Club coefficients in the UEFA Champions League: Time for the shift to an Elo-based formula

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"*Seine Pflicht erkennen und tun, das ist die Hauptsache.*"[1]

(Frederick the Great)

Abstract

One of the most popular club football tournaments, the UEFA Champions League, will see a fundamental reform from the 2024/25 season: the traditional group stage will be replaced by one league where each of the 36 teams plays eight matches. To guarantee that the opponents of the clubs are of the same strength in the new design, it is crucial to forecast the performance of the teams before the tournament as well as possible. This paper investigates whether the currently used rating of the teams, the UEFA club coefficient, can be improved by taking the games played in the national leagues into account. According to our logistic regression models, a variant of the Elo method provides a higher accuracy in terms of explanatory power in the Champions League matches. The Union of European Football Associations (UEFA) is encouraged to follow the example of the FIFA World Ranking and reform the calculation of the club coefficients in order to avoid unbalanced schedules in the novel tournament format of the Champions League.

Keywords: Elo method; logistic regression; seeding; tournament design; UEFA Champions League

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[1] "*Recognizing and doing one's duty is the main thing.*"
Source: https://www.friedrich-der-grosse.net/zitate-friedrich-des-grossen

1 Introduction

A fundamental issue of tournament design is ensuring the balancedness of the competition by avoiding that a strong team would have a lower chance to qualify than a weak team merely because of the outcome of the draw. For example, several sports tournaments start with a preliminary stage where the teams are allocated into different groups, and only the best team(s) from each group qualify for the next phase. Balancedness can be guaranteed only if one has a reliable measure of strength for the teams. However, it is better to use a transparent methodology that can be accepted by all stakeholders, which implies a trade-off between accuracy and complexity. Consequently, the calculation of the ratings should be relatively simple without requiring the estimation of difficult regression models even if they would have a higher predictive power.

1.1 A new challenge in the UEFA Champions League: scheduling should account for the strength of the teams

The UEFA Champions League, organised by the Union of European Football Associations (UEFA), is the most prestigious club football competition in European football. The format of the Champions League has essentially not changed between the 2003/04 and 2023/24 seasons, even though there have been some reforms in the entry rules (Csató, 2019), in the use of the away goals rule (Bahamonde-Birke and Bahamonde-Birke, 2023; Jost, 2021), in the seeding policy (Corona et al., 2019; Csató, 2020; Dagaev and Rudyak, 2019), and in the design of the qualification system (Csató, 2022).

However, UEFA will introduce a fundamentally new competition format in the 2024/25 season. In particular, the 36 teams will compete in one league where each team plays four matches home and four matches away instead of the previous six matches against three teams, played on a home-and-away basis (UEFA, 2022b). The top eight clubs of the league will qualify for the Round of 16, while the teams ranked between the 9th and 24th places will go to the knockout round play-offs to play two-legged clashes for the remaining eight places in the Round of 16. A similar format will be used in the other two European competitions, the UEFA Europa League and the UEFA Europa Conference League.

The novel competition design is officially called the "Swiss system" (UEFA, 2022b). The name has been inspired by a non-eliminating tournament format containing a fixed number of rounds that is widely used in chess (Csató, 2013, 2017; Dong et al., 2023). It is usually applied when the high number of participants allows only to play a considerably fewer number of rounds than required by a round-robin contest. In the original Swiss-system, the pairing of players in each round is determined by the results of previous rounds, ensuring that both opponents have an equal or similar score (Führlich et al., 2021). This is feasible in chess and some other sports, where the matches can be played in a given location or at least in the same city. However, dynamic scheduling is probably not an option in a football tournament played across the continent since the teams and the fans want to know at the moment of the draw the opponents and the field of all games.

Thus, the schedule needs to be determined at the end of the qualifying stage, and the matching cannot be influenced by the outcomes of the previous games played in the league. Hence, it is crucial to reliably estimate the performance of the teams in advance, which can be achieved by a relatively accurate rating of the clubs. Otherwise, the league phase has a high probability of becoming *unbalanced*, meaning that a particular team mostly plays against opponents with a high number of wins, while another team mainly plays

against opponents with a low number of wins. This will certainly be regarded as unfair, analogously to traditional Swiss-system tournaments (Csató, 2013, 2017). A misaligned rating method can even inspire tanking (the act of deliberately losing a game): a team may have an incentive to manipulate its rating to face weaker opponents and achieve a better result at the end of the tournament (Csató, 2021; Cseh et al., 2023; Lasek et al., 2016). The early elimination of strong clubs can also have serious financial consequences as they attract the most attention from both the media and the fans.

1.2 The aim of the study

Section 1.1 has highlighted the importance of forecasting the performance of the teams in the new format of the UEFA Champions League. Naturally, UEFA does currently use a rating of the teams, the UEFA club coefficient, in order to guarantee the balancedness of the groups in the Champions League and other competitions. The coefficient is essentially based on the results in the five previous seasons of the UEFA competitions (Champions League, Europa League, Europa Conference League UEFA (2018). However, it ignores most matches played by the clubs as it does not depend on the outcomes of matches in the national leagues and cups at all.

Therefore, our research question is whether a revised calculation formula for club coefficients can improve predictive accuracy. In particular, we compare the performance of the official UEFA club coefficient and Football Club Elo Rating, which is a readily available Elo-based measure of team strength. Their explanatory power is studied via logistic regression models. Success is defined by winning group matches, winning in the knockout stage, and obtaining a higher rank in the group stage. The database contains the 19 Champions League seasons played between 2003/04 and 2021/22.

The findings can be interesting for tournament organisers, especially for administrators who are responsible for the methodology of coefficients used for ranking, seeding, and distributing prize money in sports competitions.

1.3 The main message

The Football Club Elo Rating robustly outperforms the currently used UEFA club coefficient in terms of predictive accuracy. Accounting for the results of the games played in domestic championships leads to better estimations of team performance, and can guarantee fairer schedules in the novel tournament design of the UEFA Champions League.

1.4 The implementability of our proposal

We think that this fundamental change in the UEFA Champions League offers a unique opportunity to modify the calculation of the UEFA club coefficient, too. Two recent reforms, approved by the UEFA and the Fédération Internationale de Football Association (International Association Football Federation, FIFA), reinforce that our recommendation has a reasonable chance to be implemented in practice:

- UEFA has used the proposal of Guyon (2018) to minimise group advantage in the 2020 UEFA European Football Championship, making the tournament fairer than its previous edition;
- FIFA has developed and introduced a new model for calculating the FIFA World Ranking based on the Elo method in 2018 (FIFA, 2018).

The current algorithm of the FIFA World Ranking "*is not only intuitive, easy to understand and improves overall accuracy of the formula, but also addresses feedback received about the previous model and provides fair and equal opportunities for all teams across all confederations to ascend the FIFA World Ranking*" (FIFA, 2018). Consequently, using the Elo method to quantify the strength of European football clubs seems to be a promising recommendation.

1.5 The organisation of the paper

The study is structured as follows. A concise overview of literature is provided in Section 2. Section 3 describes the data underlying our empirical investigation, as well as the statistical methods used. The estimations are presented in Section 4. Section 5 discusses the main contributions and outlines some directions for future research.

2 Related literature

Some previous papers deal with similar topics in the UEFA Champions League. Schokkaert and Swinnen (2016) empirically examine how the changes in the format of the Champions League have affected uncertainty of outcome. According to the regression discontinuity design of Engist et al. (2021), seeding itself does not contribute positively to success in this tournament. Triguero-Ruiz and Avila-Cano (2023) analyse competitive balance in the group stage of the Champions League.

The current study is strongly connected to the literature on rating methods in football, too. Hvattum and Arntzen (2010) implement and test two Elo-based prediction methods. Lasek et al. (2013) and Gásquez and Royuela (2016) demonstrate that the Elo rating system is quite competitive in predicting the matches played by national football teams. Baker and McHale (2015) and Baker and McHale (2018) suggest time-varying rating models. Van Eetvelde and Ley (2019) give a survey of the most common ranking methods in football. Ley et al. (2019) compare several existing and novel statistical models assigning one or more strength parameters to a football team.

Szczecinski and Djebbi (2020) and Szczecinski (2022) aim to understand and extend the Elo algorithm. Cea et al. (2020) and Kaminski (2022) discuss the shortcomings of the previous FIFA World Ranking used until 2018. Lasek and Gagolewski (2021) apply a popular optimisation heuristic (the gradient descent algorithm) to build interpretable rating systems that can be easily adjusted once new results are observed. Szczecinski and Roatis (2022) show that the predictive capacity of the current FIFA World Ranking would considerably improve by incorporating home-field advantage, and can be further developed by taking the margin of victory into account. Gyarmati et al. (2023) evaluate three methods with respect to their performance in ranking European football teams.

Finally, some studies examine the predictive power of alternative measures. According to O'Leary (2017), the Yahoo crowd outperformed experts at predicting the outcomes of matches played in the 2014 FIFA World Cup and was competitive with the accuracy of betting odds. Peeters (2018) show that Transfermarkt valuations provide better forecasts on international football matches than standard predictors such as the FIFA ranking and the Elo rating.

3 Data and methodology

The UEFA Champions League has been organised in the same format between the season of 2003/04 and 2021/22. The 32 clubs are divided into eight groups of four to play a home-away round-robin contest. In each group, the top two teams qualify for the knockout stage. The knockout ties are played in a two-legged format except for the final, which is played in a predetermined neutral stadium. Consequently, the group stage consists of $8 \times 12 = 96$ games, and the knockout stage consists of 14 clashes (28 games) without the final.

In the group stage, each group contains one team from each of the four pots. The pots are primarily determined by the ranking of the teams based on their UEFA club coefficients. However, the titleholder and the champions of the strongest associations have been assigned to Pot 1 between the 2015/16 and 2017/18 seasons (Corona et al., 2019; Dagaev and Rudyak, 2019), and the titleholder, the UEFA Europa League titleholder, as well as the champions of the strongest associations, are assigned to Pot 1 since 2018/19 (Csató, 2020). This allocation rule implies that teams having a similar club coefficient usually do *not* play against each other in the group stage.

The UEFA club coefficient is either the sum of all points won in the previous five seasons of European competitions (UEFA Champions League, UEFA Europa League, UEFA Europa Conference League) or the association coefficient over the same period, whichever is the higher (UEFA, 2018). In the Champions League, the first definition usually gives a higher value, although there are a few exceptions such as the German VFL Wolfsburg in the 2021/22 season, which had 14.5 points but an association coefficient of 14.714. These data have been collected from the unofficial, but comprehensive website of *Bert Kassies* (Kassies, 2023).

The Elo method has been developed by a Hungarian-born American physics, *Árpád Élő*, as an improved chess rating system. It is now widely used in many sports, including association football, as shown by the FIFA World Ranking since 2018 (FIFA, 2018). The method calculates the expected winning probability W before any match according to the formula

$$W = \frac{1}{1 + 10^{\Delta/k}},$$

where Δ is the difference between the Elo rating of the home and the away team, while k is a scaling parameter. After the outcome of the match becomes known ($R = 1$ for home win; $R = 0.5$ for draw; $R = 0$ for away win), the ratings are updated: $E_1 = E_0 + K(R - W)$ with E_0 being the old and E_1 being the new Elo rating. Parameter K might reflect the importance of the match and also controls the speed of convergence; a high K implies a quick convergence but makes the ratings volatile, and a low K provides more stable ratings. Consequently, a win always increases the Elo rating and a loss certainly decreases it. A draw is favourable for the lower-ranked team. The two teams playing each other exchange points, that is, the sum of their ratings remains the same.

The Elo approach has many variants, we have used the Football Club Elo Ratings, which are available at `http://clubelo.com/`. Its formula applies the values $k = 400$ and $K = 20$, and accounts for home advantage and the margin of victory (Football Club Elo Ratings, 2023). This measure has served as the basis of a recent simulation that analysed a recent change in the qualifying system of the UEFA Champions League (Csató, 2022).

The Elo ratings are continuously updated once a match is played by the teams. On the other hand, the UEFA club coefficient is calculated at the beginning of each season and does not change during the season. Therefore, in order to ensure the fairness of their

Table 1: Descriptive statistics of the UEFA club coefficients and Football Club Elo Ratings

Set of matches	Rating	Mean	Median	St. dev.	Minimum	Maximum
Group matches	UEFA	70.49	65.07	38.75	1.63	177.00
Group matches	Elo	1772.54	1777.82	136.61	1297.08	2089.27
Knockout matches	UEFA	95.77	96.45	35.03	12.21	177.00
Knockout matches	Elo	1870.55	1867.13	102.58	1549.96	2089.27

comparison, we have fixed Football Club Elo Ratings at the level of 30 June each year when most European football leagues, as well as international competitions, have finished.

The performance of the UEFA club coefficients and Football Club Elo Ratings are compared by logistic regression models that contain the difference of the opposing teams' ratings as explanatory variable(s). The sample contains the 19 UEFA Champions League seasons played between 2003/04 and 2021/22, although some sensitivity analysis will be carried out on smaller sets. For the dependent variable, three options are investigated:

- *Group matches*: 1 indicates home win and 0 indicates away win, draws are excluded. The explanatory variable is the strength of the home team minus the strength of the away team.
  From the $19 \times 8 \times 12 = 1824$ group matches, 1402 were won by one of the teams. In particular, there were 863 home wins (61.6%).

- *Knockout qualification*: 1 indicates the qualification of the team hosting the first leg and 0 indicates the qualification of the team hosting the second leg, finals are excluded. The explanatory variable is the strength of the team hosting the first leg minus the strength of the team hosting the second leg.
  There are 14 two-legged clashes in each season, which implies a sample size of $19 \times 14 = 266$. However, in the 2019/20 season, quarterfinals and semifinals were played in a single-leg format on a neutral field behind closed doors. These six matches are removed from the sample. Among the remaining 260 two-legged clashes, 159 (61.2%) were won by the team hosting the second leg.

- *Group ranking*: 1 indicates that the team having a higher club coefficient is ranked higher and 0 indicates that the team having a higher club coefficient is ranked lower (two clubs with the same coefficient never played in the same group).
  In each group, six comparisons can be made between the four teams, meaning $19 \times 8 \times 6 = 912$ observations. The dependent variable equals 1 in 686 cases (75.2%).

Naturally, the COVID-19 pandemic caused some disruptions. Almost all matches were played behind closed doors in the 2020/21 season, which could have affected home advantage (Bryson et al., 2021). Furthermore, in the 2019/20 season, neither the UEFA Champions League nor many national leagues were finished by 30 June 2020. Thus, the Elo ratings used for 2020/21 do not contain the results of all matches played in the previous seasons. Therefore, the 2020/21 season will not be considered in some regressions due to this potential bias.

The descriptive statistics of the two ratings are summarised in Table 1, separately for the group stage and the knockout stage of the UEFA Champions League seasons that are

Table 2: Descriptive statistics of the dataset

Model	Variable	Mean	Median	St. dev.	Minimum	Maximum
Group matches	Δ UEFA	2.89	8.26	61.79	−159.45	159.45
Group matches	Δ Elo	9.75	11.32	216.57	−641.00	641.00
Knockout qualification	Δ UEFA	−12.70	−18.42	48.16	−140.12	128.89
Knockout qualification	Δ Elo	−53.22	−56.11	141.64	−451.45	434.14
Group ranking	Δ UEFA	50.84	47.00	32.91	−34.82	159.45
Group ranking	Δ Elo	158.76	148.69	140.49	−289.73	641.00

included in our database. Naturally, the teams qualifying for the knockout stage have a higher value on average.

Since our models will consider the difference between the ratings for each match, the descriptive statistics of the corresponding independent variables are reported in Table 1. For group matches, the average difference between the club coefficients and Elo ratings is close to zero. On the other hand, the mean is negative in the knockout stage because the runners-up are guaranteed to host the first game and the group winners are usually stronger teams in the Round of 16. It is worth noting that the highest difference with respect to Elo ratings occurred in the 2021/22 season when Sheriff Tiraspol defeated Real Madrid in Spain, causing one of the biggest shocks in the history of the UEFA Champions League (O'Connor, 2021).

The scale of the two measures is not the same, the difference between the Elo ratings is about three-four times higher than the difference between the club coefficients. Nonetheless, the variables will not be standardised since we primarily focus on comparing the performance of the models rather than the interpretation of the estimated parameters.

We will use standard metrics to evaluate logistic regression models (Allison, 2013). Naturally, the regression is estimated by maximizing the likelihood function. Denote the value of the likelihood function without predictors by L_0, the likelihood of the final model by L_M, and the sample size by n. Then Cox & Snell R^2 is

$$R^2_{C\&S} = 1 - \left(\frac{L_0}{L_M}\right)^{2/n},$$

which is a generalisation of the usual R^2 for linear regression. However, the upper bound of $R^2_{C\&S}$ is not one but

$$1 - L_0^{2/n} = 1 - \left[p^p (1-p)^{1-p}\right]^2,$$

where p is the ratio of the event to be predicted in the sample. Nagelkerke R^2 adjusts $R^2_{C\&S}$ by dividing it with its upper bound in order to get a value between zero and one.

Finally, McFadden R^2 is defined as

$$R^2_{McF} = 1 - \frac{\ln(L_M)}{\ln(L_0)}.$$

The idea behind the formula is that $\ln(L_0)$ can be regarded as the residual sum of squares in a linear regression.

Another measure to assess the performance of a logistic regression model is the area under the ROC curve. The ROC curve plots the true positive rate as a function of the false positive rate. The area under the ROC curve is the two-dimensional area below the ROC curve from $(0,0)$ to $(1,1)$.

Table 3: Predictive accuracy of the strength measures

Model / Variable	Δ UEFA	Δ Elo
Group matches	70.68%	73.32%
Knockout qualification	61.92%	65.00%
Group ranking	75.22%	78.51%

Table 4: Logistic regression models, group matches, 2003/04–2021/22

	(1)	(2)	(3)
Constant	0.559***	0.591***	0.591***
	(0.064)	(0.067)	(0.067)
UEFA	0.019***	—	0.003
	(0.001)		(0.002)
Elo	—	0.007***	0.006***
		(0.000)	(0.001)
Cox & Snell R^2	0.222	0.270	0.272
Nagelkerke R^2	0.301	0.367	0.369
Classification	73.0%	75.4%	75.2%
Area under ROC	0.784	0.814	0.815
Sample size	1402	1402	1402

Standard errors are in parentheses. * $p < 5\%$; ** $p < 1\%$; *** $p < 0.1\%$.
UEFA (Elo) is the difference between the UEFA club coefficient (Football Club Elo Rating) of the home team and the away team.
Classification is the probability of cases correctly classified if the cut is at 0.5.

4 Results

Section 4.1 presents the baseline results for the three alternative dependent variables, and Section 4.2 examines some other specifications to verify the robustness of the main findings.

4.1 Comparing the two measures of team strength

First, in order to motivate the more sophisticated models, the rough prediction accuracy of the UEFA club coefficients and Elo ratings are presented in Table 3 with the assumption that a higher (or equal) coefficient/Elo rating predicts success. As expected, group ranking is the easiest to predict, followed by group matches and knockout qualification. Crucially, the difference between Elo ratings robustly outperforms the difference between club coefficients.

Table 4 shows logistic regressions for group matches won by one of the teams. The constant is highly significant, playing on the home field means a substantial advantage. Elo rating is a stronger predictor of success than UEFA club coefficient: model (2) has a higher explanatory power than model (1), and Elo rating is significant in model (3), while the club coefficient has no additional value here.

According to Table 5, the same conclusions hold for the two-legged clashes played in the knockout stage. Again, model (2) outperforms model (1), and using the club coefficients is not able to improve the predictions based on Elo ratings.

Table 5: Logistic regression models, knockout qualification, 2003/04–2021/22

	(1)	(2)	(3)
Constant	−0.362**	−0.223	−0.218
	(0.132)	(0.140)	(0.141)
UEFA	0.009**	—	−0.007
	(0.003)		(0.004)
Elo	—	0.005***	0.007***
		(0.001)	(0.002)
Cox & Snell R^2	0.038	0.109	0.117
Nagelkerke R^2	0.051	0.148	0.159
Classification	59.6%	65.4%	68.1%
Area under ROC	0.617	0.690	0.693
Sample size	260	260	260

Standard errors are in parentheses. * $p < 5\%$; ** $p < 1\%$; *** $p < 0.1\%$.
UEFA (Elo) is the difference between the UEFA club coefficient (Football Club Elo Rating) of the team hosting the first leg and the team hosting the second leg.
Classification is the probability of cases correctly classified if the cut is at 0.5.
In the 2019/20 season, quarterfinals and semifinals were played in a single-leg format on a neutral field behind closed doors. These six matches are removed from the sample.

Table 6: Logistic regression models, group ranking, 2003/04–2021/22

	(1)	(2)	(3)
Constant	−0.095	0.015	−0.338*
	(0.141)	(0.116)	(0.154)
UEFA	0.027***	—	0.012***
	(0.003)		(0.004)
Elo	—	0.009***	0.008***
		(0.001)	(0.001)
Cox & Snell R^2	0.107	0.172	0.184
Nagelkerke R^2	0.159	0.256	0.272
Classification	78.2%	78.1%	78.1%
Area under ROC	0.704	0.776	0.784
Sample size	912	912	912

Standard errors are in parentheses. * $p < 5\%$; ** $p < 1\%$; *** $p < 0.1\%$.
UEFA (Elo) is the difference between the UEFA club coefficients (Football Club Elo Ratings) of the two teams.
Classification is the probability of cases correctly classified if the cut is at 0.5.

Analogously, Table 6 reveals that the Elo rating is more useful for predicting group ranking than the UEFA club coefficient as model (2) is more efficient than model (1), although the club coefficients now have a significant contribution when both measures of strengths are considered. In particular, a team with a fixed Elo rating is more likely to finish above another team if it has a higher club coefficient. This makes sense as better performance in previous European competitions can provide some experience for

Table 7: Logistic regression models, group ranking with an alternative dependent variable, 2003/04–2021/22

	(1)	(2)	(3)
Constant	0.437**	0.415***	0.286
	(0.141)	(0.114)	(0.151)
UEFA	0.019***	—	0.005
	(0.003)		(0.004)
Elo	—	0.007***	0.007***
		(0.001)	(0.001)
Cox & Snell R^2	0.054	0.115	0.116
Nagelkerke R^2	0.083	0.177	0.180
Classification	78.7%	78.1%	78.5%
Area under ROC	0.653	0.746	0.744
Sample size	912	912	912

Standard errors are in parentheses. * $p < 5\%$; ** $p < 1\%$; *** $p < 0.1\%$.
UEFA (Elo) is the difference between the UEFA club coefficients (Football Club Elo Ratings) of the two teams.
Classification is the probability of cases correctly classified if the cut is at 0.5.

the squads that cannot be obtained by playing against domestic teams.

4.2 Sensitivity analysis

In the regressions for group ranking (Table 6), the definition of the dependent variable is somewhat arbitrary as it "assumes" that the team with a higher club coefficient should be ranked higher. Therefore, the estimations are repeated with an alternative specification: 1 (0) indicates that the club having a higher Elo is ranked higher (lower). Then the dependent variable equals 1 for 716 observations (78.5%). The results are reported in Table 7. Again, model (2) has a better fit compared to model (1), but now the UEFA club coefficient is not able to significantly contribute to model (2) as can be seen in model (3).

Table 4 has shown the results for all group matches without draws, which may contain an inherent distortion if the drawn games are not similar to the games that have been decided. Hence, Table 8 presents multinomial logistic regressions for the three possible outcomes (home win, draw, away win) with the reference category being away win. A higher club coefficient or a higher Elo rating significantly increases the probability of winning and playing a draw compared to losing. Model (2) clearly outperforms model (1), and the UEFA club coefficient is again insignificant in model (3), thus, the Elo rating remains a better measure of strength. Now there are three alternative interpretations of the area under the ROC curve, which suggest that draws are the most difficult to forecast.

In order to identify potential trends and check the robustness of the previous findings, the sample has been cut into two equal parts of 9-9 seasons together with removing 2020/21, which was affected by the Covid-19 pandemic to a great extent (see Section 3). According to Table 9, there is only a slight difference between the parameters for group matches estimated on the basis of the first and the last nine seasons. Nonetheless, the predictions are somewhat more accurate since 2012, which might imply a worsening competitive balance that is in line with previous research (Triguero-Ruiz and Avila-Cano,

Table 8: Multinomial logistic regression models,
all group matches including draws, 2003/04–2021/22

		(1)	(2)	(3)
Home win	Constant	0.558***	0.590***	0.590***
		(0.064)	(0.066)	(0.066)
	UEFA	0.020***	—	0.004
		(0.001)		(0.002)
	Elo	—	0.007***	0.006***
			(0.000)	(0.001)
Draw	Constant	−0.061	−0.001	0.000
		(0.072)	(0.073)	(0.073)
	UEFA	0.008***	—	0.000
		(0.001)		(0.002)
	Elo	—	0.003***	0.003***
			(0.000)	(0.001)
Cox & Snell R^2		0.186	0.225	0.227
Nagelkerke R^2		0.212	0.257	0.259
McFadden R^2		0.098	0.121	0.123
Classification		56.0%	57.9%	57.7%
Area under ROC	Home win	0.737	0.761	0.762
Area under ROC	Draw	0.569	0.578	0.577
Area under ROC	Away win	0.734	0.761	0.761
Sample size		1824	1824	1824

Standard errors are in parentheses. * $p < 5\%$; ** $p < 1\%$; *** $p < 0.1\%$.
UEFA (Elo) is the difference between the UEFA club coefficient (Football Club Elo Rating) of the home team and the away team.
The reference category is away win.
Classification is the probability of cases correctly classified if the cut is at 0.5.

2023). On the other hand, the dominance of model (2) over model (1) is obvious, and the UEFA club coefficient still does not provide additional information to Football Club Elo Rating.

Table 10 focuses on qualification in the knockout stage for the two subsamples. Again, model (2) outperforms model (1), and the metrics of goodness of fit are higher for the recent Champions League seasons if the model contains the Elo rating. As before, there is no reason to favour the UEFA club coefficient over the Elo rating with respect to predicting qualification.

Finally, Table 11 presents the estimations for group ranking. The main message does not change: (a) the Champions League has been more predictable between 2012 and 2022 than between 2003 and 2012; (b) the Elo rating gives more accurate forecasts compared to the UEFA club coefficient. Furthermore, similar to Table 6, adding the club coefficient is able to improve the model as its parameter is significant in equation (3).

Table 9: Logistic regression models, group matches, sample split into two periods

Period	2003/04–2011/12			2012/13–2021/22 (w/o 2020/21)		
Model	(1)	(2)	(3)	(1)	(2)	(3)
Constant	0.631***	0.662***	0.663***	0.532***	0.558***	0.561***
	(0.093)	(0.096)	(0.096)	(0.093)	(0.097)	(0.097)
UEFA	0.019***	—	0.002	0.019***	—	0.005
	(0.002)		(0.003)	(0.002)		(0.003)
Elo	—	0.006***	0.006***	—	0.007***	0.005***
		(0.001)	(0.001)		(0.001)	(0.001)
Cox & Snell R^2	0.187	0.234	0.234	0.243	0.287	0.290
Nagelkerke R^2	0.255	0.320	0.320	0.329	0.389	0.393
Classification	72.5%	75.0%	75.0%	73.3%	74.5%	74.8%
Area under ROC	0.764	0.792	0.815	0.797	0.824	0.826
Sample size	652	652	652	674	674	674

Standard errors are in parentheses. * $p < 5\%$; ** $p < 1\%$; *** $p < 0.1\%$.
UEFA (Elo) is the difference between the UEFA club coefficient (Football Club Elo Rating) of the home team and the away team.
Classification is the probability of cases correctly classified if the cut is at 0.5.

Table 10: Logistic regression models, knockout qualification, sample split into two periods

Period	2003/04–2011/12			2012/13–2021/22 (w/o 2020/21)		
Model	(1)	(2)	(3)	(1)	(2)	(3)
Constant	−0.364	−0.275	−0.275	−0.280	−0.075	−0.049
	(0.193)	(0.199)	(0.199)	(0.193)	(0.214)	(0.219)
UEFA	0.013**	—	0.002	0.007*	—	−0.015*
	(0.005)		(0.007)	(0.003)		(0.006)
Elo	—	0.005**	0.005*	—	0.006***	0.011***
		(0.002)	(0.002)		(0.002)	(0.003)
Cox & Snell R^2	0.056	0.089	0.089	0.038	0.163	0.204
Nagelkerke R^2	0.076	0.121	0.122	0.052	0.220	0.275
Classification	63.5%	67.5%	67.5%	58.3%	67.5%	66.7%
Area under ROC	0.649	0.665	0.666	0.608	0.748	0.763
Sample size	126	126	126	120	120	120

Standard errors are in parentheses. * $p < 5\%$; ** $p < 1\%$; *** $p < 0.1\%$.
UEFA (Elo) is the difference between the UEFA club coefficient (Football Club Elo Rating) of the team hosting the first leg and the team hosting the second leg.
Classification is the probability of cases correctly classified if the cut is at 0.5.
In the 2019/20 season, quarterfinals and semifinals were played in a single-leg format on a neutral field behind closed doors. These six matches are removed from the sample.

5 Conclusions

This study has investigated the ability of two measures of strength—the official UEFA club coefficient and the alternative Football Club Elo Rating (http://clubelo.com/)—to predict the performance of the teams playing in the UEFA Champions League, a

Table 11: Logistic regression models, group ranking, sample split into two periods

Period	2003/04–2011/12			2012/13–2021/22 (w/o 2020/21)		
Model	(1)	(2)	(3)	(1)	(2)	(3)
Constant	−0.009	0.181	−0.154	−0.195	−0.165	−0.539*
	(0.207)	(0.164)	(0.217)	(0.201)	(0.173)	(0.229)
UEFA	0.026***	—	0.013*	0.027***	—	0.012**
	(0.005)		(0.005)	(0.004)		(0.005)
Elo	—	0.007***	0.006***	—	0.010***	0.009***
		(0.001)	(0.001)		(0.001)	(0.001)
Cox & Snell R^2	0.088	0.125	0.136	0.125	0.213	0.225
Nagelkerke R^2	0.130	0.184	0.204	0.184	0.314	0.332
Classification	77.3%	76.9%	77.3%	78.5%	78.5%	78.7%
Area under ROC	0.686	0.736	0.745	0.717	0.803	0.810
Sample size	432	432	432	432	432	432

Standard errors are in parentheses. * $p < 5\%$; ** $p < 1\%$; *** $p < 0.1\%$.
UEFA (Elo) is the difference between the UEFA club coefficients (Football Club Elo Ratings) of the two teams.
Classification is the probability of cases correctly classified if the cut is at 0.5.

highly prestigious and popular football competition. For the sake of comparability, the Elo ratings have also been fixed at the beginning of each season. Since the club coefficient does not take the games played in the national leagues and cups into account, it is not surprising that it is outperformed by the Elo rating, which contains this information.

Our finding has a clear message for the Union of European Football Association (UEFA): it is time to reform the calculation of club coefficients used for seeding and distributing prize money (Csató, 2023; UEFA, 2022a) in European club football. This would be especially important because the new tournament format of the Champions League, to be introduced in the 2024/25 season, requires an accurate measurement of teams' strength in order to create a fair schedule.

Naturally, the Football Club Elo Rating is not necessarily the best possible predictor. The Elo algorithm is able to incorporate several characteristics of the matches and preferences of the decision-makers (Szczecinski and Roatis, 2022); for instance, games played in European competitions could have a higher weight compared to games played in the national leagues. Hopefully, testing and comparing these variants will be the topic of future papers. In addition, simulations may uncover the sporting effects of using an inaccurate measure of strength such as the current UEFA club coefficient, and the importance of finding the hidden ranking of the teams in various competition formats.

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References

Allison, P. (2013). What's the best R-squared for logistic regression. *Statistical Horizons*, 13.

Bahamonde-Birke, F. J. and Bahamonde-Birke, R. A. (2023). About the "away goals rule" in association football. Does scrapping the rule increase the fairness of the game? *Journal of Sports Economics*, 24(3):310–328.

Baker, R. D. and McHale, I. G. (2015). Time varying ratings in association football: the all-time greatest team is.... *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, 178(2):481–492.

Baker, R. D. and McHale, I. G. (2018). Time-varying ratings for international football teams. *European Journal of Operational Research*, 267(2):659–666.

Bryson, A., Dolton, P., Reade, J. J., Schreyer, D., and Singleton, C. (2021). Causal effects of an absent crowd on performances and refereeing decisions during Covid-19. *Economics Letters*, 198:109664.

Cea, S., Durán, G., Guajardo, M., Sauré, D., Siebert, J., and Zamorano, G. (2020). An analytics approach to the FIFA ranking procedure and the World Cup final draw. *Annals of Operations Research*, 286(1-2):119–146.

Corona, F., Forrest, D., Tena, J. D., and Wiper, M. (2019). Bayesian forecasting of UEFA Champions League under alternative seeding regimes. *International Journal of Forecasting*, 35(2):722–732.

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. (2019). UEFA Champions League entry has not satisfied strategyproofness in three seasons. *Journal of Sports Economics*, 20(7):975–981.

Csató, L. (2020). The UEFA Champions League seeding is not strategy-proof since the 2015/16 season. *Annals of Operations Research*, 292(1):161–169.

Csató, L. (2021). *Tournament Design: How Operations Research Can Improve Sports Rules*. Palgrave Pivots in Sports Economics. Palgrave Macmillan, Cham, Switzerland.

Csató, L. (2022). UEFA against the champions? An evaluation of the recent reform of the Champions League qualification. *Journal of Sports Economics*, 23(8):991–1016.

Csató, L. (2023). The unfairness of the revenue distribution system used in the UEFA club competitions. *International Journal of Sport Policy and Politics*, 15(1):187–192.

Cseh, Á., Führlich, P., and Lenzner, P. (2023). The Swiss gambit. Manuscript. DOI: 10.48550/arXiv.2302.10595.

Dagaev, D. and Rudyak, V. (2019). Seeding the UEFA Champions League participants: Evaluation of the reform. *Journal of Quantitative Analysis in Sports*, 15(2):129–140.

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.

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

FIFA (2018). Revision of the FIFA / Coca-Cola World Ranking. https://img.fifa.com/image/upload/edbm045h0udbwkqew35a.pdf.

Football Club Elo Ratings (2023). The system or how this works. http://clubelo.com/System.

Führlich, P., Cseh, Á., and Lenzner, P. (2021). Improving ranking quality and fairness in Swiss-system chess tournaments. Manuscript. DOI: 10.48550/arXiv.2112.10522.

Gásquez, R. and Royuela, V. (2016). The determinants of international football success: A panel data analysis of the Elo rating. *Social Science Quarterly*, 97(2):125–141.

Guyon, J. (2018). What a fairer 24 team UEFA Euro could look like. *Journal of Sports Analytics*, 4(4):297–317.

Gyarmati, L., Orbán-Mihálykó, É., Mihálykó, Cs., and Vathy-Fogarassy, Á. (2023). Aggregated rankings of top leagues' football teams: Application and comparison of different ranking methods. *Applied Sciences*, 13(7):4556.

Hvattum, L. M. and Arntzen, H. (2010). Using ELO ratings for match result prediction in association football. *International Journal of Forecasting*, 26(3):460–470.

Jost, P.-J. (2021). Competitive balance and the away goals rule during extra time. *Journal of Sports Economics*, 22(7):823–863.

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

Kassies, B. (2023). UEFA European club football. https://kassiesa.net/uefa/index.html.

Lasek, J. and Gagolewski, M. (2021). Interpretable sports team rating models based on the gradient descent algorithm. *International Journal of Forecasting*, 37(3):1061–1071.

Lasek, J., Szlávik, Z., and Bhulai, S. (2013). The predictive power of ranking systems in association football. *International Journal of Applied Pattern Recognition*, 1(1):27–46.

Lasek, J., Szlávik, Z., Gagolewski, M., and Bhulai, S. (2016). How to improve a team's position in the FIFA ranking? A simulation study. *Journal of Applied Statistics*, 43(7):1349–1368.

Ley, C., Van de Wiele, T., and Van Eetvelde, H. (2019). Ranking soccer teams on the basis of their current strength: A comparison of maximum likelihood approaches. *Statistical Modelling*, 19(1):55–73.

O'Connor, R. (2021). Sheriff Tiraspol: Champions League team from an unrecognised state. 28 September. https://www.bbc.com/sport/football/58729231.

O'Leary, D. E. (2017). Crowd performance in prediction of the World Cup 2014. *European Journal of Operational Research*, 260(2):715–724.

Peeters, T. (2018). Testing the Wisdom of Crowds in the field: Transfermarkt valuations and international soccer results. *International Journal of Forecasting*, 34(1):17–29.

Schokkaert, J. and Swinnen, J. (2016). Uncertainty of outcome is higher in the Champions League than in the European Cup. *Journal of Sports Economics*, 17(2):115–147.

Szczecinski, L. (2022). G-Elo: generalization of the Elo algorithm by modeling the discretized margin of victory. *Journal of Quantitative Analysis in Sports*, 18(1):1–14.

Szczecinski, L. and Djebbi, A. (2020). Understanding draws in Elo rating algorithm. *Journal of Quantitative Analysis in Sports*, 16(3):211–220.

Szczecinski, L. and Roatis, I.-I. (2022). FIFA ranking: Evaluation and path forward. *Journal of Sports Analytics*, 8(4):231–250.

Triguero-Ruiz, F. and Avila-Cano, A. (2023). On competitive balance in the group stage of the UEFA Champions League. *Scottish Journal of Political Economy*, 70(3):231–248.

UEFA (2018). How the club coefficients are calculated. 1 July. https://www.uefa.com/nationalassociations/uefarankings/news/0252-0cda38714c0d-0874a

UEFA (2022a). Distribution to clubs from the 2022/23 UEFA Champions League, UEFA Europa League and UEFA Europa Conference League and the 2022 UEFA Super Cup. 4 July. https://editorial.uefa.com/resources/0277-158b0bea495a-ba6c18158cd3-1000/20220704_c

UEFA (2022b). UEFA approves final format and access list for its club competitions as of the 2024/25 season. 10 May. https://www.uefa.com/returntoplay/news/0275-151c779310c3-b92bbf0d24f9-1000--uefa-ap

Van Eetvelde, H. and Ley, C. (2019). Ranking methods in soccer. In Kenett, R. S., Longford, T. N., Piegorsch, W., and Ruggeri, F., editors, *Wiley StatsRef: Statistics Reference Online*, pages 1–9. Springer, Hoboken, New Jersey, USA.