

van Ours, Jan C.

Working Paper

Circular triads of overperformance in top European football leagues

Tinbergen Institute Discussion Paper, No. TI 2026-009/IV

Provided in Cooperation with:

Tinbergen Institute, Amsterdam and Rotterdam

Suggested Citation: van Ours, Jan C. (2026) : Circular triads of overperformance in top European football leagues, Tinbergen Institute Discussion Paper, No. TI 2026-009/IV, Tinbergen Institute, Amsterdam and Rotterdam

This Version is available at:

<https://hdl.handle.net/10419/339246>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

TI 2026-009/IV
Tinbergen Institute Discussion Paper

Circular Triads of overperformance in top European football leagues

Jan van Ours¹

Tinbergen Institute is the graduate school and research institute in economics of Erasmus University Rotterdam, the University of Amsterdam and Vrije Universiteit Amsterdam.

Contact: discussionpapers@tinbergen.nl

More TI discussion papers can be downloaded at <https://www.tinbergen.nl>

Tinbergen Institute has two locations:

Tinbergen Institute Amsterdam
Gustav Mahlerplein 117
1082 MS Amsterdam
The Netherlands
Tel.: +31(0)20 598 4580

Tinbergen Institute Rotterdam
Burg. Oudlaan 50
3062 PA Rotterdam
The Netherlands
Tel.: +31(0)10 408 8900

Circular Triads of Overperformance in Top European Football Leagues

Jan C. van Ours*

Erasmus School of Economics, Rotterdam, The Netherlands

Tinbergen Institute, Amsterdam/Rotterdam, The Netherlands

Erasmus Center for Applied Sports Economics, Rotterdam, the Netherlands

CEPR, London, United Kingdom

March 3, 2026

Abstract

This study examines eight seasons of professional football matches in the English Premier League, German Bundesliga, Italian Serie A, and Spanish La Liga. The focus is on the existence of non-transitive triads in match outcomes in terms of points, the quality of performance as indicated by expected points, and the difference between the two, which reflects overperformance or underperformance. The main finding is that there are quite a few non-transitive triads in match outcomes. Surprisingly, these are related to non-transitive patterns in overperformance, but not to non-transitive patterns in quality of performance. Persistent overperformance over a long period of time is generally unlikely to occur; however, it does appear in these non-transitive triads. Circular triads of overperformance may be related to psychological effects, such as placebo or nocebo effects, whereby recent histories of encouraging or disappointing match outcomes have long-lasting consequences.

Keywords: Circular triads, Football

JEL-codes: C23, D01, Z20

*Address: Erasmus School of Economics, Burg. Oudlaan 50, 3062 PA Rotterdam, the Netherlands;
ORCID: 0000-0002-0144-9956; email: vanours@ese.eur.nl.

1 Introduction

There are familiar examples of non-transitivity in games. One is rock–paper–scissors. In this game, two players simultaneously make a hand signal: rock beats scissors, scissors beat paper, and paper beats rock. No strategy is dominant. Another example is found in non-transitive dice, where each die has a special distribution of numbers. For instance, suppose the red die has faces $\{2, 4, 9\}$, the green die has $\{1, 6, 8\}$, and the blue die has $\{3, 5, 7\}$. In this setup, red beats green with probability $5/9$, green beats blue with probability $5/9$, and blue beats red with probability $5/9$. Unlike rock–paper–scissors, this game is stochastic: red does not always beat green, but in the long run the statistical advantage becomes clear. Importantly, the game has a second-mover advantage: once the first player chooses a die, the second can always respond with one that is more likely to win. A similar second-mover advantage appears in Penney’s game (Penney, 1969). Here, two players select sequences of three coin tosses with a different sequence of heads and tails. The winner is the first whose sequence appears in order during the tosses. Surprisingly, the second player always has a winning response. For example, if the first player picks $\{HTT\}$, the second should pick $\{HHT\}$, which has a higher chance of appearing first. If the first player opts for $\{HHT\}$, the second should choose $\{THH\}$. Similarly, if the first player chooses $\{THH\}$, the second should select $\{TTH\}$. Finally, if the first player chooses $\{TTH\}$, the second player can choose the winning $\{HTT\}$ and thus the circle is round. So, also in Penney’s game there is a circular triad in which the second player can always choose a sequence that is more likely to appear first and therefore wins.

The rock-paper-scissors game is interesting since it has no dominant strategy, but it can be used to study the behavior of individuals. According to Cason et al. (2014), the game is iconic because it provides a simple illustration of non-transitive dominance, where outcomes occur with equal probabilities. Simple as it may be, the game is popular. There are rock-paper-scissors championship competitions worldwide, and since 2002 there has been a World Rock Paper Scissors Society (You, 2021). Outcomes of rock-paper-scissors games are also studied to understand human behavior. Batzilis et al. (2019) analyzed Facebook data concerning the outcomes of hundreds of thousands of players engaging in the game, with varying levels of information about previous player behavior. Their findings indicated that more experienced players utilized this information to their advantage.

The game with the colored dice and Penney’s game are interesting too, but not very exciting to play once non-transitivity is recognized. Because of the second-mover advantage, the winner can be predicted with certainty, provided that the game lasts long

enough for the winning probabilities to materialize. Non-transitivity in sports matches have been studied a number of times. Kaiser (2019), investigating the sensitivity of point systems in determining the final ranking in Formula 1 Drivers' seasons, showed that in the 2007 season there was non-transitivity among the top three drivers: Räikkönen defeated Alonso more than the other way around, Alonso defeated Hamilton more than the other way around and Hamilton defeated Räikkönen more than the other way around. This example of non-transitivity could have been caused by the small number of matches, as luck is one of the determinants of match outcomes. However, non-transitivity is also found over a longer period of time.

Bozóki et al. (2016) used results from tennis matches to rank male tennis players, and Temesi et al. (2024) did the same for female tennis players. Players are sometimes ranked even if they have never played against each other. Both studies found that non-transitivity in match outcomes between three players occurred frequently. Poddiakov (2024) mentioned that non-transitivity not only occurs in stochastic real-world games but also in deterministic positional games such as chess and checkers, in terms of non-transitive player positions. Spearing et al. (2023) studied non-transitivity in baseball using data from nine seasons of American League Baseball. The main finding was that allowing for non-transitivity improves the prediction of match outcomes. In Van Ours (2024), a triad of non-transitive match outcomes was found for the top three teams of the Dutch professional football league, namely Feyenoord, PSV, and Ajax. In Van Ours (2025a), for a panel of ten English Premier League clubs over a period of 25 seasons, ten non-transitive triads were found. In Van Ours (2025b), for a panel of seven clubs over a period of 24 seasons, eight non-transitive triads were found for the top league of professional football in the Netherlands.

The main finding of these earlier papers is that non-transitivity exists, but the reasons for the phenomenon are not clear. The current paper adds to the small literature on non-transitivity in sports match outcomes by presenting an analysis of professional football matches in the top four leagues of European football. A distinction is made between two components of points obtained in a match. First, there is the quality of play in preparing to score a goal, as indicated by the number of expected goals scored and conceded. This quality of play can be expressed in terms of the number of expected points. The second component is simply the difference between actual points and expected points. This represents the quality of finishing. Overperformance occurs if there are more actual points than expected points. In the long run, the number of actual points should align with the number of expected points, so over a long period there should be no overperformance. However, as shown below, for some circular triads of teams, overperformance materializes for at least eight seasons in a row.

The current paper analyzes football data to understand non-transitivity in a competitive environment. As such, using sports data to understand an economic phenomenon is part of a growing literature (Palacios-Huerta, 2025). The paper is set up as follows. Section 2 discusses the measurement of performance, expected goals, and how to interpret the differences between goals and expected goals. Section 3 describes the four leagues whose information is analyzed over the seasons 2017/18 to 2024/25. Section 4 presents the results of the empirical analysis. To illustrate the reasoning, a case study is presented on the triad Inter Milan – Napoli – Juventus. Then, the setup of the analysis is discussed, followed by the presentation and discussion of parameter estimates. The main finding is that there are quite a few non-transitive triads in match outcomes, but these do not originate from triads in quality of performance. Rather, they are based on circular triads of overperformance. Section 5 provides conclusions.

2 Measuring Performance

Football is a low-scoring sport in which individual match outcomes are significantly affected by random events. A shot on target may be successful but it may also hit the post and bounce back. Whether a shot leads to a goal is sometimes a matter of centimeters.¹ As such, actual match results may not accurately reflect team performance. Expected goals (xG) are considered more reliable indicators of underlying performance. An expected goal is a metric that represents the estimated probability that a shot (or a header) on target would have resulted in a goal. The probability that a shot results in a goal is calculated through the analysis of thousands of shots and is related to the location of the shooter (distance and angle to the goal), the body part used, the type of pass, and the type of attack (Rathke, 2017). Expected goals do not take into account the quality of the players involved in a particular play. It is an estimate of how an average player or team would perform in a similar situation.²

Expected points based on expected goals provide an indication of the quality of performance. Expected goals are first converted into a probability distribution of a discrete number of goals. Then, by comparing goals scored and conceded, the distribution of the number of expected points is calculated (see, for a similar approach, Partida et al. (2021)). Assume that P_s is a Poisson distribution and k the number of

¹Gauriot and Page (2019) showed that in football, players who scored by narrowly missing the post received higher performance ratings and more playing time than those who hit the post and missed. From this they conclude that randomness is sometimes rewarded.

²The term “expected goals” is somewhat confusing, as the expectation is not future-oriented but past-oriented. Expected goals refer to goals that, in hindsight, could have been scored given the opportunities to do so. Potential goals might be a more accurate description. Note that While expected points based on expected goals are backward-looking, expected points based on bookmaker odds are forward-looking.

goals scored. Then, it holds that $P_s(k; xG_s) = \frac{(xG_s)^k e^{-xG_s}}{k!}$, where xG_s is the number of expected goals scored. The same holds for the distribution of goals conceded: $P_c(k; xG_c) = \frac{(xG_c)^k e^{-xG_c}}{k!}$, where xG_c is the number of expected goals conceded. The probability of a match ending in a draw is given by $P^{\text{draw}} = \sum_{k=0}^{N_{\text{max}}} P_s(k; xG_s) P_c(k; xG_c)$, where N_{max} is the maximum number of goals scored (and conceded). The probability of a win is $P^{\text{win}} = \sum_{k=0}^{N_{\text{max}}} (P_s(k; xG_s) \sum_{m=0}^{k-1} P_c(m; xG_c))$. Then, the expected number of points is equal to $xP = 3 \times P^{\text{win}} + P^{\text{draw}}$.

In a league over a season actual points are likely to be close to expected points. During periods in which actual points of a club exceed expected points, the club is overperforming. When actual points are lower than expected points, there is underperformance. Usually at the club level overperforming or underperforming is a temporary phenomenon. However, also over a season overperforming of a club is possible simply because a club may have skillful forwards who are more able than average forwards to convert expected goals into actual goals.

Information about expected goals are often used to predict future performance. Brechot and Flepp (2020) argued that shots on goal contain informational value even if they do not result in goals, showing that recent expected goals are better predictors of future performance than recent actual goals (see also Mead et al. (2023) and Rocchetti et al. (2024) for similar conclusions). Furthermore, differences between expected goals and actual goals can be informative about other economic phenomena. Van Ours (2026a,b) used match results based on expected goals scored and expected goals conceded as indicators of underlying performance. Actual match results are a combination of underlying performance and randomness in converting expected goals into actual goals. If decisions are based on outcomes rather than performance, they are outcome-biased. Van Ours (2026a) found an outcome bias in consumer demand for professional football, specifically in stadium attendance in the top divisions of the five European football leagues. Van Ours (2026b) showed that decisions to replace football managers mid-season in the top divisions of the five major European football leagues were outcome-biased.

Non-transitive triads of match outcomes are difficult to understand.³ However, something may be learned from long-lasting overperformance. Persistent overperformance may be related to psychological effects, that is, expectations based on past match outcomes. Such expectations can generate placebo effects. Kennedy (1961) coined the term

³Nevertheless, non-transitivity is not only present in behavior but also in preferences. The voting paradox, also known as Condorcet paradox, is based on non-transitive voter preferences such that if voting occurs in pairs, the order in which the pairs are presented determines the outcome. Non-transitivity is not limited to human behavior or human preferences. It is also present in nature where in California blue lizards dominate yellow lizards, yellow lizards dominate orange lizards and orange lizards in their turn dominate blue lizards (Sinervo and Lively, 1996). See Poddiakov (2026) for an overview of non-transitive patterns in mathematics, physics and biology.

nocebo (Latin for “I shall harm”) to denote the counterpart of placebo (Latin for “I shall please”), a substance that may produce a beneficial, healthful, pleasant, or desirable effect. More generally, the nocebo effect refers to becoming ill simply by consciously or subconsciously anticipating a harmful event. This could apply to football matches, where players may respond negatively to information about previous match outcomes against the same opponents. Medical research has shown that people are more likely to react to negative information than to positive information (Colloca and Barsky, 2020). Nocebo effects, for example, cause treatment of pain to be less effective. The nocebo effects are related to negative thinking, such as having negative outcome expectations of proposed treatments (Thomaidou et al., 2021). Because of these negative expectations patients actually experience more pain than they would experience in absence of the negative expectations. In the context of non-transitive match outcomes, expectations based on recent history could therefore have a nocebo effect on performance. In other words, past events may have negative effects on future outcomes even though there is no direct causal effect other than the nocebo effect.

3 Four Football Leagues

The analysis covers eight seasons, from 2017/18 to 2024/25, based on the availability of expected goals data. The number of clubs in the league over the period of analysis was 18 for the German Bundesliga and 20 for the other leagues. In the analysis a balanced panel of clubs is used, i.e., clubs that were present in every season of the sample period 2017/18 to 2024/25. By coincidence in every league the balanced panel consists of eleven clubs.

Table 1 shows the number of times a club won their championship. The English Premier League and German Bundesliga were dominated by one club. In England Man City won the league six times, in Germany, Bayern Munich won seven times.

Table 1 also provides match level descriptives for every club distinguishing between points, expected points and the difference between the two. These descriptives are based on matches played between the eleven clubs in the balanced panels. Overall the number of points per match is 1.5-1.6 in every league. Also the number of expected points per match is 1.5-1.6 so the difference between the two is equal to zero. At the club level the number of points are often not the same as the number of expected points. In the English league, Man City has the highest number of points and expected points but for Liverpool there is a difference between the two of 0.3, i.e., on average Liverpool has been overperforming. Crystal Palace has been underperforming with an average of 0.9 points per match while the average expected points per match was 1.3. In the other leagues

Table 1: Match-level Descriptives Four Leagues; 2017/18-2024/25

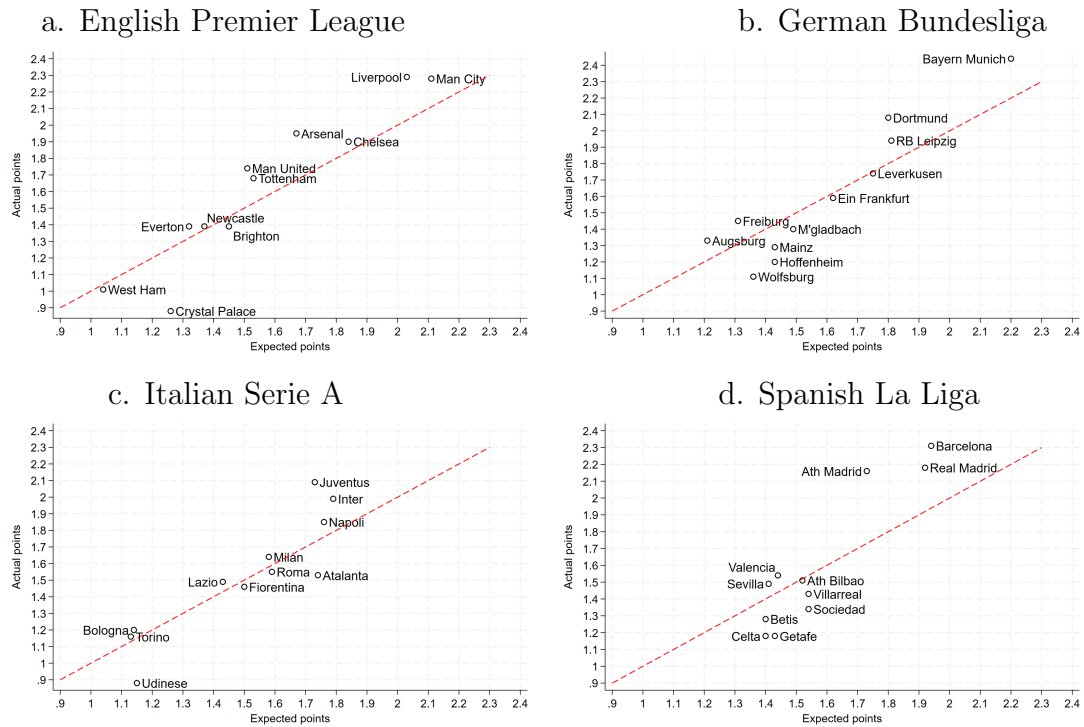
Club	P	xP	P-xP	Club	P	xP	P-xP
<u>a. English Premier League</u>				<u>b. German Bundesliga</u>			
Arsenal	2.0	1.7	0.3	Augsburg	1.3	1.2	0.1
Brighton	1.4	1.5	-0.1	Bayern Munich (7)	2.4	2.2	0.2
Chelsea	1.9	1.8	0.1	Dortmund	2.1	1.8	0.3
Crystal Palace	0.9	1.3	-0.4	Frankfurt	1.6	1.6	0.0
Everton	1.4	1.3	0.1	Freiburg	1.5	1.3	0.1
Liverpool (2)	2.3	2.0	0.3	Hoffenheim	1.2	1.4	-0.2
Man City (6)	2.3	2.1	0.2	Leverkusen (1)	1.7	1.8	0.0
Man United	1.7	1.5	0.2	M'gladbach	1.4	1.5	-0.1
Newcastle	1.4	1.4	0.0	Mainz	1.3	1.4	-0.1
Tottenham	1.7	1.5	0.1	RB Leipzig	1.9	1.8	0.1
West Ham	1.0	1.0	0.0	Wolfsburg	1.1	1.4	-0.3
Total	1.6	1.6	0.0	Total	1.6	1.6	0.0
<u>c. Italian Serie A</u>				<u>d. Spanish La Liga</u>			
Atalanta	1.5	1.7	-0.2	Ath Bilbao	1.5	1.5	0.0
Bologna	1.2	1.1	0.1	Ath Madrid (1)	2.2	1.7	0.5
Fiorentina	1.5	1.5	0.0	Barcelona (4)	2.3	1.9	0.4
Inter Milan (2)	2.0	1.8	0.2	Betis	1.3	1.4	-0.1
Juventus (3)	2.1	1.7	0.4	Celta	1.2	1.4	-0.2
Lazio	1.5	1.4	0.1	Getafe	1.2	1.4	-0.2
AC Milan (1)	1.6	1.6	0.1	Real Madrid (3)	2.2	1.9	0.3
Napoli (2)	1.9	1.8	0.1	Sevilla	1.5	1.4	0.1
Roma	1.6	1.6	0.0	Sociedad	1.3	1.5	-0.2
Torino	1.2	1.1	0.0	Valencia	1.5	1.4	0.1
Udinese	0.9	1.1	-0.2	Villarreal	1.4	1.5	-0.1
Total	1.5	1.5	0.0	Total	1.6	1.6	0.0

In parentheses: number of championships; P (xP) = (Expected) points per match in the 20 matches each team played every season against the other 10 teams in the balanced panel.

there are similar differences. In the German league, Dortmund has been overperforming with an average number of points per match of 2.1 and a number of expected points per match of 1.8. Wolfsburg has been underperforming with 1.1 points and 1.4 expected points per match. In the Italian league, Juventus was overperforming with 2.1 points per match and 1.7 expected points per match. Atalanta and Udinese were underperforming with a difference between points and expected points of -0.2. In Spain, Athletic Madrid has been overperforming with a difference between points and expected points of 0.5 while Celta, Getafe and Sociedad were underperforming with a difference of -0.2.

Figure 1 shows the relationship between actual points and expected points for all clubs. Overperforming is more likely at the high end of the distribution of expected points while at the bottom end underperforming is more likely. There are two alternative

Figure 1: Actual Points and Expected Points; Four Leagues - 2017/18-2024/25



explanations for this. First, luck. It could be by coincidence that at the high end of the distribution clubs are overperforming. The second explanation is skills. It seems likely that clubs at the high end of the distribution have more skills to convert expected goals into actual goals and thus to convert expected points in actual points.

4 Empirical Analysis

4.1 A case study

Consider three teams, i , j , and k . The pairwise match outcomes R_{ij} are determined by the difference in quality Q between the two teams: $R_{ij} = Q_i - Q_j$, $R_{jk} = Q_j - Q_k$, and $R_{ki} = Q_k - Q_i$. If the match outcomes are transitive, then $R_{ij} + R_{jk} + R_{ki} = 0$. The match outcomes are non-transitive if $R_{ij} + R_{jk} + R_{ki} = \theta > 0$.

To illustrate the lines of reasoning in the empirical analysis, a case study is helpful. The case study concerns the triad of Inter Milan–Napoli–Juventus, three of the top Italian football teams. Over the eight seasons analyzed, each team played 16 matches against the other two teams. In their home matches against Napoli, Inter Milan obtained 18 points, while Napoli, in their home matches against Inter Milan, obtained 10 points. Thus, Inter Milan’s balance of points against Napoli was +8 points. Napoli obtained 18 points in

their home matches against Juventus, while Juventus obtained 14 points in their home matches against Napoli, giving Napoli a positive balance of 4 points. If match outcomes were transitive, one would expect the balance of points of Juventus against Inter Milan to be negative. On net, Inter Milan beat Napoli, and Napoli beat Juventus. However, these results are in fact non-transitive, since on net Juventus beat Inter Milan by 8 points (17 points in their home matches versus Inter Milan’s 9 points in theirs).

Adding up the results for Inter Milan–Napoli, Napoli–Juventus, and Juventus–Inter Milan yields a total of 20 points, which corresponds to an average of 1.25 points per match pair per season. The positive overall balance indicates that the triad exhibits non-transitive match outcomes. This is not the case for the expected points, where the balance for Inter Milan–Napoli is -0.07 , for Napoli–Juventus 0.21 , and for Juventus–Inter Milan the balance is equal to zero. The sum of the three is positive, $+0.14$, but not large. The match outcomes in terms of expected points are therefore close to being transitive.

The situation is different when considering the difference between points and expected points, that is, overperformance. Here, Inter Milan overperformed against Napoli by 0.57 points, Napoli overperformed against Juventus by 0.04 points, and Juventus overperformed against Inter Milan by 0.50 points. The sum of the three equals 1.11 points per match pair per season, suggesting that the overperformance outcomes are non-transitive. The main conclusion from this case study is that there is non-transitivity in match outcomes within the triad Inter Milan, Napoli, and Juventus, which is related to the non-transitive pattern of overperformance between the three teams.

4.2 Set-up of the analysis

To model non-transitivity, a logit model can be used (Bradley and Terry, 1952). Following the example in the previous subsection, to allow for the possibility of non-transitivity in the third pair, an interaction term is introduced (Spearing et al., 2023):

$$p_{ij} = \frac{e^{Q_i - Q_j}}{1 + e^{Q_i - Q_j}}, \quad p_{jk} = \frac{e^{Q_j - Q_k}}{1 + e^{Q_j - Q_k}}, \quad p_{ik} = \frac{e^{Q_i - Q_k + \theta_{ik}}}{1 + e^{Q_i - Q_k + \theta_{ik}}} \quad (1)$$

If $\theta_{ik} = 0$, there is cardinal transitivity, and p_{ik} is fully determined by p_{ij} and p_{jk} . If $\theta_{ik} \neq 0$, this indicates that i , j , and k form a triad with non-transitive match outcomes.

The qualities of the first two teams in each triad are estimated, normalizing the quality of the third team to zero. Furthermore, a dummy variable is included for matches between the first and third clubs in each triad. To allow for variation across seasons, seasonal fixed effects are included. Because of the discrete nature of match outcomes (0, 1, or 3 points), an ordered logit specification is used. For the expected points and

overperformance, linear specifications are applied. A triad of clubs is considered to have non-transitive match outcomes if the interaction term is different from zero at at least a 5% level of significance.

4.3 Parameter estimates

According to Kendall and Smith (1940), if the number of clubs, n , is odd, the maximum number of circular triads is $\frac{n^3-n}{24}$, which implies that with 11 teams this is 55. The minimum number is zero.⁴ The parameter estimates shown in Table 2 provide an overview of the non-transitive triads in the four leagues (Appendix Table A1 provides accompanying descriptives). Clearly, non-transitivity in match outcomes is not negligible in the English Premier League and the German Bundesliga, as the number of circular triads found in both leagues is twelve. In the Italian Serie A, eight non-transitive triads in match outcomes are found, while in the Spanish La Liga there are seven.

For the English Premier League, the parameter estimates of the interaction terms are shown in panel a. Among the triads of non-transitive outcomes, there are many overlaps in terms of teams. Crystal Palace is part of a triad seven times, Chelsea six times, and Everton, Manchester City, and Tottenham five times. Brighton and Newcastle do not appear in any non-transitive triad. Overlaps are also substantial within pairs. Chelsea and Crystal Palace are present in four triads, together with Arsenal, Manchester City, Manchester United, and West Ham. Similarly, Everton and Crystal Palace are present in three triads, together with Manchester City, Manchester United, and West Ham. Tottenham and Manchester City are also present in three triads, with Arsenal, Chelsea, and West Ham. Of the twelve non-transitive triads in actual points, none are non-transitive in expected points, whereas ten exhibit non-transitivity in overperformance.

In the German Bundesliga, there are also twelve triads of non-transitive outcomes with overlaps. Augsburg and Bayern Munich are present five times, whereas Leverkusen is absent. The combination Bayern Munich–Monchengladbach appears in three triads, together with Dortmund, Freiburg, and Wolfsburg. As shown in panel b of Table 2, there are two significant non-transitive triads in expected points and seven non-transitive triads in overperformance.

In the Italian Serie A, there are eight non-transitive triads of match outcomes, with Bologna and Torino present in four triads and Fiorentina and Lazio not present in any triad. As shown in panel c, none of the triads in expected points are significantly different from zero, while six triads are significantly different from zero in terms of overperformance.

Finally, panel d of Table 2 shows the parameter estimates for the Spanish La Liga.

⁴If the number of clubs is even, the maximum number of circular triads is $\frac{n^3-4n}{24}$.

Table 2: **Non-transitive Triads; Interaction Terms**

	Team 1	Team2	Team 3	Points	xPoints	Points-xPoints
a. English Premier League						
1	Arsenal	Chelsea	Cr Palace	-2.09 (1.00)*	-0.43 (0.31)	-0.76 (0.41)
2	Arsenal	Tottenham	Man City	-2.35 (1.15)*	-0.01 (0.23)	-1.17 (0.50)*
3	Chelsea	Cr Palace	Man City	-2.48 (1.09)*	-0.40 (0.22)	-0.79 (0.44)
4	Chelsea	Cr Palace	Man United	-3.08 (1.20)*	-0.35 (0.27)	-0.90 (0.41)*
5	Chelsea	Cr Palace	West Ham	-2.16 (1.10)*	-0.41 (0.22)	-0.65 (0.47)
6	Chelsea	Tottenham	Everton	-2.45 (1.07)*	-0.10 (0.29)	-1.21 (0.43)**
7	Chelsea	Tottenham	Man City	-2.36 (1.04)*	0.05 (0.26)	-1.36 (0.51)*
8	Cr Palace	Man City	Everton	-2.85 (1.02)**	-0.11 (0.22)	-1.14 (0.45)*
9	Cr Palace	Man United	Everton	-2.96 (1.11)**	-0.23 (0.27)	-1.14 (0.42)**
10	Cr Palace	West Ham	Everton	-1.96 (0.88)*	-0.42 (0.24)	-0.71 (0.47)
11	Everton	Liverpool	Tottenham	-2.45 (1.15)*	0.10 (0.28)	-0.98 (0.37)*
12	Man City	West Ham	Tottenham	-2.77 (0.93)**	0.15 (0.23)	-1.09 (0.42)*
b. German Bundesliga						
1	Augsburg	Dortmund	Freiburg	-2.15 (0.97)*	-0.30 (0.21)	0.82 (0.45)
2	Augsburg	Frankfurt	Freiburg	-2.02 (1.01)*	-0.26 (0.27)	-0.93 (0.50)
3	Augsburg	Frankfurt	Hoffenheim	-2.30 (0.97)*	-0.57 (0.24)*	-0.68 (0.48)
4	Augsburg	Mainz	Hoffenheim	-2.32 (1.12)*	-0.63 (0.30)*	-0.56 (0.43)
5	Augsburg	Mainz	RB Leipzig	-2.08 (0.99)*	-0.33 (0.30)	-0.85 (0.37)*
6	Bayern Munich	Dortmund	M'gladbach	-3.06 (1.15)**	-0.02 (0.29)	-1.42 (0.54)*
7	Bayern Munich	Freiburg	Hoffenheim	-2.31 (1.04)*	-0.15 (0.21)	-1.10 (0.42)*
8	Bayern Munich	Freiburg	M'gladbach	-3.04 (1.18)**	-0.29 (0.24)	-1.02 (0.41)*
9	Bayern Munich	Wolfsburg	M'gladbach	-2.75 (1.40)*	0.01 (0.26)	-1.01 (0.42)*
10	Bayern Munich	Wolfsburg	Mainz	-3.15 (1.47)*	-0.13 (0.27)	-0.99 (0.45)*
11	Dortmund	Wolfsburg	Mainz	-2.82 (1.34)*	-0.37 (0.25)	-0.95 (0.44)*
12	Dortmund	Wolfsburg	RB Leipzig	-2.10 (1.04)*	-0.18 (0.17)	-0.63 (0.47)
c. Italian Serie A						
1	Atalanta	Juventus	Inter Milan	-2.75 (1.01)**	-0.02 (0.28)	-1.23 (0.45)**
2	Atalanta	Roma	Torino	-2.88 (1.07)**	0.24 (0.27)	-1.13 (0.47)*
3	Bologna	Inter Milan	AC Milan	-2.39 (1.09)*	-0.29 (0.22)	-0.96 (0.46)*
4	Bologna	Roma	Udinese	-2.44 (1.04)*	-0.04 (0.25)	-1.02 (0.47)*
5	Bologna	Torino	AC Milan	-2.17 (1.03)*	-0.04 (0.26)	-0.83 (0.48)
6	Bologna	Torino	Udinese	-1.83 (0.92)*	0.18 (0.24)	-1.11 (0.46)*
7	Inter Milan	Napoli	Juventus	-2.46 (1.18)*	-0.14 (0.25)	-1.11 (0.52)*
8	AC Milan	Roma	Torino	-2.71 (1.16)*	-0.36 (0.26)	-0.95 (0.48)
d. Spanish La Liga						
1	Ath Bilbao	Villarreal	Real Madrid	-2.07 (1.03)*	-0.41 (0.27)	-0.40 (0.48)
2	Ath Madrid	Betis	Real Madrid	-2.37 (1.16)*	-0.09 (0.22)	-0.91 (0.46)
3	Ath Madrid	Celta	Barcelona	-2.67 (1.21)*	-0.15 (0.25)	-0.72 (0.53)
4	Barcelona	Sevilla	Celta	-2.13 (0.89)*	-0.33 (0.25)	-0.36 (0.52)
5	Betis	Real Madrid	Celta	-2.92 (1.14)*	-0.19 (0.21)	-0.96 (0.44)*
6	Betis	Real Madrid	Sevilla	-2.28 (1.01)*	-0.02 (0.27)	-1.11 (0.50)*
7	Celta	Villarreal	Real Madrid	-2.23 (1.10)*	-0.18 (0.26)	-0.44 (0.49)

Note: Points: ordered logit; xPoints and Points-xPoints: linear regression. All estimates contain dummy variables for the first and second club and seasonal fixed effects (not reported). Reported are the parameters related to dummy variables representing interactions between the first and the third club. In parentheses robust standard errors; ** (*): significant at a 1% (5%) level.

There are seven non-transitive triads in match outcomes, with Betis and Real Madrid present in three of them, together with Atlético Madrid, Celta, and Sevilla. None of the triads in expected points are significantly different from zero, while only two of the triads are significantly different from zero in terms of overperformance.

The main conclusion from Table 2 is that there are substantial numbers of triads with non-transitive match outcomes. By and large, these are more closely related to non-transitivity in overperformance than to non-transitivity in expected points.

5 Conclusions

The origin of non-transitivity in match outcomes within triads of football clubs is puzzling. Particularly puzzling is strong non-transitivity, where not only the sum of the outcomes of pairs of matches between clubs in a triad is positive, but the individual outcomes are also positive. Such strong non-transitivity is observed not only among ordinary teams but also among top teams such as Inter Milan, Napoli, and Juventus, teams that have won the Italian league one or more times in the last eight seasons.

Introducing expected points based on expected goals provides new insights, but it does not offer a complete explanation. Expected points themselves rarely underlie non-transitive outcomes. The situation is different when considering the difference between points and expected points. Overperformance, defined as actual points exceeding expected points, frequently exhibits a non-transitive structure. In fact, most triads with non-transitive match outcomes are associated with non-transitive overperformance.

Overperformance or underperformance at the club level is usually temporary. A club may obtain more points than expected for a period, but it is likely to return to a normal level of points in line with expected points. An exception may arise when there are clear differences in the ability to convert expected goals into actual goals. It is possible that some teams are better able to convert expected goals into actual goals and are therefore able to sustain overperformance over a long period of time. However, even if this is the case for some clubs, it would not explain persistent non-transitivity in overperformance.

The analysis in this paper demonstrates the importance of persistent overperformance in contributing to non-transitive match outcomes. The origin of overperformance in circular triads remains unclear, and one can only speculate about possible explanations. Psychological effects similar to placebo and nocebo effects observed in medical research on drug efficacy may play a role. If patients believe that a drug has a beneficial effect, even if it is merely a placebo, the treatment effect may still materialize. If patients expect a treatment to be painful, they may experience more pain because of nocebo effects than they would in the absence of negative expectations. Similarly, if players, consciously

or unconsciously, believe they are likely to win a match against a particular opponent while the opposing players believe they will lose, circular triads of overperformance may emerge. The mere fact that the results of some teams are worse than expected against particular opponents over several seasons may create something akin to a placebo effect for winners and a nocebo effect for losers. Although such effects are unlikely to persist indefinitely, the analysis in this paper shows that they can materialize over a prolonged period.

References

- Batzilis, D., S. Jaffe, S. Levitt, J. A. List, and J. Picel (2019). Behavior in strategic settings: Evidence from a million Rock-Paper-Scissors games. *Games* 10(2), 1–34.
- Bozóki, S., L. Csató, and J. Temesi (2016). An application of incomplete pairwise comparison matrices for ranking top tennis players. *European Journal of Operational Research* 248(1), 211–218.
- Bradley, R. A. and M. E. Terry (1952). Rank analysis of incomplete block design: I. The method of paired comparisons. *Biometrika* 29(3/4), 324–345.
- Brechot, M. and R. Flepp (2020). Dealing with randomness in match outcomes: How to rethink performance evaluation in European club football using expected goals. *Journal of Sports Economics* 21(4), 335–362.
- Cason, T. N., D. Friedman, and E. D. Hopkins (2014). Cycles and instability in a Rock–Paper–Scissors population game: A continuous time experiment. *The Review of Economic Studies* 81(1), 112–136.
- Colloca, L. and A. J. Barsky (2020). Placebo and nocebo effects. *New England Journal of Medicine* 382(6), 554–561.
- Gauriot, R. and L. Page (2019). Fooled by performance randomness: Overrewarding luck. *Review of Economics and Statistics* 101(4), 658–666.
- Kaiser, B. (2019). Strategy and paradoxes of Borda count in Formula 1 racing. *Decyzje* (31), 115–132.
- Kendall, M. G. and B. B. Smith (1940). On the method of paired comparisons. *Biometrika* 31(3/4), 324–345.
- Kennedy, W. P. (1961). The nocebo reaction. *Medical world* 95, 203–205.
- Mead, J., A. O’Hare, and P. McMenemy (2023). Expected goals in football: Improving model performance and demonstrating value. *PLoS ONE* 18(4), e0282295.
- Palacios-Huerta, I. (2025). The beautiful dataset. *Journal of Economic Literature* 63(4), 1363–1423.

- Partida, A., A. Martinez, C. Durrer, O. Gutierrez, and F. Posta (2021). Modeling of football match outcomes with expected goals statistic. *Journal of Student Research* 10(1), 1–10.
- Penney, W. (1969). Problem 95. Penney-Ante. *Journal of Recreational Mathematics* 2, 241.
- Poddiakov, A. (2024). Intransitively winning chess players' positions. *Doklady Mathematics* 110(Supp 2), S391–S398.
- Poddiakov, A. (2026). Are mathematicians, physicists and biologists irrational? Intransitivity studies vs. the transitivity axiom. *Human Arenas*, forthcoming.
- Rathke, A. (2017). An examination of expected goals and shot efficiency in soccer. *Journal of Human Sport and Exercise* 12, S514–S529.
- Rocchetti, M., F. Berveglieri, and G. Cappiello (2024). Football data analysis: The predictive power of expected goals (xG). *GAME-ON 2024*, 20–24.
- Sinervo, B. and C. M. Lively (1996). The rock–paper–scissors game and the evolution of alternative male strategies. *Nature* 380(6571), 240–243.
- Spearing, H., J. Tawn, D. Irons, and T. Paulden (2023). Modeling intransitivity in pairwise comparisons with application to baseball data. *Journal of Computational and Graphical Statistics* 32(4), 1383–1392.
- Temesi, J., Zs. Szádóczki, and S. Bozóki (2024). Incomplete pairwise comparison matrices: Ranking top women tennis players. *Journal of the Operational Research Society* 75(1), 145–157.
- Thomaidou, M. A., K. J. Peerdeman, M. I. Koppeschaar, A. W. M. Evers, and D. S. Veldhuzen (2021). How negative experience influences the brain: A comprehensive review of the neurobiological underpinnings of placebo hyperalgesia. *Frontiers in Neuroscience* 15, 1–16.
- Van Ours, J. C. (2024). Non-transitive patterns in long-term football rivalries. *Journal of Sports Economics* 25(7), 802–826.
- Van Ours, J. C. (2025a). Non-transitive patterns in sports match outcomes: A profitable anomaly. *Empirical Economics* 69(6), 4057–4087.
- Van Ours, J. C. (2025b). On bogey teams and circular triads: Psychological factors in team performance. *Sports Economics Review* 10, 100051.
- Van Ours, J. C. (2026a). Good vibrations: Outcome bias in consumer demand. *Applied Economics Letters*, forthcoming.
- Van Ours, J. C. (2026b). Outcome bias in managerial decisions. *Journal of Economic Psychology* 112, 102872.
- You, J. S. (2021). Random actions in experimental zero-sum games. *Journal of Economics and Behavioral Studies* 13(1), 69–81.

Appendix A: Descriptives

Table A.1: Non-transitive Triads; Points and Expected Points

	Team 1	Team2	Team 3	Points				xPoints				Points - xPoints			
				1-2	2-3	3-1	Sum	1-2	2-3	3-1	Sum	1-2	2-3	3-1	Sum
a. English Premier League															
1	Arsenal	Chelsea	Cr Palace	0.57	1.12	-0.50	1.19	-0.03	0.70	-0.24	0.43	0.60	0.42	-0.26	0.75
2	Arsenal	Tottenham	Man City	0.44	-0.12	0.87	1.19	0.07	-0.77	0.71	0.01	0.37	0.64	0.17	1.17
3	Chelsea	Cr Palace	Man City	1.12	-0.69	0.75	1.19	0.70	-0.71	0.41	0.40	0.42	0.03	0.34	0.79
4	Chelsea	Cr Palace	Man United	1.12	-0.06	0.19	1.25	0.70	-0.22	-0.13	0.35	0.42	0.16	0.32	0.90
5	Chelsea	Cr Palace	West Ham	1.12	0.25	-0.31	1.06	0.70	0.27	-0.57	0.41	0.42	-0.02	0.25	0.65
6	Chelsea	Tottenham	Everton	0.69	0.69	-0.07	1.31	0.31	0.21	-0.42	0.10	0.38	0.48	0.36	1.21
7	Chelsea	Tottenham	Man City	0.69	-0.12	0.75	1.31	0.31	-0.77	0.41	-0.05	0.38	0.64	0.34	1.36
8	Cr Palace	Man City	Everton	-0.69	1.12	0.81	1.25	-0.71	0.61	0.22	0.11	0.03	0.52	0.59	1.14
9	Cr Palace	Man United	Everton	-0.06	0.62	0.81	1.38	-0.22	0.23	0.22	0.23	0.16	0.39	0.59	1.14
10	Cr Palace	West Ham	Everton	0.25	0.06	0.81	1.12	0.27	-0.07	0.22	0.42	-0.02	0.13	0.59	0.70
11	Everton	Liverpool	Tottenham	-0.62	0.81	0.69	0.88	-0.54	0.23	0.21	-0.10	-0.08	0.59	0.48	0.98
12	Man City	West Ham	Tottenham	1.38	-0.31	-0.13	0.94	0.91	-0.29	-0.77	-0.14	0.46	-0.02	0.64	1.08
b. German Bundesliga															
1	Augsburg	Dortmund	Freiburg	-0.50	0.87	0.75	1.12	-0.61	0.71	0.20	0.30	0.11	0.17	0.54	0.82
2	Augsburg	Frankfurt	Freiburg	-0.06	0.50	0.75	1.19	-0.25	0.30	0.21	0.26	0.19	0.20	0.54	0.93
3	Augsburg	Frankfurt	Hoffenheim	-0.06	0.75	0.56	1.25	-0.25	0.36	0.46	0.57	0.19	0.39	0.10	0.68
4	Augsburg	Mainz	Hoffenheim	0.31	0.31	0.56	1.19	0.03	0.13	0.46	0.63	0.28	0.18	0.10	0.56
5	Augsburg	Mainz	RB Leipzig	0.31	0.00	0.88	1.19	0.03	-0.39	0.69	0.34	0.28	0.39	0.18	0.85
6	Bayern Munich	Dortmund	M'gladbach	0.88	0.88	-0.19	1.56	0.46	0.28	-0.60	0.15	0.41	0.59	0.41	1.41
7	Bayern Munich	Freiburg	Hoffenheim	1.19	0.62	-0.56	1.25	0.84	0.06	-0.76	0.15	0.35	0.56	0.19	1.10
8	Bayern Munich	Freiburg	M'gladbach	1.19	0.31	-0.19	1.31	0.84	0.05	-0.60	0.29	0.35	0.26	0.41	1.02
9	Bayern Munich	Wolfsburg	M'gladbach	1.31	-0.12	-0.19	1.00	0.70	-0.11	-0.60	-0.01	0.62	-0.01	0.41	1.01
10	Bayern Munich	Wolfsburg	Mainz	0.48	0.13	0.27	1.12	0.70	0.09	-0.65	0.13	0.62	0.48	-0.10	0.99
11	Dortmund	Wolfsburg	Mainz	1.13	0.56	-0.38	1.31	0.49	0.09	-0.21	0.37	0.63	0.48	-0.16	0.95
12	Dortmund	Wolfsburg	RB Leipzig	1.13	-0.32	0.00	0.81	0.49	-0.39	0.08	0.18	0.63	0.08	-0.08	0.63
c. Italian Serie A															
1	Atalanta	Juventus	Inter Milan	0.00	0.50	0.75	1.25	-0.04	0.00	0.06	0.02	0.04	0.50	0.69	1.23
2	Atalanta	Roma	Torino	0.63	0.94	-0.19	1.38	0.18	0.47	-0.41	0.25	0.45	0.46	0.22	1.13
3	Bologna	Inter Milan	AC Milan	-0.25	0.56	0.94	1.25	-0.54	0.42	0.41	0.29	0.29	0.14	0.53	0.96
4	Bologna	Roma	Udinese	-0.06	0.88	0.25	1.06	-0.30	0.54	-0.20	0.04	0.24	0.33	0.45	1.02
5	Bologna	Torino	AC Milan	0.00	-0.06	0.94	0.88	0.07	-0.43	0.41	0.04	-0.07	0.37	0.53	0.83
6	Bologna	Torino	Udinese	0.00	0.69	0.25	0.94	0.07	-0.04	-0.20	-0.17	-0.07	0.73	0.45	1.11
7	Inter Milan	Napoli	Juventus	0.50	0.25	0.50	1.25	-0.07	0.21	-0.00	0.14	0.57	0.04	0.50	1.11
8	AC Milan	Roma	Torino	0.44	0.94	-0.06	1.31	0.31	0.47	-0.43	0.36	0.12	0.46	0.37	0.95
d. Spanish La Liga															
1	Ath Bilbao	Villarreal	Real Madrid	0.44	-0.44	0.81	0.81	0.17	-0.21	0.45	0.41	0.26	-0.22	0.36	0.40
2	Ath Madrid	Betis	Real Madrid	0.88	-0.12	0.25	1.00	0.35	-0.38	0.12	0.09	0.52	0.26	0.13	0.91
3	Ath Madrid	Celta	Barcelona	0.88	-0.56	0.56	0.88	0.01	-0.17	0.32	0.15	0.87	-0.39	0.25	0.72
4	Barcelona	Sevilla	Celta	1.18	0.06	-0.56	0.69	0.53	-0.04	-0.17	0.32	0.66	0.10	-0.39	0.36
5	Betis	Real Madrid	Celta	-0.12	1.31	0.00	1.19	-0.38	0.56	0.02	0.19	0.26	0.76	-0.02	1.00
6	Betis	Real Madrid	Sevilla	-0.12	0.94	0.44	1.25	-0.38	0.43	0.10	0.15	0.26	0.51	0.34	1.10
7	Celta	Villarreal	Real Madrid	-0.25	-0.44	1.31	0.62	-0.16	-0.21	0.56	0.18	-0.09	-0.22	0.76	0.44

A description of the content of this table for the triad Inter Milan–Napoli–Juventus is provided in section 4.1.