the trade-off between a strategy-proof tournament design and the interest of stakeholders, such as fans, sponsors, and teams. Indeed, attractiveness, efficacy in determining the best player, and operational aspects, are often deemed equally if not more important than strategy-proofness by practitioners. Although there have been some success stories where research has nudged practitioners towards a more strategy-proof design (e.g. FIFA abandoning the idea of groups of 3 for the World Cup, and revising its country ranking system), we believe that neglecting this trade-off has been one of the main reasons why such stories remain rare. Therefore, in the remainder of this section, we discuss some promising intermediate solutions.

Community thinking can be reduced by introducing a draw after each round, with the constraint that pairings between community members should be avoided as much as possible. Such constraints are prevalent in international club competitions, where matchups between teams from the same association are often forbidden in the first round of the knockout stage. However, if the favorite teams are concentrated in the same associations, Csató[86] finds that this policy may increase their probability of winning the tournament. Hence, the use of this policy can come at the cost of strengthening the dominance of a community.

Unfortunately, it seems that asymmetric matches or common interests cannot be avoided without dynamic scheduling. In case of dynamic scheduling, information about manipulation opportunities can be taken into account if they are revealed throughout the season. Therefore, although perhaps not applicable to all settings due to practical reasons, we believe dynamic scheduling could emerge as a powerful instrument against manipulation. However, the possible reduction of manipulation opportunities with dynamic scheduling depends on the number of teams, since at some point the possible pairings may be too limited to prevent manipulation opportunities. Future research is needed to clarify this relationship. Moreover, we emphasize that the Swiss system is not strategy-proof per se, as customized pairing rules are needed to avoid manipulation opportunities.

In case of a group stage, awarding a single prize per group rules out shared interests. If that is not manageable, partitioning the teams into groups of even size prevents that, in the last round, some teams collude at the expense of the passive team. Scheduling all games of the last matchday simultaneously creates maximal uncertainty, thereby limiting opportunities for collusion and meeting a preferred opponent. Moreover, a carefully selected schedule can further decrease these opportunities. In the case of four teams, pairing the strongest with the weakest opponent in the last round was found to reduce collusion opportunities the most. The choose your opponent design seems a promising tool as well, since here, teams always have an incentive to finish in a higher position.

Finally, in case of multiple qualification tournaments (not in Figure 4), a natural solution would be to allocate vacant spots based on the ranking in exactly one tournament. If nevertheless a round robin and a knockout tournament grant access to the main tournament, the ranking in the round robin tournament should be favored. In case of multiple round robin tournaments, the probability of manipulation opportunities can be reduced by draw restrictions, that is, by avoiding group matches that may be vulnerable to manipulation. Such matches can be identified with, for example, the help of simulation.[33]

7 Concluding remarks

The purpose of this study was to structure the literature on non-betting related manipulation in sports tournaments, and organize it in a common framework. A limitation of this framework is therefore that is based only on tournament designs and manipulation opportunities that have been described in the academic literature. The vast majority of this literature focuses on single knockout tournaments, round robin tournaments, or particular multi-stage (hybrid) tournament designs corresponding to a few well-known competitions (e.g. FIFA World Cup, UEFA Champions League) and sports (mainly football). However, several other designs and sports, such as the various knockout designs with repechage (fencing, martial arts), serial knockout tournaments (darts), ladder tournaments (squash), have not been studied from a manipulation perspective. Therefore, our framework might be biased in the sense that it does not align well with undocumented manipulation opportunities. However, since a ladder tournament is a single knockout tournament where the winner of each match plays the next entrant in increasing order of rank, we expect that it only suffer from community thinking. The opportunity “meeting a preferred opponent" is possible in knockout tournaments with repechage, although the extent to which this opportunity can occur is unknown. In a serial knockout tournament, a series of single knockout tournaments is played. In this format, seeding in later SKOs is sometimes determined based on the performance in earlier SKOs. Hence, a direction for future research would

be to analyze whether the opportunity "meeting a preferred opponent" can occur in this format (and if yes, to what extent).

The flowchart presented in Figure 4 gives a comprehensive overview of the most common tournament designs: (incomplete) round robin tournaments, knockout tournaments, or a multi-stage combination of both. The implications of other designs are, however, not identified here. Nevertheless, the framework and the flowchart provide a good starting point. Next, the seriousness of the majority of the potential problems discussed in the paper remains unknown in practice. Therefore, more effort is needed to consider strategy-proofness in a probabilistic framework rather than as a binary concept. It would also be interesting to see empirical research on manipulation opportunities. For example, the FIFA World Cup and UEFA club competitions are often taken as case studies for simulation models, but the results are almost never compared with actual (or suspected, e.g. based on betting odds) manipulation opportunities.

In any case, the effect of tournament design choices on manipulation opportunities cannot be neglected. It remains important for sports' integrity that tournaments offer as few manipulation opportunities as possible.

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References

[1] Devriesere K, Csató L and Goossens D. Tournament design: A review from an operational research perspective. *Eur J Oper Res* 2024; 324(1): 1–21.

[2] Dagaev D and Sonin K. Winning by losing: Incentive incompatibility in multiple qualifiers. *J Sports Econom* 2018; 19(8): 1122–1146*.

[3] Vong AI. Strategic manipulation in tournament games. *Games Econ Behav* 2017; 102: 562–567*.

[4] Csató L. *Tournament Design: How Operations Research Can Improve Sports Rules*. 1st ed. Cham, Switzerland: Palgrave Macmillan, 2021*.

[5] Huggins M. Match-fixing: A Historical Perspective. In Huggins M and Hess R (eds.) *Match Fixing and Sport: Historical Perspectives*, 1st ed. London: Routledge, 2020. pp. 1–18.

[6] International Olympic Committee. Code of ethics and other texts. https://stillmed.olympic.org/Documents/Commissions_PDFfiles/Ethics/2016_ioc_code_of_ethics-book-en.pdf. (2002, accessed 29 November 2024).

[7] Vanwersch L, Willem A, Constandt B, et al. A scoping review of the causes and consequences of fraud in sport. *J Sport Soc Issues* 2022; 46(6): 546–584*.

[8] Tak M, Sam MP and Choi CH. Too much at stake to uphold sport integrity? High-performance athletes' involvement in match-fixing. *Crime Law Soc Change* 2020; 74: 27–44.

[9] Van Der Hoeven S, De Waegeneer E, Constandt B, et al. Match-fixing: Moral challenges for those involved. *Ethics Behav* 2020; 30(6): 425–443.

[10] Jetter M and Walker JK. Good girl, bad boy? Evidence consistent with collusion in professional tennis. *South Econ J* 2017; 84(1): 155–180*.

[11] Nowy T and Breuer C. Match-fixing in European grassroots football. *Eur Sport Manag Q* 2017; 17(1): 24–44.

[12] Van Der Hoeven S, Constandt B, Manoli AE, et al. Understanding how individuals engage in match-fixing: the role of moral disengagement. *Eur Sport Manag Q* 2024; 24(4): 979–999.

[13] Harvey A. Match-fixing: Working towards an ethical framework. *J Philos Sport* 2015; 42(3): 393–407.

[14] Moriconi M and Almeida JP. Portuguese fight against match-fixing: Which policies and what ethic? *J Glob Sport Manag* 2019; 4(1): 79–96.

[15] Kendall G and Lenten LJ. When sports rules go awry. *Eur J Oper Res* 2017; 257(2): 377–394*.

[16] Medcalfe S. Behavioral responses to sporting contest design: A review of the literature. *Am Behav Sci* 2024; 0(0).

[17] Goodman LA. Snowball sampling. *Ann Math Stat* 1961; 32(1): 148–170.

[18] Arksey H and O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol* 2005; 8(1): 19–32.

[19] Daudt HM, Van Mossel C and Scott SJ. Enhancing the scoping study methodology: a large, inter-professional team's experience with Arksey and O'Malley's framework. *BMC Med Res Methodol* 2013; 13: 1–9.

[20] Li M, Van Bulck D and Goossens D. Beyond leagues: A single incomplete round robin tournament for multi-league sports timetabling. *Eur J Oper Res* 2025; 323(1): 208–223.

[21] Csató L. Ranking by pairwise comparisons for Swiss-system tournaments. *Cent Eur J Oper Res* 2013; 21: 783–803.

[22] Csató L. On the ranking of a Swiss system chess team tournament. *Ann Oper Res* 2017; 254(1): 17–36.

[23] Dong ZL, Ribeiro CC, Xu F, et al. Dynamic scheduling of e-sports tournaments. *Transp Res E* 2023; 169: 102988.

[24] Cseh Á, Führlich P and Lenzner P. The swiss gambit. Manuscript. URL: https://arxiv.org/abs/2302.10595, 2023.

[25] Stanton I and Williams VV. The structure, efficacy, and manipulation of double-elimination tournaments. *J Quant Anal Sports* 2013; 9(4): 319–335*.

[26] Sziklai BR, Biró P and Csató L. The efficacy of tournament designs. *Comput Oper Res* 2022; 144: 105821.

[27] Csató L, Molontay R and Pintér J. Tournament schedules and incentives in a double round-robin tournament with four teams. *Int Trans Oper Res* 2024; 31(3): 1486–1514*.

[28] Csató L and Gyimesi A. Increasing competitiveness by imbalanced groups: The example of the 48-team FIFA World Cup. Manuscript. URL: https://arxiv.org/abs/2502.08565, 2025*.

[29] Chater M, Arrondel L, Gayant JP, et al. Fixing match-fixing: Optimal schedules to promote competitiveness. *Eur J Oper Res* 2021; 294(2): 673–683*.

[30] Caruso R. The basic economics of match fixing in sport tournaments. *Econ Anal Policy* 2009; 39(3): 355–377*.

[31] Faella M and Sauro L. Irrelevant matches in round-robin tournaments. *Auton Agents Multi-Agent Syst* 2021; 35(1): 1–34*.

[32] Feddersen A, Humphreys BR and Soebbing BP. Contest incentives, team effort, and betting market outcomes in European football. *Eur Sport Manag Q* 2023; 23(3): 605–621.

[33] Csató L. Quantifying incentive (in)compatibility: A case study from sports. *Eur J Oper Res* 2022; 302(2): 717–726*.

[34] Csató L. Was Zidane honest or well-informed? How UEFA barely avoided a serious scandal. *Econ Bull* 2018; 38(1): 152–158*.

[35] Csató L. UEFA Champions League entry has not satisfied strategyproofness in three seasons. *J Sports Econom* 2019; 20(7): 975–981*.

[36] Arlegi R and Dimitrov D. Fair elimination-type competitions. *Eur J Oper Res* 2020; 287(2): 528–535.

[37] Scarf P, Yusof MM and Bilbao M. A numerical study of designs for sporting contests. *Eur J Oper Res* 2009; 198(1): 190–198.

[38] Scarf P and Yusof MM. A numerical study of tournament structure and seeding policy for the soccer world cup finals. *Stat Neerl* 2011; 65(1): 43–57.

[39] Goossens DR, Beliën J and Spieksma FC. Comparing league formats with respect to match importance in Belgian football. *Ann Oper Res* 2012; 194(1): 223–240*.

[40] Lenten LJ. Mitigation of perverse incentives in professional sports leagues with reverse-order drafts. *Rev Ind Organ* 2016; 49(1): 25–41*.

[41] Dagaev D and Rudyak VY. Seeding the UEFA Champions League participants: Evaluation of the reforms. *J Quant Anal Sports* 2019; 15(2): 129–140.

[42] Stronka W. Anti-tanking pair matching before an elimination phase of a two-phase tournament. *Econ Theory* 2020; 8(3): 66*.

[43] Stronka W. Demonstration of the collusion risk mitigation effect of random tie-breaking and dynamic scheduling. *Sports Econ Rev* 2024; 5: 100025*.

[44] Csató L. Mitigating the risk of tanking in multi-stage tournaments. *Ann Oper Res* 2025; 344(1): 135–151*.

[45] Forrest D and McHale IG. Using statistics to detect match fixing in sport. *IMA J Manage Math* 2019; 30(4): 431–449.

[46] Preston I and Szymanski S. Cheating in contests. *Oxf Rev Econ Policy* 2003; 19(4): 612–624*.

[47] Speer JD. The consequences of promotion and relegation in european soccer leagues: A regression discontinuity approach. *Sports Econ Rev* 2023; 1: 100003.

[48] Maennig W. Corruption in international sports and sport management: Forms, tendencies, extent and countermeasures. *Eur Sport Manag Q* 2005; 5(2): 187–225*.

[49] Vanwersch L, Vandercruysse L, Vermeersch A, et al. The grayness of match-fixing: A study of the prevalence and sanctionability of non-betting-related match-fixing in football and tennis. *Deviant Behav* 2024; 1–22.

[50] Elaad G, Krumer A and Kantor J. Corruption and sensitive soccer games: Cross-country evidence. *J Law Econ Organ* 2018; 34(3): 364–394.

[51] Hill D. To fix or not to fix? How corruptors decide to fix football matches. *Glob Crime* 2009; 10(3): 157–177.

[52] Csató L. How to avoid uncompetitive games? The importance of tie-breaking rules. *Eur J Oper Res* 2023; 307(3): 1260–1269*.

[53] Duggan M and Levitt SD. Winning isn't everything: Corruption in sumo wrestling. *Am Econ Rev* 2002; 92(5): 1594–1605*.

[54] Dietl HM, Lang M and Werner S. Corruption in professional Sumo: An update on the study of Duggan and Levitt. *J Sports Econom* 2010; 11(4): 383–396*.

[55] Gyimesi A. Competitive balance in the post-2024 champions league and the european super league: A simulation study. *J Sports Econom* 2024; 25(6): 707–734*.

[56] Glickman ME. Bayesian locally optimal design of knockout tournaments. *J Stat Plan Inference* 2008; 138(7): 2117–2127.

[57] Rennó-Costa C. A double-elimination format for a 48-team FIFA World Cup. Manuscript. URL: https://arxiv.org/abs/2301.03411, 2023.

[58] Guajardo M and Krumer A. Tournament design for a FIFA World Cup with 12 Four-Team Groups: Every Win Matters. In Breuer M and Forrest D (eds.) *The Palgrave Handbook on the Economics of Manipulation in Sport*, 2nd ed. Cham, Switzerland: Palgrave Macmillan, 2024. pp. 207–230.

[59] Guyon J. Risk of collusion: Will groups of 3 ruin the FIFA World Cup? *J Sports Anal* 2020; 6(4): 259–279*.

[60] Krumer A, Megidish R and Sela A. The optimal design of round-robin tournaments with three players. *J Sched* 2020; 23: 379–396*.

[61] Lasek J, Szlávik Z, Gagolewski M, et al. How to improve a team's position in the FIFA ranking? A simulation study. *J Appl Stat* 2016; 43(7): 1349–1368*.

[62] Berker Y. Tie-breaking in round-robin soccer tournaments and its influence on the autonomy of relative rankings: UEFA vs. FIFA regulations. *Eur Sport Manag Q* 2014; 14(2): 194–210*.

[63] Csató L. On head-to-head results as tie-breaker and consequent opportunities for collusion. *IMA J Manage Math* 2024; 00: 1–16*.

[64] Eurosport. Coach admits match fixing. https://www.eurosport.com/olympics/coach-admits-match-fixing_sto1519075/story.shtml. (2008, accessed 29 November 2024).

[65] Moul CC and Nye JV. Did the Soviets collude? A statistical analysis of championship chess 1940–1978. *J Econ Behav Organ* 2009; 70(1-2): 10–21.

[66] Goal. Explained: Why England face conflict of interests backlash ahead of Scotland Nations League clash - with 2024 Olympics on the horizon. https://www.goal.com/en/lists/explained-england-scotland-nations-league-%netherlands-belgium-sarina-wiegman/%blt89da05a3c14c0125#csaef8d1b87ea10616. (2023, accessed 29 November 2024).

[67] Russell T and Walsh T. Manipulating tournaments in cup and round robin competitions. In Rossi F and Tsoukias A (eds.) *Algorithmic Decision Theory. ADT 2009. Lecture Notes in Computer Science*, volume 5783. Berlin, Heidelberg: Springer, pp. 26–37*.

[68] Haugen KK and Krumer A. On the importance of tournament design in sports management: Evidence from the UEFA Euro 2020 qualification. In Ratten V (ed.) *Innovation and Entrepreneurship in Sport Management*. Cheltenham, UK: Edward Elgar Publishing, 2021. pp. 22–35*.

[69] Csató L and Ilyin S. Misaligned incentives in sports: A mathematical analysis of the post-2024 UEFA Champions League qualification. Manuscript. URL: https://arxiv.org/abs/2406.12636, 2025*.

[70] Csató L. The UEFA Champions League seeding is not strategy-proof since the 2015/16 season. *Ann Oper Res* 2020; 292(1): 161–169*.

[71] Scelles N, François A and Valenti M. Impact of the UEFA Nations League on competitive balance, competitive intensity, and fairness in European men's national team football. *Int J Sport Policy Politics* 2024; 16(3): 519–537.

[72] Csató L. When neither team wants to win: A flaw of recent UEFA qualification rules. *Int J Sports Sci Coach* 2020; 15(4): 526–532*.

[73] Kaminski MM. How strong are soccer teams? The "host paradox" and other counterintuitive properties of FIFA's former ranking system. *Games* 2022; 13(2): 22.

[74] Csató L. How to design a multi-stage tournament when some results are carried over? *OR Spectrum* 2022; 44(3): 683–707*.

[75] Csató L. The incentive (in)compatibility of group-based qualification systems. *Int J Gen Syst* 2020; 49(4): 374–399*.

[76] Lasek J and Gagolewski M. The efficacy of league formats in ranking teams. *Stat Modelling* 2018; 18(5-6): 411–435.

[77] Csató L. A paradox of tournament seeding. *Int J Sports Sci Coach* 2023; 18(4): 1277–1284*.

[78] Engist O, Merkus E and Schafmeister F. The effect of seeding on tournament outcomes: Evidence from a regression-discontinuity design. *J Sports Econom* 2021; 22(1): 115–136.

[79] Baumann R, Matheson VA and Howe CA. Anomalies in tournament design: The madness of March Madness. *J Quant Anal Sports* 2010; 6(2*).

[80] Pauly M. Can strategizing in round-robin subtournaments be avoided? *Soc Choice Welfare* 2014; 43(1): 29–46*.

[81] Kräkel M. Sandbagging. *J Sports Econom* 2014; 15(3): 263–284*.

[82] Hwang FK. New concepts in seeding knockout tournaments. *Am Math Mon* 1982; 89(4): 235–239.

[83] Guyon J. "Choose your opponent": A new knockout design for hybrid tournaments. *J Sports Anal* 2022; 8(1): 9–29*.

[84] Hall NG and Liu Z. Opponent choice in tournaments: winning and shirking. *J Quant Anal Sports* 2024; 20(2): 67–86*.

[85] Csató L. The unfairness of the revenue distribution system used in the UEFA club competitions. *Int J Sport Policy Politics* 2023; 15(1): 187–192*.

[86] Csató L. The effects of draw restrictions on knockout tournaments. *J Quant Anal Sports* 2022; 18(4): 227–239.