

Swiss-system chess tournaments and unfairness

László Csató*

Alex Krumer†

26th February 2026

*“Das lebhafteste Vergnügen, das ein Mensch in der Welt haben kann ist, neue Wahrheiten zu entdecken; das nächste von diesem ist, alte Vorurteile loszuwerden.”*¹

(Frederick the Great)

Abstract

The Swiss-system is an increasingly popular competition format as it provides a favourable trade-off between the number of matches and ranking accuracy. However, there is no empirical study on the potential unfairness of Swiss-system chess tournaments caused by the odd number of rounds played. To analyse this issue, our paper compares the number of points scored in the tournament between players who played one game more with the white pieces and players who played one game less with the white pieces. Using data from 28 highly prestigious competitions, we find that players with an extra white game score significantly more points. In particular, the advantage exceeds the value of a draw in the four Grand Swiss tournaments. A potential solution to this unfairness could be organising Swiss-system chess tournaments with an even number of rounds, and guaranteeing a balanced colour assignment for all players using a recently proposed pairing mechanism.

Keywords: chess; fairness; ranking; Swiss-system; tournament design

MSC class: 62F07, 62P20, 90B90, 91B14

JEL classification number: C44, D71, Z20

* Corresponding author. Email: laszlo.csato@sztaki.hun-ren.hu

Institute for Computer Science and Control (SZTAKI), Hungarian Research Network (HUN-REN), Laboratory on Engineering and Management Intelligence, Research Group of Operations Research and Decision Systems, Budapest, Hungary
Corvinus University of Budapest (BCE), Institute of Operations and Decision Sciences, Department of Operations Research and Actuarial Sciences, Budapest, Hungary

† Email: alex.krumer@himolde.no

Molde University College, Faculty of Business Administration and Social Sciences, Molde, Norway

¹ “The greatest and noblest pleasure which men can have in this world is to discover new truths; and the next is to shake off old prejudices.”

Sources: <https://www.aphorismen.de/zitat/7643> (German); <https://www.forbes.com/quotes/3151/> (English).

1 Introduction

Ensuring fairness is a key responsibility of tournament organisers. Although fairness has several different interpretations in the literature, any sports rule can be judged unfair if it violates equal treatment of equals, and some players enjoy an advantage over the other players due to random factors. For example, penalty shootouts in football are widely accepted to be fair only if the outcome of the coin toss—that determines the shooting order—does not affect their outcome (Apesteguia and Palacios-Huerta, 2010; Kocher et al., 2012; Palacios-Huerta, 2014; Vollmer et al., 2024; Pipke, 2025; Csató and Petróczy, 2026). Our study aims to analyse Swiss-system chess competitions from this perspective.

The Swiss-system is a non-eliminating tournament format where the contestants play a predetermined number of rounds, which is substantially smaller than required by a round-robin tournament. The Swiss-system is especially popular in chess; indeed, it was invented by *Dr. Julius Müller*, a Swiss teacher, who developed a new pairing system in 1895 for the 5. Schweizerische Schachturnier in Zurich (Schulz, 2020). It is now applied in other sports, too, such as badminton, croquet, and various esports (Dong et al., 2023), and has inspired the incomplete round-robin format of UEFA club competitions, introduced in the 2024/25 season (Gyimesi, 2024; Csató et al., 2025).

The Swiss-system is a reasonable choice if (i) a high number of contestants makes a round-robin tournament infeasible due to time constraints; and (ii) eliminating any contestant before the end of the tournament is undesirable. According to the Monte Carlo simulations of Sziklai et al. (2022), the Swiss-system offers the best trade-off between the number of matches and the ability of the competition to reproduce the latent true ranking of the players, especially if all contestants should be ranked.

In chess, most Swiss-system tournaments contain an odd number of rounds, typically nine or 11, when (about) half of the players play more games with the white pieces than the other players. This might be unfair since the player with the white pieces starts the game and enjoys an advantage over their opponent (Fecker, 2024; González-Díaz and Palacios-Huerta, 2016; Henery, 1992; Milvang, 2015). Indeed, Brams and Seven (2025) noted that 66% of the top 10 finishers in major Swiss-system tournaments had an extra white game. Analogously, in the four editions of probably the most important Swiss-system chess tournament, the FIDE (Fédération Internationale des Échecs, International Chess Federation) Grand Swiss, 22 players scored at least 7.5 points, and 20 of them (90.9%) played one game more with the white pieces.

Inspired by this anecdotal evidence, our paper aims to quantify the advantage provided by the extra game with the white pieces. To the best of our knowledge, this is the first paper that makes such an attempt. For that, data from 28 top-level Swiss-system tournaments played between 2014 and 2025 with an average Elo rating of at least 2400 are used. We find that playing more games with the white pieces significantly increases the number of points scored in the tournament. The effect is slightly above 0.25 points for all tournaments and above 0.5 points for the four Grand Swiss tournaments, when wins, draws, and losses are awarded by 1, 0.5, and 0 points, respectively. This robust advantage suggests a severe *ex post* fairness problem in Swiss-system in professional chess.

The paper is structured as follows. Section 2 presents the main characteristics of the Swiss-system, and Section 3 gives a concise overview of previous research on this field. The data are described in Section 4 and the methodology in Section 5. The results are reported in Section 6. Finally, Section 7 summarises our message for governing bodies in sports and offers a potential solution to the unfairness of Swiss-system chess tournaments.

2 The Swiss-system in chess

The two central design issues in the Swiss-system are (i) how to pair the contestants in each round; and (ii) how to rank the contestants based on their previous results.

In Swiss-system chess tournaments, the pairing should satisfy three hard constraints (FIDE, 2020):

- Two players cannot play against each other more than once;
- The difference between the number of black and the number of white games should be between -2 and $+2$ for each player;
- No player is allowed to receive the same colour three times in a row.

The last two constraints may exceptionally be violated in the last round of a tournament.

Furthermore, three soft criteria exist that can be used to evaluate a pairing mechanism:

- In general, players are paired to others with the same score;
- In general, a player is given the colour with which they played fewer games;
- If colours are already balanced, then, in general, a player is given the colour that alternates from the last one.

Currently, FIDE accepts four variants of the Swiss-system, the classical Dutch system, as well as the Lim, Dubov, and Burnstein systems, which differ in their pairing method (FIDE, 2020). The Dutch and Dubov systems are compared via simulations by Held (2020). However, FIDE does not provide any official algorithm to pair the players in Swiss-system tournaments. Pairing has traditionally been done by hand; today, various software, some of them approved by FIDE, are available on the market to do this.

In chess, every match has three possible outcomes: white wins (black loses), white loses (black wins), and draw. The winner receives 1 point, the loser 0 points, and a draw gives 0.5-0.5 points to both players. Thus, the number of points for any player could be between 0 and the number of rounds with a step of 0.5. The ranking is based on the number of points scored, followed by various tie-breaking criteria (Freixas, 2022). Tie-breaking rules are not considered in our study.

Almost all players have an Elo rating, a measure of strength based on past performances (Elo, 1978; Aldous, 2017; Gomes de Pinho Zanco et al., 2024). Let R_i and R_j denote the Elo ratings of players i and j , respectively. The expected result of their match is

$$E_{ij} = \frac{1}{1 + 10^{(R_j - R_i)/400}}.$$

Note that $E_{ji} = 1 - E_{ij}$. The actual scores S_{ij} and $S_{ji} = 1 - S_{ij}$ determine the updates of the ratings $R'_i = R_i + K(S_{ij} - E_{ij})$ and $R'_j = R_j + K(S_{ji} - E_{ji})$. Consequently, $R_i + R_j = R'_i + R'_j$. The maximum possible adjustment per game, K , is set to 10 once the published rating of a player reaches 2400, and remains at that level subsequently.

In a tournament with $2m + 1$ rounds, where m is a positive integer, about half of the players play $m + 1$ games with the white pieces and m games with the black pieces, and the other half of the players play m games with the white pieces and $m + 1$ games with the black pieces. On the other hand, the FIDE rules do not exclude the possibility that a player has $m + 1$ or $m - 1$ games with the white pieces in a tournament with $2m$ rounds. We will return to this issue in Section 7.

3 Related literature

The pairing methods of Swiss-system tournaments have received serious attention in the operations research literature. Ólafsson (1990) provides an efficient computer program to pair the players in each round. It is based on finding a maximum weight matching in a graph, where the players are nodes and the possible matches are edges such that the pairing rules are converted into edge weights. Kujansuu et al. (1999) translate the main principles behind the Swiss-system pairing (players with roughly equal scores play against each other and their colours alternate) into a stable roommates problem. This approach results in better colour balance but higher score differences than the official FIDE pairing.

Glickman and Jensen (2005) propose adaptive pairings by maximising the expected Kullback–Leibler distance between the prior and posterior densities of strength parameters. In contrast to the Swiss-system that tends to pair players of similar strength in later rounds, their algorithm pairs players of similar strength as soon as possible. The pairing mechanism outperforms the modified Swiss system of Ólafsson (1990) if 16 rounds are played by 50 players, regardless of using a vague or an informative prior distribution. However, we do not know of any Swiss-system chess tournament containing more than 11 rounds. Biró et al. (2017) uncover how the main priority rules of the Dutch system can be replaced by efficient matching algorithms, making computation in polynomial time possible.

In contrast to Ólafsson (1990), Sauer et al. (2024) formulate alternative pairing rules, again enforced by finding maximum weight matchings in an appropriate graph. According to extensive numerical simulations, this procedure yields fairer pairings and leads to a final ranking that better reflects the strengths of the players than the official FIDE pairing system. Furthermore, the proposed method allows for great flexibility by changing edge weights. In particular, maximum colour difference can be reduced by allowing more games between players who have scored different numbers of points (Sauer et al., 2024, Section 4.4). This trade-off will be important for us in Section 7.

A unique feature of the Swiss-system, dynamic scheduling, can also be advantageous in other sports. For instance, Dong et al. (2023) develop and evaluate dynamic scheduling methods for e-sports tournaments based on the Swiss-system design: an integer programming model is used to maximise game attractiveness and the utility of spectators. Di Mattia and Krumer (2025) demonstrate that reducing the number of matches per team in groups of four teams from three (round-robin) to two (Swiss-system) in beach volleyball does affect neither the probability of the favourite team winning a single match, nor the overall efficacy of the tournament.

Some papers study ranking in the Swiss-system. Csató (2013) converts the results of the 2010 Chess Olympiad Open tournament into an incomplete pairwise comparison matrix and applies standard weighting techniques in this field to derive alternative rankings. The new rankings are intuitively better than the traditional lexicographical orders, in which the number of points scored is the first criterion. Following this line of research, Csató (2017) suggests a family of paired comparison-based scoring procedures for ranking in Swiss-system chess team tournaments. The method contains two parameters: one reflecting the role of the opponents, and another for the trade-off between match and board points. The analysis of the 2011 and 2013 European Team Chess Championship open tournaments uncovers inherent flaws of the official rankings. Freixas (2022) identifies four shortcomings of the Buchholz method, the most popular tie-breaking rule in the Swiss-system. An alternative procedure based on weighted averages of the scores of opponents is suggested

that does not suffer from these weaknesses.

[Brams and Ismail \(2021\)](#) suggest the so-called *Balanced Alternating* rule, which reverses the third and fourth moves in standard chess: after white moves first, black has a double move followed by a double move of white, and then alternating play. This modification gives a boost to black to make chess fairer, which is supported by a computer analysis of chess openings. [Brams and Seven \(2025\)](#) introduce a novel system of matching and scoring players in tournaments with a high number of players and a small number of rounds. These multi-tier tournaments are able to solve some problems of the Swiss-system.

Three empirical studies in chess are also closely related to our topic. The first is [Linnemer and Visser \(2016\)](#), who find that, when lowly rated players play against highly rated players in a Swiss-system tournament, the former perform better than predicted by the Elo formula (see Section 2). The reason is self-selection: the expected strength-shock, which is private information, decreases with the Elo rating because lowly rated players enter the tournament only if they observe their actual strength to be higher than their Elo rating.

The second paper, [González-Díaz and Palacios-Huerta \(2016\)](#) analyse 197 chess matches with an even number of games between two opponents, where the colour of the pieces alternates in each round. Even though there is no rational reason why winning frequencies should differ from 50-50%, winning probabilities turn out to be about 60-40%, favouring the player who plays with the white pieces in the first and subsequent odd rounds.

Interestingly, FIDE has moved in the opposite direction as proposed by [González-Díaz and Palacios-Huerta \(2016\)](#). From 2008 to 2018, the World Chess Championships were contested by the reigning champion and the challenger, such that one player played with the white pieces in the odd games in the first part of the match, while this pattern was reversed in the second half. However, since the World Chess Championship 2021, the player who gets white in the first game has white in all odd games.

Finally, [Fecker \(2024\)](#) examines more than 12.5 million chess games to explore white advantage. The results can be summarised as follows: (1) white advantage increases as a function of Elo rating (at the level of Grandmasters, it is approximately twice as high as at the level of amateurs); (2) white advantage has generally remained stable, or even slightly increased, in all categories from 2010 to 2023; (3) the only exception is for games with an average Elo rating above 2600, where white advantage has decreased over time.

Last but not least, the current paper contributes to the rapidly growing literature on fairness in tournament design. Recent surveys ([Kendall and Lenten, 2017](#); [Goossens et al., 2020](#); [Lenten and Kendall, 2022](#); [Devriesere et al., 2025a,b](#)) and a book ([Csató, 2021](#)) provide an insight into this area.

4 Data and variables

Data are collected from top-levels individual chess tournaments between the years 2014 and 2025 that used the Swiss-system with standard time control. We have considered the following six series: Aeroflot Open, Dubai Open, (FIDE) Grand Prix, (FIDE) Grand Swiss, Qatar Masters, and Sharjah Masters. A tournament was included if it had an average Elo rating of the participants of 2400 or above, which represents the level of International Master.

Overall, our dataset consists of 2602 entries (i.e., players per tournament). However, in some cases, the players did not play in all rounds. This could happen when a player had a “bye”, which occurs in tournaments with an odd number of players. In this case,

Table 1: List of the most prestigious Swiss-system chess tournaments, 2014–2025

Tournament	Average	Std. Dev.	Min	Max	Players	Rounds
Aeroflot 2015	2591	78	2379	2756	63	9
Aeroflot 2016	2589	77	2395	2735	80	9
Aeroflot 2017	2584	77	2418	2738	94	9
Aeroflot 2018	2570	75	2386	2724	86	9
Aeroflot 2019	2573	76	2426	2733	93	9
Aeroflot 2020	2556	79	2402	2728	79	9
Aeroflot 2024	2439	102	2270	2732	132	9
Aeroflot 2025	2437	120	2195	2753	120	9
Dubai 2023	2486	120	2227	2729	63	9
Dubai 2024	2455	92	2303	2654	44	9
Dubai 2025	2475	82	2277	2693	60	9
Grand Prix 2017 Geneva	2728	46	2638	2809	18	9
Grand Prix 2017 Moscow	2730	52	2621	2795	18	9
Grand Prix 2017 Palma	2728	48	2629	2801	18	9
Grand Prix 2017 Sharjah	2724	50	2628	2796	18	9
Grand Swiss 2019	2618	101	2300	2876	145	11
Grand Swiss 2021	2639	56	2467	2800	108	11
Grand Swiss 2023	2638	85	2225	2786	111	11
Grand Swiss 2025	2641	69	2287	2785	114	11
Qatar 2014	2514	140	2210	2776	152	9
Qatar 2015	2533	136	2260	2834	126	9
Qatar 2023	2465	123	2250	2839	148	9
Qatar 2024	2439	132	2205	2801	129	9
Sharjah 2021	2533	135	2173	2704	56	9
Sharjah 2022	2566	93	2365	2701	75	9
Sharjah 2023	2617	55	2519	2734	74	9
Sharjah 2024	2598	73	2463	2761	81	9
Sharjah 2025	2559	66	2453	2771	67	9

Columns Average, Std. Dev., Min, Max show the descriptive statistics of the Elo ratings of all players. *Source:* <https://chess-results.com/>; the hyperlinks of the tournaments directly navigate to the relevant URL.

the player currently ranked last receives a so-called half-point “bye” in each round—but no player can receive a “bye” more than once. Another situation where players did not compete in all rounds is when they simply retired before the end of the tournament; for example, because of health or travel issues. In total, we had 230 players per tournament that did not compete in all the matches because of a “bye” or retirement. Removing these cases, we are left with 2372 entries.

Table 1 presents the 28 tournaments used in our analysis with the 2372 player-tournament observations, representing players who competed in all rounds of the respected tournaments. In four of them, there were 11 rounds (Grand Swiss), whereas in the other 24 tournaments, nine rounds were used. The average Elo rating was above 2500 in 21 tournaments (and above 2700 in the four Grand Prix tournaments), which corresponds to the level of Grandmaster, the highest title awarded by FIDE. The average Elo in the other seven tournaments is between 2400 and 2500.

Table 2: Descriptive statistics of the variables used

Variable	One game more with white			One game less with white		
	Mean (sd)	Min	Max	Mean (sd)	Min	Max
Points won	5.033 (1.041)	2	8.5	4.571 (1.132)	0.5	8
Elo rating	2564 (122)	2195	2876	2535 (126)	2173	2812
First game with white	0.794 (0.405)	0	1	0.203 (0.402)	0	1
Observations		1,198			1,174	

The performance of the players is quantified by their number of points, which is the first criterion in the final tournament ranking (see Section 2). Pre-tournament Elo ratings serve as the measure of abilities. In addition, we have information about the number of games played with the white pieces, and whether the first match was played with the white pieces. Table 2 presents the descriptive statistics of these variables, separately for the two sets of players. Players who had one game more with the white pieces scored a higher number of points on average. However, they also have a higher Elo rating and started the tournament substantially more often with the white pieces compared to players who played one game less with the white pieces.

5 Estimation strategy

We are interested in studying the impact of playing more games with the white pieces on the overall performance in Swiss-system chess tournaments. If the allocation of the players between the schedules with more or less games with the white pieces was entirely random, then we would just compare the means of the final points obtained by the players from these two groups. The difference would be a consistent estimate of the desired effect. However, such a simple approach would yield biased and inconsistent estimates in our case. The reason is that, as observed in Table 2, the allocation of players who play more games with the white pieces is not determined at random. Rather, there is a selection into playing more games with the white pieces that is driven by the players' Elo ratings and whether they played the first match with the white pieces. To obtain an unbiased causal effect, it is essential to disentangle the effect coming with the selection (e.g., the abilities of the players) from the effect caused by playing more games with the white pieces.

To address this issue, we use a statistical matching approach. More specifically, we apply the radius-matching-on-the-propensity score estimator with bias adjustment (Lechner et al., 2011). It is not only competitive among a range of propensity score related estimators, but the subsequent paper Huber et al. (2013) actually showed its superior finite sample and robustness properties in a large-scale empirical Monte Carlo study.

The main idea behind this estimator is to compare treated and non-treated observations within a specific radius. The first step consists of a distance-weighted radius matching on the propensity score. In contrast to standard matching algorithms, where controls within the radius have the same weight independent of their location, in the radius matching method, controls within the radius are weighted proportionally to the inverse of their

Table 3: Propensity score estimation

Variable	Effect
First game with white pieces	2.825*** (0.111)
Elo rating	0.004*** (0.0006)
Tournaments dummies	Yes
Number of observations	2372

Logit estimates based on all data. Dependent variable is a dummy of whether a player played one game more with the white pieces.

Standard errors, given in parentheses, are clustered at the tournament level. Level of significance: * $p < 10\%$; ** $p < 5\%$; *** $p < 1\%$.

distance to the respective treated observations to which they are matched. The second step uses the weights obtained from the matching in a weighted linear or non-linear regression in order to remove biases due to mismatches. This approach uses all comparison observations within a predefined distance around the propensity score, which allows for greater precision than the fixed nearest neighbour matching in regions where many similar comparison observations are available.²

The analysis was executed using the `radiusmatch` command in Stata 16 (Huber et al., 2012). See Huber et al. (2015) for its details and implementation in different software packages such as Gauss, Stata, and R.

6 Empirical evidence of unfairness

Our study aims to determine whether playing more games with the white pieces has any effect on overall performance, as measured by the total number of points obtained at the end of the tournament. Table 3 reports the results of the propensity score estimation. Although this estimation serves only technical purposes, namely, to allow the easy purging of the results from the selection effects, it is nevertheless interesting to see which variables drive selection. In line with the descriptive results presented in Table 2, Elo ratings and playing the first game with the white pieces are significantly associated with playing more games with the white pieces. Tournament dummies are used in this exercise to control for the invariant features that are assumed to apply to all players (e.g., monetary prize, number of rounds, number of players, location, weather, etc.).

Table 4 shows the results of the radius matching average impact of playing one game more with the white pieces on the number of points scored at the end of the tournament. Each line represents the estimations on different subsamples. Based on all the data (Line 1), players with one game more with the white pieces achieve 0.351 more points on average than players with one game less. This value is significant at the 1% level. In tournaments with nine rounds (Line 2), players with one game more with the white pieces score on

² A number of previous studies have applied this estimator to investigate scheduling and fairness issues in sports, see, for example, Cohen-Zada et al. (2018); Goller and Krumer (2020); Krumer and Lechner (2018); Krumer (2020).

Table 4: Levels and effects of playing one game more with the white pieces

(a) All tournaments

Sample	Exp. points with more white	Exp. points with less white	Effect	Std. Error	Obs.	On-supp.
(1) All data	4.999	4.648	0.351***	0.055	2372	2362
(2) Nine Rounds	4.776	4.509	0.267***	0.055	1894	1887
(3) Eleven Rounds	5.509	5.242	0.568***	0.107	478	455

(b) Tournaments with average Elo above 2500

Sample	Exp. points with more white	Exp. points with less white	Effect	Std. Error	Obs.	On-supp.
(4) All data	5.041	4.681	0.359***	0.061	1676	1670
(5) Nine Rounds	4.707	4.476	0.231***	0.062	1198	1195

Logit estimates based on all data. Dependent variable is a dummy of whether a player played one game more with the white pieces.

Obs.: Total sample used in the estimation. On-supp.: Effective sample after removing units that are off common support.

Standard errors are clustered at the tournament level. Level of significance: * $p < 10\%$; ** $p < 5\%$; *** $p < 1\%$.

average 0.267 points more than their counterparts with one game less. However, the size of this effect in tournaments with 11 rounds is more than doubled to 0.568 points (Line 3). Both are significant at the 1% level.

Finally, we present the estimations for tournaments where the mean Elo rating is above 2500 points, which represents a level of Grandmaster. Seven tournaments with a mean Elo rating between 2400 and 2500 are excluded, which leaves us with 21 tournaments (see Table 1). The results for this subset, reported in Table 4.b, are analogous to the results for all tournaments in Table 4.a.³

7 Discussion

We have examined Swiss-system chess tournaments with an odd number of rounds from the perspective of fairness. These competitions turn out to be unfair as players who play more games with the white pieces enjoy a substantial advantage.

At first sight, a simple solution could be organising Swiss-system tournaments with an even number of rounds. However, according to Schulz (2020), Swiss-system tournaments with an even number of rounds are undesirable because they allow for playing two more games with the black pieces. The reason is that, in order to pair players with a similar current number of points, the FIDE rules merely restrict the difference between the number of black and the number of white games between -2 and $+2$, as we have seen in Section 2. For example, in the Gibraltar International Chess Festival 2020 - Masters tournament

³ Note that all tournaments with 11 rounds have an average Elo rating above 2600.

(<https://chess-results.com/tnr471965.aspx>), 5-5 players had 4 and 6 white games out of the total 10, respectively.

Nevertheless, Sauer et al. (2024) proposed a sufficiently flexible pairing mechanism that allows a balanced allocation of white and black pieces between the players in tournaments with an even number of rounds. Furthermore, while the number of float pairs (players with different current number of points who are paired in a round) naturally increases, the ranking quality remains almost the same.

Our finding on the substantial advantage of playing an extra game with the white pieces suggests that it is worth considering an even number of rounds for Swiss-system chess tournaments—provided the gain in fairness from equalising colours outweighs the downsides of more float games, which seems to be probably for us. Exploring this trade-off remains a promising direction for future research.

Acknowledgements

Kjetil K. Haugen and three anonymous colleagues have given useful remarks.

The research was supported by the National Research, Development and Innovation Office under Grants Advanced 152220 and FK 145838, and the János Bolyai Research Scholarship of the Hungarian Academy of Sciences.

References

- Aldous, D. (2017). Elo ratings and the sports model: A neglected topic in applied probability? *Statistical Science*, 32(4):616–629.
- Apestequia, J. and Palacios-Huerta, I. (2010). Psychological pressure in competitive environments: Evidence from a randomized natural experiment. *American Economic Review*, 100(5):2548–2564.
- Biró, P., Fleiner, T., and Palincza, R. P. (2017). Designing chess pairing mechanisms. In Frank, A., Recski, A., and Wiener, G., editors, *Proceedings of the 10th Japanese-Hungarian Symposium on Discrete Mathematics and Its Applications*, pages 77–86, Budapest. Budapesti Műszaki és Gazdaságtudományi Egyetem.
- Brams, S. J. and Ismail, M. S. (2021). Fairer chess: A reversal of two opening moves in chess creates balance between White and Black. In *2021 IEEE Conference on Games (CoG)*, pages 1–4. IEEE.
- Brams, S. J. and Seven, M. M. (2025). Multi-tier tournaments: Matching and scoring players. *PLoS ONE*, 20(8):e0328826.
- Cohen-Zada, D., Krumer, A., and Shapir, O. M. (2018). Testing the effect of serve order in tennis tiebreak. *Journal of Economic Behavior & Organization*, 146:106–115.
- Csató, L. (2013). Ranking by pairwise comparisons for Swiss-system tournaments. *Central European Journal of Operations Research*, 21(4):783–803.
- Csató, L. (2017). On the ranking of a Swiss system chess team tournament. *Annals of Operations Research*, 254(1-2):17–36.

- Csató, L. (2021). *Tournament Design: How Operations Research Can Improve Sports Rules*. Palgrave Pivots in Sports Economics. Palgrave Macmillan, Cham, Switzerland.
- Csató, L., Devriesere, K., Goossens, D., Gyimesi, A., Lambers, R., and Spieksma, F. (2025). Ranking matters: Does the new format select the best teams for the knockout phase in the UEFA Champions League? *International Journal of Sports Science & Coaching*, in press. DOI: [10.1177/17479541251405330](https://doi.org/10.1177/17479541251405330).
- Csató, L. and Petróczy, D. G. (2026). Are penalty shootouts better than a coin toss? Evidence from international club football in Europe. Manuscript. DOI: [10.48550/arXiv.2510.17641](https://doi.org/10.48550/arXiv.2510.17641).
- Devriesere, K., Csató, L., and Goossens, D. (2025a). Tournament design: A review from an operational research perspective. *European Journal of Operational Research*, 324(1):1–21.
- Devriesere, K., Goossens, D., and Willem, A. (2025b). Manipulation unraveled: A new framework to analyze the impact of tournament design on manipulation opportunities. *International Journal of Sports Science & Coaching*, in press. DOI: [10.1177/17479541251339972](https://doi.org/10.1177/17479541251339972).
- Di Mattia, A. and Krumer, A. (2025). The effect of reducing the number of matches in round-robin tournaments with four teams: evidence from beach volleyball. *Annals of Operations Research*, in press. DOI: [10.1007/s10479-025-06933-w](https://doi.org/10.1007/s10479-025-06933-w).
- Dong, Z.-L., Ribeiro, C. C., Xu, F., Zamora, A., Ma, Y., and Jing, K. (2023). Dynamic scheduling of e-sports tournaments. *Transportation Research Part E: Logistics and Transportation Review*, 169:102988.
- Elo, A. E. (1978). *The Rating of Chessplayers: Past and Present*. Arco, New York.
- Fecker, N. (2024). Skewed expectations in the Elo rating system: Home advantage in football and white advantage in chess. Bachelor thesis, ETH Zürich.
- FIDE (2020). *Handbook*. <https://handbook.fide.com/>.
- Freixas, J. (2022). The decline of the Buchholz tiebreaker system: A preferable alternative. In Nguyen, N. T., Kowalczyk, R., Mercik, J., and Motylska-Kuźma, A., editors, *Transactions on Computational Collective Intelligence XXXVII*, pages 1–20. Springer, Berlin, Heidelberg, Germany.
- Glickman, M. E. and Jensen, S. T. (2005). Adaptive paired comparison design. *Journal of Statistical Planning and Inference*, 127(1-2):279–293.
- Goller, D. and Krumer, A. (2020). Let’s meet as usual: Do games played on non-frequent days differ? Evidence from top European soccer leagues. *European Journal of Operational Research*, 286(2):740–754.
- Gomes de Pinho Zanco, D., Szczecinski, L., Kuhn, E. V., and Seara, R. (2024). Stochastic analysis of the Elo rating algorithm in round-robin tournaments. *Digital Signal Processing*, 145:104313.

- González-Díaz, J. and Palacios-Huerta, I. (2016). Cognitive performance in competitive environments: Evidence from a natural experiment. *Journal of Public Economics*, 139:40–52.
- Goossens, D., Yi, X., and Van Bulck, D. (2020). Fairness trade-offs in sports timetabling. In Ley, C. and Dominicy, Y., editors, *Science Meets Sports: When Statistics Are More Than Numbers*, pages 213–244. Cambridge Scholars Publishing, Newcastle upon Tyne, United Kingdom.
- Gyimesi, A. (2024). Competitive balance in the post-2024 Champions League and the European Super League: A simulation study. *Journal of Sports Economics*, 25(6):707–734.
- Held, M. (2020). Swiss Dubov and FIDE Swiss (Dutch). Manuscript. <https://spp.fide.com/wp-content/uploads/2020/11/Dubov-vs-FIDE-Swiss.pdf>.
- Henery, R. J. (1992). An extension to the Thurstone–Mosteller model for chess. *Journal of the Royal Statistical Society Series D: The Statistician*, 41(5):559–567.
- Huber, M., Lechner, M., and Steinmayr, A. (2012). RADIUSMATCH: Stata module to perform distance-weighted radius matching with bias adjustment. Statistical Software Components S457575, Boston College Department of Economics, revised 19 Aug 2014.
- Huber, M., Lechner, M., and Steinmayr, A. (2015). Radius matching on the propensity score with bias adjustment: tuning parameters and finite sample behaviour. *Empirical Economics*, 49(1):1–31.
- Huber, M., Lechner, M., and Wunsch, C. (2013). The performance of estimators based on the propensity score. *Journal of Econometrics*, 175(1):1–21.
- Kendall, G. and Lenten, L. J. A. (2017). When sports rules go awry. *European Journal of Operational Research*, 257(2):377–394.
- Kocher, M. G., Lenz, M. V., and Sutter, M. (2012). Psychological pressure in competitive environments: New evidence from randomized natural experiments. *Management Science*, 58(8):1585–1591.
- Krumer, A. (2020). Testing the effect of kick-off time in the UEFA Europa League. *European Sport Management Quarterly*, 20(2):225–238.
- Krumer, A. and Lechner, M. (2018). Midweek effect on soccer performance: Evidence from the German Bundesliga. *Economic Inquiry*, 56(1):193–207.
- Kujansuu, E., Lindberg, T., and Mäkinen, E. (1999). The stable roommates problem and chess tournament pairings. *Divulgaciones Matemáticas*, 7(1):19–28.
- Lechner, M., Miquel, R., and Wunsch, C. (2011). Long-run effects of public sector sponsored training in West Germany. *Journal of the European Economic Association*, 9(4):742–784.
- Lenten, L. J. A. and Kendall, G. (2022). Scholarly sports: Influence of social science academe on sports rules and policy. *Journal of the Operational Research Society*, 73(12):2591–2601.

- Linnemer, L. and Visser, M. (2016). Self-selection in tournaments: The case of chess players. *Journal of Economic Behavior & Organization*, 126:213–234.
- Milvang, O. (2015). Probability for the outcome of a chess game based on rating. Manuscript. <http://www.nordstrandsjakk.no/documents/spp/Probability.pdf>.
- Ólafsson, S. (1990). Weighted matching in chess tournaments. *Journal of the Operational Research Society*, 41(1):17–24.
- Palacios-Huerta, I. (2014). *Beautiful Game Theory: How Soccer Can Help Economics*. Princeton University Press, Princeton, New Jersey, USA.
- Pipke, D. (2025). No evidence of first-mover advantage in a large sample of penalty shootouts. *Journal of Economic Psychology*, 108:102816.
- Sauer, P., Cseh, Á., and Lenzner, P. (2024). Improving ranking quality and fairness in Swiss-system chess tournaments. *Journal of Quantitative Analysis in Sports*, 20(2):127–146.
- Schulz, A. (2020). 125 years Swiss System. 17 June. <https://en.chessbase.com/post/125-years-swiss-system>.
- Sziklai, B. R., Biró, P., and Csató, L. (2022). The efficacy of tournament designs. *Computers & Operations Research*, 144:105821.
- Vollmer, S., Schoch, D., and Brandes, U. (2024). Penalty shoot-outs are tough, but the alternating order is fair. *PLoS ONE*, 19(12):e0315017.