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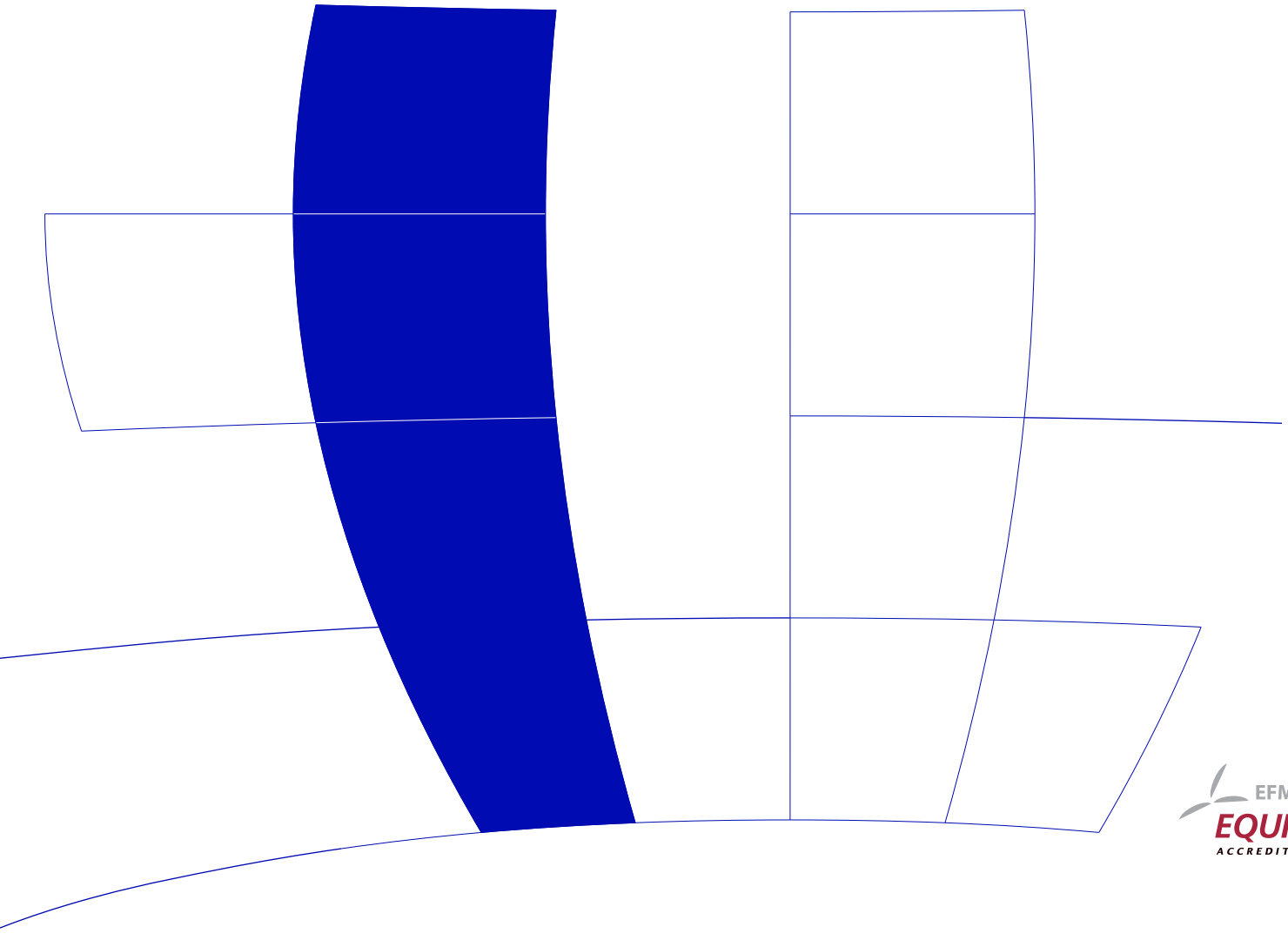

Predicting the winner of the EURO 2008
(A statistical investigation of bookmakers odds)

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Abstract

In June 2008 one of the biggest and most popular sports tournaments took place in Austria and Switzerland, the *European football championship 2008* (UEFA EURO 2008). Before the tournament started millions of football supporters throughout the world were asking themselves, just as we did: "Who is going to win the EURO 2008?".

We investigate a method for forecasting the tournament outcome, that is not based on historical data (such as scores in previous matches) but on quoted winning odds for each of the 16 teams as provided by 45 international bookmakers. By using a mixed-effects model with a team-specific random effect and fixed effects for the bookmaker and the preliminary group we model the unknown "true" log-odds for winning the championship.

The final of the EURO 2008 was played by the teams Germany and Spain. This was exactly the fixture that our method forecasted with a probability of about 20.2%. Furthermore, estimated winning probabilities can be derived from our model, where team Germany, the runner-up of the final had the highest probability (17.6%) to win the title and team Spain the winner of the tournament had the second best chance to win the championship (12.3%). To adjust for effects of the tournament schedule including the group draw, we recovered the latent team strength (underlying the bookmakers' expectations) to answer the question: Will the "best" team win? An ex post analysis of the tournament showed that our method yields good predictions of the tournament outcome and outperforms the FIFA/Coca Cola World rating and the Elo rating.

Keywords: Sports forecasting, EURO 2008, odds, mixed-effects model.

1 Introduction

> *"Football is a simple game;* 22 *men chase a ball for* 90 *minutes and at the end, the Germans always win."* Gary Lineker

The main result of our study, forecasting team Germany as the winner of the EURO 2008, will not come as a surprise for many football supporters and it could be wrapped up much more expressively as in the (in-)famous quote of Gary Lineker. But is this really the end of the story? From a statistical point of view, it would clearly be desirable to complement such a result with the corresponding probability, leading to further questions: e.g., who is the expected runner-up, which teams has the best chance to reach quarter- and semi-finals and with which probabilities. Here, we suggest a new method for answering these questions and compare them with other approaches.

Our method uses prospective data, namely bookmakers odds from 45 international bookmakers for winning the championship for each of the 16 teams. Whereas other forecasting strategies employ historical or retrospective data based on scores in previous games—e.g., the Elo rating (Advanced Satellite Consulting Ltd, 2008) or the FIFA/Coca Cola World rating (Fédération Internationale de Football Association, 2008)—or using additional variables like the overall value of the team players, performance in past tournaments, or performance during the qualification (e.g., Raiffeisen Zentralbank, 2008; UBS Wealth Management Research Switzerland, 2008), our forcasting method is only based on the bookmakers expectations.

The motivation for using bookmakers odds is twofold: (1) As indicated above, they are an assessment of the expected chance to win this specific tournament (rather than the performance in previous games). (2) The bookmakers have strong economic incentives to rate the teams correctly because this is how they earn their money. A bias (in either direction, too good or too bad) will cost them money, or, in other words, will reduce their profits. Because of their economic incentives, bookmakers can be seen as experts in the matter of rating teams (see Pope and Peel, 1989) and, as Forrest and Simmons (2000) show, experts give more accurate predictions than a random process. Other empirical studies show that fixed odds provide an efficient forecasting instrument for the outcome of single games (e.g., Vlastakis *et al.*, 2008; Forrest *et al.*, 2005; Dixon and Pope, 2004). Building on these ideas, we go beyond these strategies and use bookmakers odds to forecast the outcome of a whole tournament. In doing so, it should be considered that in tournament schedules (unlike most major soccer league schedules) typically not every teams plays every other team: For the EURO 2008, the 16 participating teams are divided into four groups (A–D) and only the best teams advance to a knockout stage. Hence, the drawing might increase or decrease a team's winning probability depending on the other teams drawn in its group. Our method derives the effect of this tournament schedule.

The EURO 2008 is now past, but we used the quoted longterm odds for winning the European championship of 45 international bookmakers which we collected from all bookmakers' websites before the tournament started (accessed 2008-04-21 and provided in Appendix A in Tables 7 and 8). Using only this information we employed a mixed-effects model with a team-specific random effect and fixed effects for the bookmaker and the group modelling the unknown "true" log-odds. With this result we computed the chances to win the tournament for all 16 teams, yielding better results as the FIFA/Coca Cola World rating and the Elo rating.

This paper is organized as follows: Section 2 gives a description of the method which is applied in Section 3. In addition we recover the latent team strength and show the influence of the tournament schedule (Section 4). Section 5 discusses the method used and the results including an ex post analysis comparing the actual result with our predictions.

2 Method

Our method assumes a relationship between the quoted odds and the unknown "true" odds for winning the tournament. To estimate these latent "true" odds, we first adjust the quoted odds $\widetilde{odds}_{i,j}$ of bookmaker j for team i into the adjusted odds $odds_{i,j}$ (reflecting the underlying beliefs of bookmaker j for team i) by subtracting one, the stake, and removing the over-round in Section 2.1. Subsequently, an estimate of the latent "true" odds $\widehat{odds}_i$ for each team i is obtained employing a mixed-effects model (e.g., Pinheiro and Bates, 2000) in Section 2.2.

2.1 Pre-processing

The quoted odds of the bookmakers do not represent the true chances that a team will win the tournament, but are the amounts that the bookmaker will pay out on winning bets. In deriving the quoted odds,

bookmakers include a profit margin which effectively means that the payout to a successful punter is less than that represented by the true chance of the event occurring. This profit is known as the "over-round" on the "book". The odds or amounts the bookmaker will pay are determined by the amounts bet on each of the respective possible events. They reflect the balance of wagers on either side of the event, and include the deduction of a bookmaker's brokerage fee (for further details see e.g., Wikipedia, 2008).

Therefore, we have to adjust the quoted odds to recover the underlying beliefs of the bookmakers. We first reduce the quoted odds from Tables 7 and 8 by one, the stake, to get the profit for the successful punter and then we adjust it by the profit of the bookmaker (the over-round). We assume that the over-round is constant for each bookmaker across all teams, i.e.,

$$\widetilde{odds}_{i,j} - 1 = \delta_j \, odds_{i,j}, \tag{1}$$

where $\widetilde{odds}_{i,j}$ are the quoted odds, $odds_{i,j}$ are the adjusted odds of bookmaker j for team i, and δ_j is the proportion that bookmaker j pays in case of a win (i.e., the reciprocal value of the over-round) in addition to the stake. These odds can be transformed to a probability scale via

$$p_{i,j} = 1 - \frac{odds_{i,j}}{1 + odds_{i,j}}, \tag{2}$$

where $p_{i,j}$ is the expected winning probability of bookmaker j for team i. Note, that we have to use complementary probabilities as the bookmakers odds represent expectations for losing the tournament. For computation of the pay-out proportion δ_j for each bookmaker j we use the constraint that the sum of all probabilities has to be one:

$$\sum_i p_{i,j} = 1 \quad \forall j. \tag{3}$$

2.2 Modeling

Using the adjusted winning odds $odds_{i,j}$ for each of the $i = 1, \ldots, 16$ teams of the $j = 1, \ldots, 45$ international bookmakers, we propose a stochastic model capturing the underlying odds distribution on a log-scale and including an additional error term. The model relates the adjusted log-odds $\log(odds_{i,j})$ to the (unobservable) "true" log-odds $\log(odds_i)$ in the form

$$\log(odds_{i,j}) = \log(odds_i) + \epsilon_{i,j} \tag{4}$$

where $\epsilon_{i,j}$ is the error term (on the log-odds scale) of bookmaker j for team i. To capture varying bookmaker systems and different levels of information a mixed-effects model is employed: The errors are assumed to be independent from $\log(odds_i)$ with bookmaker-specific means μ_j and standard deviations σ_j. Furthermore, the true log-odds $\log(odds_i)$ are split into a team and a group effect $\log(odds_i) = \alpha_i + \beta_{g(i)}$ (where $g(i)$ denotes the group of team i). In summary, this yields the mixed-effects model

$$\log(odds_{i,j}) = \alpha_i + \beta_{g(i)} + \mu_j + \sigma_j Z_{i,j} \tag{5}$$

where $Z_{i,j}$ is the standardized error terms of bookmaker j for team i. Under suitable normality and independence assumptions for $Z_{i,j}$, the parameters in Equation 5 can be fitted via maximum likelihood yielding $\widehat{\alpha}_i$, $\widehat{\beta}_{g(i)}$, $\widehat{\mu}_j$, and $\widehat{\sigma}_j$. The sum of the estimated team effect $\widehat{\alpha}_i$ and the estimated group effect $\widehat{\beta}_{g(i)}$ then gives the estimated log-odds $\widehat{\log(odds_i)}$ (also denoted $\log(\widehat{odds}_i)$), an estimate of the true log-odds for team i. Using Equation 2, the associated estimated winning probabilities for all participating teams can easily be derived.

3 Results

Based on the method discussed in the previous section, the log-odds and associated probabilities for winning the EURO 2008 are computed for all teams in Section 3.1. In addition to the winning probability,

	$\log(\widehat{odds}_i)$	$\widehat{odds}_i$	$\widehat{p}_i(\%)$	Code	Group
Austria	4.67	107.05	0.93	AT	B
Croatia	2.62	13.76	6.78	HR	B
Czech Republic	2.76	15.83	5.94	CZ	A
France	2.31	10.03	9.07	FR	C
Germany	1.54	4.69	17.59	DE	B
Greece	3.37	29.22	3.31	GR	D
Italy	2.06	7.86	11.28	IT	C
Netherlands	2.64	14.05	6.64	NL	C
Poland	3.86	47.58	2.06	PL	B
Portugal	2.19	8.97	10.03	PT	A
Romania	3.82	45.56	2.15	RO	C
Russia	3.59	36.22	2.69	RU	D
Spain	1.96	7.12	12.31	ES	D
Sweden	3.52	33.83	2.87	SE	D
Switzerland	3.20	24.61	3.90	CH	A
Turkey	3.78	43.78	2.23	TR	A

Table 1: Estimated log-odds of all teams $\log(\widehat{odds}_i)$, with the corresponding odds $\widehat{odds}_i$ and probabilities $\widehat{p}_i$ for all teams.

the group effect is investigated in Section 3.2 and some more information about the bookmakers is discussed in Section 3.3. A comparison of these results with the actual tournament outcome is deferred to Section 5.

3.1 Probability to win the European championship

By estimating the model from Equation 5, we estimate the true log-odds $\log(\widehat{odds}_i)$ for team i to win the tournament $(\widehat{\alpha}_i + \widehat{\beta}_{g(i)})$. Table 1 shows these estimated log-odds $\log(\widehat{odds}_i)$ and corresponding odds $\widehat{odds}_i$ and probabilities $\widehat{p}_i$ to win the championship for all participating teams. Additionally, the country code and the origin groups of the preliminaries of the tournament are shown.

According to the estimated log-odds of Table 1 team Germany, a member of group B is the top favorite of the European championship 2008 ($\widehat{odds} = 4.69$, $\widehat{p} = 17.59\%$). Another member of group B, team Austria, one of the host countries clearly has the lowest chance to win the EURO 2008 ($\widehat{odds} = 107.05$, $\widehat{p} = 0.93\%$). Despite its home advantage (see Baker and Scarf, 2006) team Switzerland is not the favorite in group A. It has rather low probability to win the tournament ($\widehat{odds} = 24.61$, $\widehat{p} = 3.90\%$), whereas the team of the last host country Portugal has much better chances ($\widehat{odds} = 8.97$, $\widehat{p} = 10.03\%$). The favorite of group C, team Italy, has the third largest probability to win the tournament ($\widehat{odds} = 7.86$, $\widehat{p} = 11.28\%$), but group member France follows closely ($\widehat{odds} = 10.03$, $\widehat{p} = 9.07\%$). The second top favorite of the EURO 2008 is team Spain which is a member of group D ($\widehat{odds} = 7.12$, $\widehat{p} = 12.31\%$). Another group member of group D, the defending champion team Greece has low chances to win the title again ($\widehat{odds} = 29.22$, $\widehat{p} = 3.31\%$).

3.2 Group effects

Our model (Equation 5) captures the difference $\widehat{\beta}_{g(i)}$ between the average log-odds (for winning the tournament) in group g and an average group of all 16 participating teams of the EURO 2008. Table 2 shows the estimated differences, the group effects $\widehat{\beta}_{g(i)}$ for all four groups (A–D).

	A	B	C	D
$\widehat{\beta}_{g(i)}$	−0.010	0.181	−0.288	0.117

Table 2: Estimated group effects $\widehat{\beta}_{g(i)}$ for groups A–D in the mixed-effects model (Equation 5).

Despite the fact that group B includes the bookmakers' favorite to win the European championship (Germany), group B clearly has the smallest chance to include the winner ($\widehat{\beta}_B = 0.181$), followed by group D ($\widehat{\beta}_D = 0.117$). On the other hand, group C (often called: the "group of death") has the greatest probability to include the champion ($\widehat{\beta}_C = -0.288$). Group A can be interpreted as the average group ($\widehat{\beta}_A = -0.010$).

3.3 Rater information

In our study we focus on the participating teams of the EURO 2008, but in addition, we can also derive information about the raters, the bookmakers. By computing the teams' probabilities to win the tournament in the pre-process, the over-rounds for the bookmaker can be estimated. The over-rounds of the 45 bookmakers ($1/\delta$) are between 11.6% and 32.2% with a median over-round of 20.6%.

Modeling the relationship between the bookmakers quoted odds and the unknown true odds of a team, we also estimate the mean $\widehat{\mu}_j$ and the standard deviation $\widehat{\sigma}_j$ of the error term for bookmaker j. The mean of the errors $\widehat{\mu}_j$ is rather low, differing between −0.054 and 0.062 on the log-odds scale. A positive or negative mean indicates that the bookmaker rates teams worse or better on average, respectively. The corresponding standard deviation $\widehat{\sigma}_j$ is between 0.04 and 0.184 on the log-odds scale. In general, the mean of the error term and the over-round have a negative association, i.e., bookmakers who overestimate the team's chance to win (low odds) have higher over-rounds and bookmakers with rather high odds for the teams have lower over-rounds.

4 Will the "best" team win?

In football, as in many other sports, winners and losers are determined by pairwise comparisons, called matches or games. In most football leagues every team plays against every other team over the season at least once. At the end of a season, the winner of the league is determined by a ranking scheme which counts the wins (three points), the ties (one point), the defeats and the scores of all games. In a tournament like the European championship, however, there is a group phase and play-offs so that not every team plays against every other. Hence, the question arises whether the draw of the groups is "fair" or whether the tournament schedule changes the winning probabilities of the teams compared to their current team strengths (see e.g. Rathgeber and Rathgeber, 2007). In other words: Will the "best" team win or might a weaker team outperform the strongest team due to luck of the draw? For the Euro 2008, it has been speculated that the German team benefits disproportionately from the draw while Italy was extremely unlucky to be drawn in the "group of death".

As the bookmakers know the group draw and the tournament schedule, the quoted odds include this information in addition to their assessments of the current team strengths. Therefore, a natural question is how different the beliefs about the underlying team strengths and the odds for winning this particular tournament are. For example, is team Germany really stronger than teams Italy or Spain who are ranked before them in both the Elo and the FIFA/Coca Cola World ranking?

This fact motivates us to recover the latent team strength (underlying the bookmakers' expectations) and to adjust for the influence of the schedule (including the influence of the group draw). Using a simulation approach, we determine an approximation of the team strength, compare it with the log-odds (for winning

the tournament) as well as the Elo and FIFA/Coca Cola ranking. Additionally, we gain further insights into pairwise winning probabilities and the teams' performance over the course of the tournament.

4.1 Simulation of the tournament

Given a suitable measure of "strength" or "ability" for each team, we could derive pairwise winning probabilities for all combinations of teams and, based on this, simulate the whole tournament. Specifically, assuming the abilities $ability_i$ are measured on a ratio scale, the corresponding probability that team A beats team B are given by

$$\hat{p}_{A,B} = \frac{ability_A}{ability_A + ability_B} \qquad (A \neq B). \tag{6}$$

Using these pairwise winning probabilities all games of the tournament can be simulated and the group effect (introduced by the tournament schedule) can be recovered. In addition, we obtain probabilities not only for winning the tournament but also for reaching the quarter-final, semi-final and final. The 16 participating teams of the EURO 2008 are divided into four groups, labeled A through D. Each group of four plays a round-robin—every team plays every other team, for a total of six games within the group—and the top two teams in each group advance to the next stage, the quarter-final. The winner of group A plays against the second best team of group B (first quarter-final) and reversely (second quarter-final). Analogously, the third and forth quarter-final are formed with the best teams from group C and D. The four winners of the quarter-finals reach the semi-finals, where the winner of the first quarter-final plays against the winner of the second one and the winner of the third quarter-final plays against the winner of the forth. The winners of the semi-finals then play the final and the final winner is called the winner of the European championship.

For our simulation we simulate the winners and losers of all tournament games given the above defined pairwise winning probabilities. Ties are excluded because in the play-offs of the real tournament these are resolved anyway (by over-time and penalties). Only for the preliminaries in our simulation, we need to resolve potential ties by simulating one or more "fictitious" games between the tied teams (teams with equal number of winnings in the end of the preliminaries), if necessary, to get the winners and the runner-ups of the groups. Our simulation method could be extended by using more elaborate simulation techniques including ties, e.g., a model where the team scores follow independent Poisson distributions (e.g., Maher, 1982; Dixon and Coles, 1997), or an ordered probit regression model (Goddard and Asimakopoulos, 2004). However, all approaches should give reasonable approximations of the probabilities for being promoted to the next round.

4.2 Team strength vs. winning odds

To find an approximation of the team strength (as perceived by the bookmakers), excluding the effects of the tournament draw, we build on the simulation approach described above. The idea is to find a set of team abilities that, after simulation, leads to the same winning probabilities as implied by the log-odds in Table 1. More precisely, we want to find a set of team strengths $str = (str_1, \ldots, str_{16})$ that result in simulated winning probabilities $p_{sim,i}(str)$ that are as similar as possible compared to the probabilities $\hat{p}_i$ derived from $\widehat{odds}_i$. For ease of comparison, we choose str_i to be on an odds scale, i.e., $ability_i$ from Equation 6 is $\log(1/str_i)$. $100,000$ tournament runs are used for computing $p_{sim,i}(str)$. Then, we solve the following optimization problem

$$\widehat{str} = \underset{str}{\operatorname{argmin}} \frac{1}{16} \sum_{i=1}^{16} |\widehat{p}_i - p_{sim,i}(str)| \tag{7}$$

	$\log(\widehat{str}_i)$	$\widehat{str}_i$	$\widehat{p}_{str_i}$ (%)
Austria	4.85	128.18	0.77
Croatia	2.63	13.82	6.75
Czech Republic	2.69	14.75	6.35
France	2.17	8.80	10.21
Germany	1.71	5.54	15.29
Greece	3.34	28.23	3.42
Italy	1.98	7.26	12.11
Netherlands	2.46	11.74	7.85
Poland	3.97	52.73	1.86
Portugal	2.19	8.95	10.05
Romania	3.64	38.05	2.56
Russia	3.56	35.23	2.76
Spain	1.97	7.20	12.19
Sweden	3.50	33.06	2.94
Switzerland	3.14	23.19	4.13
Turkey	3.78	43.90	2.23

Table 3: Team strength of all teams in log-odds $\log(\widehat{str}_i)$, with the corresponding odds $\widehat{str}_i$ and probabilities $\widehat{p}_{str_i}$ for all teams.

using a local search strategy, leading to the estimated team strengths in Table 3. Again, the results are shown in terms of log-odds as well as the corresponding odds and probabilities.

Germany, with $\log(\widehat{str}) = 1.71$, is still clearly the best team, but the gap to the next best teams Spain and Italy ($\log(\widehat{str}) = 1.97$ and 1.98, respectively) is somewhat decreased compared to the winning log-odds $\log(\widehat{odds}_i)$ of Table 1. On the other side the team strength of team Austria ($\log(\widehat{str}) = 4.85$) is clearly worse than its winning log-odds ($\log(\widehat{odds}) = 4.67$). The probabilities of the last column of Table 3 can be interpreted as the chances to win a tournament where every team plays each other.

In Figure 1 we compare the estimated winning log-odds and the estimated team strength and show which team profits most or least of the tournament schedule. The difference of the two measures is plotted against the group-specific average log-odds. Although our favorite team for the title, Germany, is a group member of group B, group B is according to the log-odds level of the groups (average log-odds of all group members, shown on the x-axis of Figure 1) the "easiest" group, i.e., the group with the weakest teams in total (with the highest average log-odds of 3.18). That leads to the conclusion that the other three teams of group B are rather weak. The "group of death", group C is clearly with an average log-odds of 2.71 the group with the strongest teams. Group A and D are rather balanced groups. The differences of the estimated "true" log-odds $\log(\widehat{odds}_i)$ and the team strength $\log(\widehat{str}_i)$ (shown on the y-axis of Figure 1) reflect whether teams gain or lose from the group allocation. Team Austria is therefore the biggest winner of being in the weakest group, i.e., Austria's probability to win the championship increases most due to this group allocation. Also teams Germany and Poland profit by being members of group B. In group C all teams suffer from the fact that they are group members of the "group of death", whereas the strongest team (Italy) suffers least. In the balanced groups group A and D there are only limited changes in the winning probabilities due to the group draw.

4.3 Pairwise winning probabilities

Using the estimated team strengths $\log(\widehat{str}_i)$ of Table 3, all pairwise winning probabilities for each team to win against each other team computed according to Equation 6 are shown in Figure 2. The pairwise

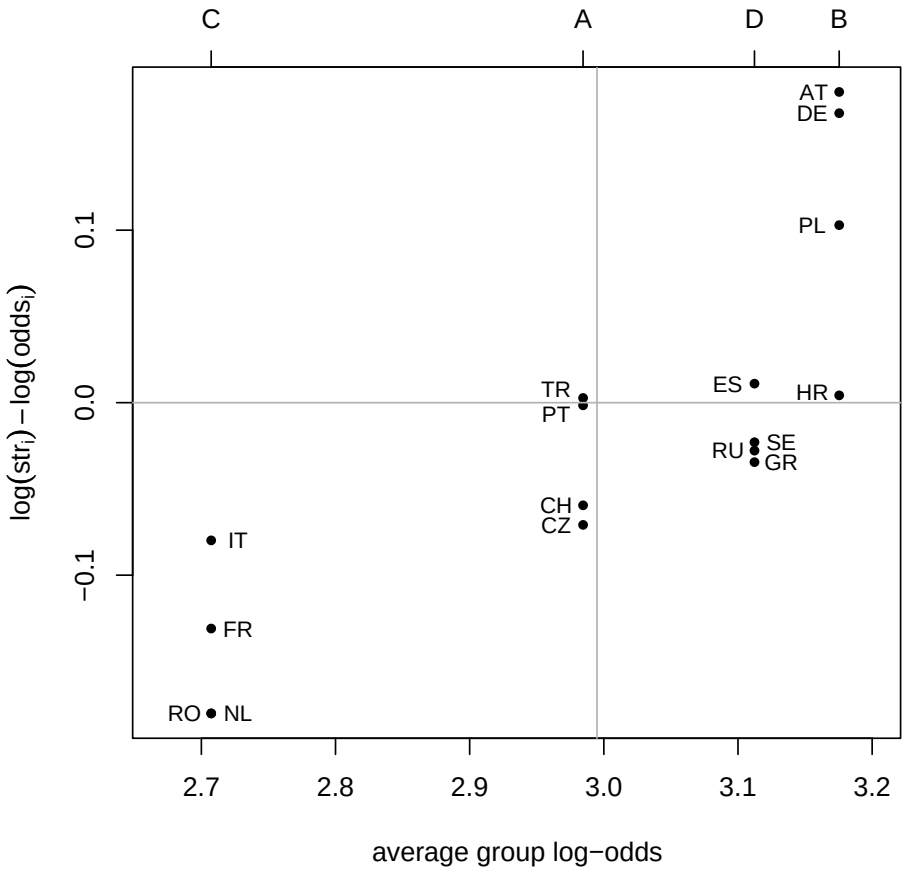

Figure 1: Group effects by comparing the estimated winning log-odds $\log(\widehat{odds}_i)$ (Table 1) and the estimated team strengths $\log(\widehat{str}_i)$. The x-axis depicts average $\log(\widehat{odds}_i)$ for each group A–D.

winning probabilities have been placed in five color categories. Figure 2 conveys that team Germany has a probability above 55% to beat all other teams, except Spain and Italy. Spain and Italy follow with rather high winning probabilities against many other teams. There is a subgroup of six teams (Switzerland, Greece, Sweden, Russia, Turkey, Romania, and Poland) with rather balanced winning chances against each other. The best chance to win a game for team Austria is against team Poland, with an almost even winning probability of 44.96%.

4.4 Team performance

As pointed out above, using the estimated team strengths and resulting pairwise winning probabilities, the whole tournament can be simulated to derive the expected tournament performance of all 16 teams (see Table 4).

The last column of Table 4 shows the simulated winning probabilities for the EURO 2008, which by construction (Equation 7) are almost identical to the probabilities derived from the estimated winning log-odds (Table 1). However, using the simulation approach we gain further information about the chances

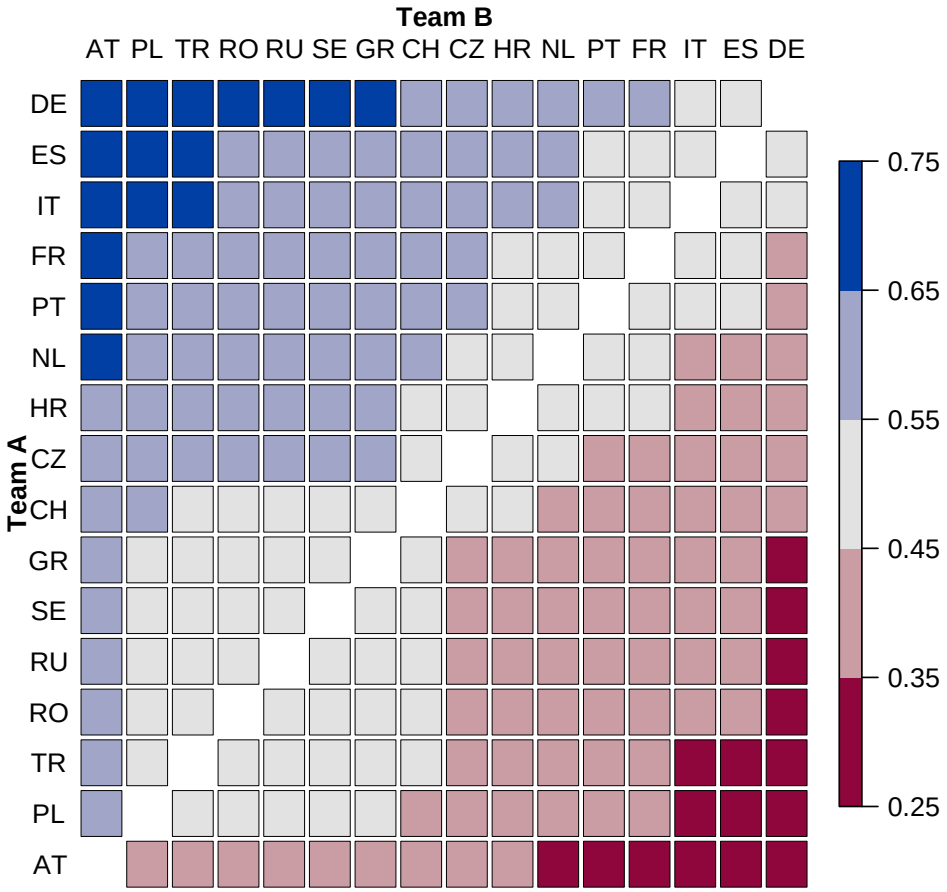

Figure 2: Probability that team A beats team B based $\log(\widehat{str}_i)$ for teams A and B (see Table 3).

to reach the quarter-final, the semi-final or the final (Table 4 and Figure 3). In particular, we predict that the following eight teams has the best chance to reach the quarter-final: Portugal, Czech Republic, Germany, Croatia, Italy, France, Spain and Greece. Furthermore, we can also derive the probabilities for some other tournament events, e.g., the most frequent final. We forecast that the teams Germany and Spain has the highest probability (20.17%) to play the final, where Germany has only a slight advantage with a winning probability of 53.19%.

Figure 3 shows that the performance curves of the teams in group B are a long way away from each other. Team Germany clearly has the highest chance to "survive" during the course of the tournament, e.g., with a probability of almost 80% for reaching the quarter-final. The comparison of the curves in group D show that this group also has a clear favorite, namely team Spain. All other teams of group D have rather similar chances to be promoted to the second round (and also for reaching the semi-final and final) with rather low probabilities to win the tournament for all three teams. The performance curves of the teams in group A and group C are nearly parallel without a clear favorite. Furthermore, the expected runner-ups from these groups (in the preliminaries) have relatively low chances of beating the clear favorites from the other two groups in the resulting quarter-finals.

	Quarter	Semi	Final	Winner
Austria	26.84	9.76	3.31	1.12
Croatia	59.04	30.28	14.35	6.87
Czech Republic	53.98	26.61	12.67	6.00
France	57.02	32.11	17.12	9.07
Germany	77.99	48.06	30.26	17.51
Greece	44.78	18.63	7.71	3.25
Italy	61.81	36.32	20.50	11.29
Netherlands	50.36	26.77	13.26	6.60
Poland	36.13	14.89	5.58	2.09
Portugal	64.54	35.04	19.08	10.08
Romania	30.81	13.59	5.32	2.08
Russia	41.38	16.59	6.70	2.73
Spain	71.50	38.91	22.52	12.36
Sweden	42.33	17.07	6.87	2.83
Switzerland	45.64	20.75	9.01	3.91
Turkey	35.84	14.61	5.75	2.22

Table 4: Simulated probabilities in percent (from 100,000 simulated tournaments) to reach the quarter-final, the semi-final, the final and to win the European championship 2008 for each of the 16 teams by simulating the tournament matches based on the pairwise winning probabilities (see Figure 2).

4.5 Comparison of the team strengths with common ratings

Using the estimated team strength we can rank the teams, like the common FIFA/Coca Cola World ranking according to Fédération Internationale de Football Association (2008) and the Elo ranking system developed by Arpad Elo to rate chess players, adapted by Bob Runyan (1997) for international football (Advanced Satellite Consulting Ltd, 2008).

Table 5 compares the team strength (in log-odds) with the Elo rating from 2008-04-21 (Advanced Satellite Consulting Ltd, 2008) and the FIFA/Coca Cola World rating from 2008-04-09 (Fédération Internationale de Football Association, 2008) for all championship participants where the ratings of the three rating systems are scaled to the unit interval. The team with the worst rating is set to zero and the team with the best rating is set to one. Therefore, the teams can be compared according to their ranks and their relative rating distances. In the last column, the actual result of the EURO 2008 is shown. A comparison of the rating methods with the actual result is part of the discussion in Section 5.

The comparison of the different rankings shows that the bookmakers' top favorite team Germany is not the best-rated European team by the Advanced Satellite Consulting Ltd (2008) and the Fédération Internationale de Football Association (2008). Whereas the FIFA rates team Germany as the third best team, Germany is only at the fifth rank of the current Elo ranking. According to both retrospective rankings Italy is the best European team. We suppose that the bookmakers include the information that Germany's performance at the last world championship two years ago (third place) was better than expected and the German football society has proclaimed the mission "Euro champion 2008 ". Whereas the distance of team Switzerland to favorite Germany is very similar according to the strength rating and the Elo rating, Switzerland is clearly ranked better according to the bookmakers expectations than by the FIFA/Coca Cola World ranking. According to the FIFA/Coca Cola World rating system, team Switzerland is the second weakest team (behind Austria) at the tournament. The main reason for the better ranking and rating of team Switzerland according to the estimated team strength is the home advantage which is included in our estimated team strength. As a co-host country of the championship team Switzerland played all their games of the preliminaries in Basel. Despite the fact that Austria is a host country too (were playing all preliminary games in Vienna), team Austria is according to the

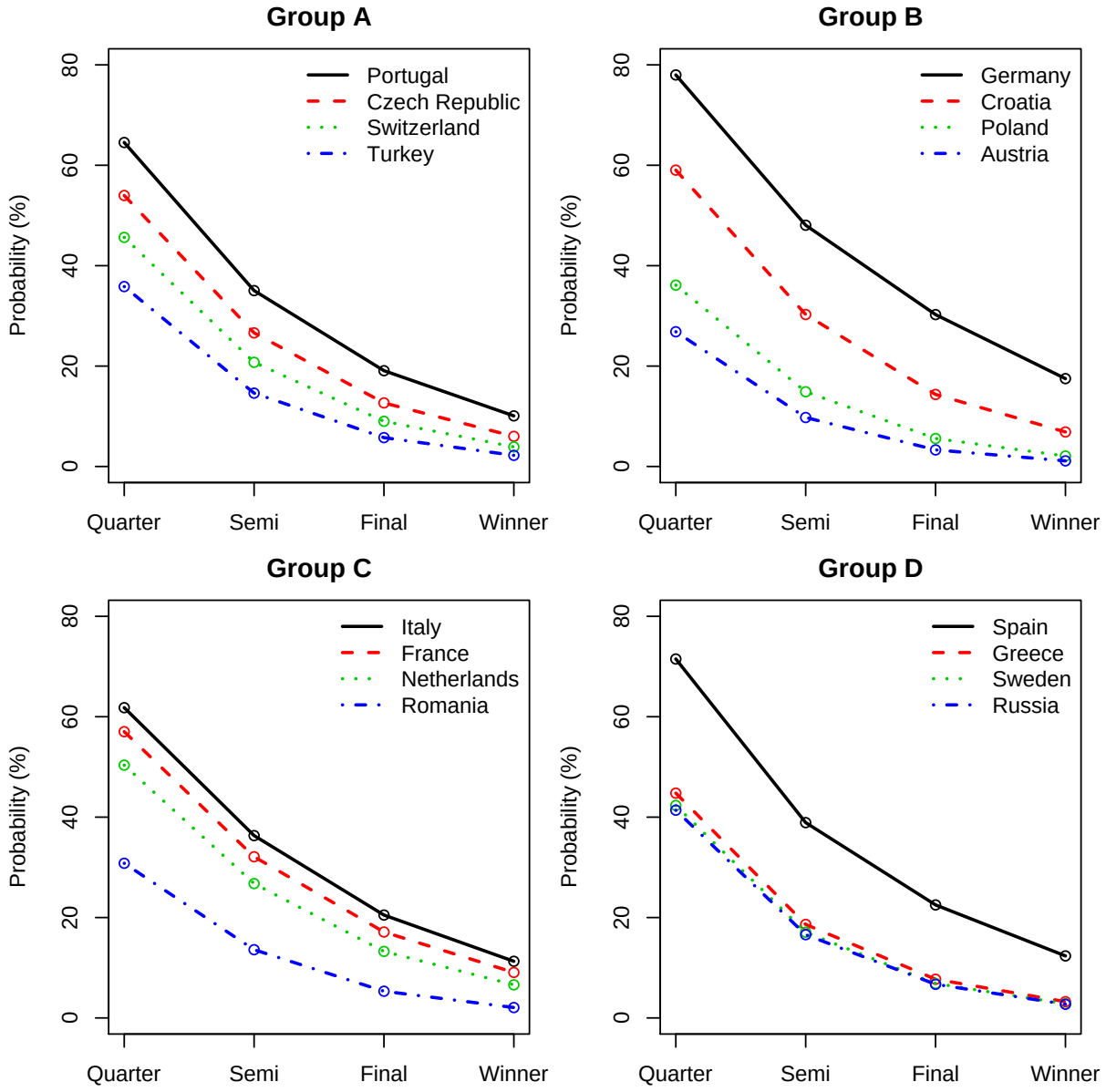

Figure 3: Simulated probabilities (from 100,000 simulated tournaments) to reach the quarter-final, the semi-final, the final and to win the European championship 2008 for each of the 16 teams by simulating the tournament matches based on the pairwise winning probabilities (see Figure 2).

strength ranking, as well as according to the Elo and FIFA/Coca Cola World ranking, the outsider of the tournament. However, the distance to the next team is in the case of our rating closer than in the other two rating systems what signifies a small included home advantage, too. On the other hand Romania is much worse ranked by the strength ranking than in the Elo ranking or FIFA/Coca Cola World ranking. A potential explanation could be the fact that the bookmakers over-estimate the fact that this team is a member of the "group of death". The bookmakers assume that Romania has the smallest chance to survive this group. We suppose that if Romania would be a participant in another group they would have much better odds than in this group C.

	Strength		Elo		FIFA/Coca Cola World		Tournament
	Rank	Rating	Rank	Rating	Rank	Rating	Rank
Germany	1	1.000	5	0.853	3	0.878	2
Spain	2	0.917	3	0.887	2	0.933	1
Italy	3	0.914	1	1.000	1	1.000	5
France	4	0.853	2	0.950	5	0.826	9
Portugal	5	0.847	10	0.612	7	0.751	5
Netherlands	6	0.761	4	0.857	8	0.750	5
Croatia	7	0.709	8	0.646	10	0.672	5
Czech Republic	8	0.688	6	0.723	4	0.853	9
Switzerland	9	0.544	14	0.449	15	0.279	9
Greece	10	0.482	9	0.621	6	0.809	9
Sweden	11	0.431	12	0.467	12	0.501	9
Russia	12	0.411	15	0.429	13	0.494	3
Romania	13	0.387	7	0.703	9	0.713	9
Turkey	14	0.341	11	0.488	11	0.503	3
Poland	15	0.283	13	0.454	14	0.483	9
Austria	16	0.000	16	0.000	16	0.000	9

Table 5: Comparison of the team strengths (on a log-odds scale) with the Elo rating and the FIFA/Coca Cola World rating in terms of ranks and scaled ratings. All three ratings are scaled to the unit interval where the rating of the best team is set to one and the rating of the weakest team is set to zero. In the last column the actual result of the EURO 2008 is shown.

5 Discussion

This paper introduces a novel method to rate participants of a sports tournament and forecasting the winner based on quoted winning odds. Using these odds we employ a mixed-effects model with team-specific random effect and fixed effects for the bookmaker and the tournament schedule to model the "true" log-odds for winning the championship. As the bookmakers odds take into account the tournament schedule and in particular the group draw, we recover the underlying team strengths (excluding schedule effects) using a simulation approach. Furthermore, we suggest to assess team strengths by computing pairwise winning probabilities and simulating the full tournament. Such an approach can capture group and play-off effects and yield more granular information about the probability for each participant to "survive" during the tournament.

In particular, we use this method to forecast the winner of the EURO 2008: Team Germany. In addition to the simple prediction, our method quantifies the result by providing winning probabilities (e.g., about 18% for Germany and 12% for Spain, the second-best team), showing that there is a clear tendency for a winner but that the result is by no means certain. The speculation that Germany benefits from the draw can be confirmed, nevertheless Germany is still the best team (according to the bookmakers' expectations) after adjustment for effects of the tournament schedule and group draw.

Luckily for all football supporters, football is, like all other sports, a game and cannot be truly predicted using rational strategies and statistical methods. Nevertheless, our method correctly forecasts the actual final played by the teams Germany and Spain, assigning a slightly higher winning probability of 53.19% in the final to the actual runner-up of the tournament, team Germany. Moreover, an ex post analysis comparing the outcome of the EURO 2008 with all ratings from Table 5 shows that our methods outperforms other ratings.

Table 6 assesses the predictive performance of all ratings discussed in the paper by comparing them with the actual tournament using Spearman's rank correlation. For the actual result, a total ranking including

	Winning Odds	Strength	FIFA	Elo
Tournament	0.525	0.477	0.373	0.270
Winning Odds		0.991	0.803	0.741
Strength			0.821	0.788
FIFA				0.903

Table 6: Spearman's rank correlation between the actual tournament result, the estimated winning log-odds, the estimated team strengths, the FIFA/Coca Cola World rating and the Elo rating.

ties is employed, as commonly used in rankings of such incomplete tournaments. Various strategies for dissolving the ties have been explored but did not lead to qualitatively different results.

Thus, the latent "true" winning log-odds estimated from the bookmakers odds have the highest correlation of 0.525 with the actual tournament result. The estimated team strengths (which remove group draw effects) have a lower correlation of 0.477 but still perform better than the FIFA/Coca Cola World rating (0.373) and the Elo rating (0.270). Furthermore, the big surprises of the tournament were teams Russia and Turkey who both reached the semi-finals rather unexpectedly. Whereas our method ranked team Russia better than the FIFA/Coca Cola World ranking and the Elo ranking, both common rankings ranked team Turkey better than our method. On the other side, it was a great suprise that team France did not reach the quarter-finals. This weak performance was neither expected by the bookmakers nor using the common ranking systems.

Computational details

All computations were carried out in the R system (version 2.7.1) for statistical computing (R Development Core Team, 2008). In particular, the R package nlme version 3.1-89 (Pinheiro *et al.*, 2008) was used for estimation of the parameters in the mixed-effects model (see Pinheiro and Bates, 2000). Furthermore, for visualizing the pairwise probabilities in Figure 2, the strucplot framework (Meyer *et al.*, 2006) as implemented in R package vcd version 1.2-0 (Meyer *et al.*, 2008) was employed.

References

Advanced Satellite Consulting Ltd (2008). "The World Football Elo Rating System." [Online; accessed 2008-04-21], URL http://www.eloratings.net/.

Baker R, Scarf P (2006). "Predicting the Outcomes of Annual Sporting Contests." *Journal of the Royal Statistical Society C*, **55**, 225–239.

Dixon M, Coles S (1997). "Modelling Association Football Scores and Inefficiencies in the UK Football Betting Market." *Journal of the Royal Statistical Society C*, **46**, 265–280.

Dixon M, Pope P (2004). "The Value of Statistical Forecasts in the UK Association Football Betting Market." *International Journal of Forecasting*, **20**, 697–711.

Fédération Internationale de Football Association (2008). "FIFA/Coca-Cola World Ranking." [Online; accessed 2008-04-21], URL http://www.fifa.com/worldfootball/ranking/lastranking/gender=m/fullranking.html.

Forrest D, Goddard J, Simmons R (2005). "Odds-Setters as Forecasters: The Case of English Football." *International Journal of Forecasting*, **21**, 551–564.

Forrest D, Simmons R (2000). "Forecasting Sport: The Behaviour and Performance of Football Tipsters." *International Journal of Forecasting*, **16**, 317–331.

Goddard J, Asimakopoulos I (2004). "Modelling Football Match Results and the Efficiency of Fixed-Odds Betting." *Journal of Forecasting*, **23**, 51–66.

Maher M (1982). "Modelling Association Football Scores." *Statistica Neerlandica*, **36**, 109–118.

Meyer D, Zeileis A, Hornik K (2006). "The Strucplot Framework: Visualizing Multi-Way Contingency Tables with vcd." *Journal of Statistical Software*, **17**(3), 1–48. URL http://www.jstatsoft.org/v17/i03/.

Meyer D, Zeileis A, Hornik K (2008). *vcd: Visualizing Categorical Data*. R package version 1.1-1, URL http://CRAN.R-project.org/package=vcd.

Pinheiro J, Bates D (2000). *Mixed-Effects Models in S and S-PLUS*. Statistics and Comupting. Springer-Verlag New York, New York, USA. ISBN 0-387-98957-9.

Pinheiro J, Bates D, DebRoy S, Sarkar D (2008). *nlme: Linear and Nonlinear Mixed Effects Models*. R package version 3.1-89, URL http://CRAN.R-project.org/package=nlme.

Pope PF, Peel DA (1989). "Information, Prices and Efficiency in Fixed-Odds Betting Market." *Economica*, **56**, 323–341.

R Development Core Team (2008). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

Raiffeisen Zentralbank (2008). "RZB-Analyse: Wer wird Fußball-Europameister?" [Online; accessed 2008-05-09], URL http://www.rzb.at/eBusiness/rzb_template1/1023296711504-1023296711595_1024688700058-471732017160149076-NA-NA-DE.html.

Rathgeber A, Rathgeber H (2007). "Why Germany Was Supposed To Be Drawn in the Group of Death and Why It Escaped." *Chance*, **20**(2), 22–24.

UBS Wealth Management Research Switzerland (2008). "European Champions for 2008 Will Be. . . ." [Online; accessed 2008-04-21], URL http://www.ubs.com/1/e/ubs_ch/wealth_management_switzerland/euro.html.

Vlastakis N, Dotsis G, Markellos RN (2008). "How Efficent is the European Football Betting Market?" *Journal of Forecasting*. Forthcoming.

Wikipedia (2008). "Odds — Wikipedia, The Free Encyclopedia." [Online; accessed 2008-04-21], URL http://en.wikipedia.org/w/index.php?title=Odds&oldid=204179204.

A Bookmakers odds

	AT	HR	CZ	FR	DE	GR	IT	NL
bwin	81.00	14.00	15.00	10.00	4.75	26.00	7.00	14.00
X888	81.00	13.00	13.00	8.50	5.00	26.00	8.00	12.00
bet365	101.00	12.00	13.00	9.00	4.50	23.00	8.00	13.00
betdirect	101.00	13.00	15.00	9.00	5.00	21.00	7.00	11.00
bet1128	91.00	14.00	17.00	8.50	5.50	25.00	7.50	12.00
betChronicle	104.00	14.00	14.00	9.20	5.00	29.00	7.90	13.50
betfred	101.00	13.00	13.00	9.00	5.00	26.00	8.00	13.00
betinternet	101.00	13.00	15.00	9.50	5.00	26.00	8.00	13.00
better	101.00	13.00	15.00	9.00	5.00	21.00	7.00	11.00
bluesq	81.00	13.00	13.00	8.50	5.00	26.00	8.00	12.00
boylesports	81.00	13.00	15.00	10.00	5.00	26.00	7.50	15.00
canbet	101.00	13.00	15.00	9.00	4.75	26.00	6.50	12.00
centrebet	101.00	11.00	15.00	10.00	5.00	26.00	8.00	15.00
coral	81.00	13.00	15.00	8.00	4.50	26.00	7.00	13.00
ladbrokes	81.00	13.00	15.00	9.00	5.00	26.00	7.00	13.00
lasseters	101.00	13.00	15.00	9.00	5.00	26.00	7.00	13.00
paddypower	67.00	13.00	13.00	9.00	5.00	26.00	8.00	13.00
pagebet	101.00	12.00	13.00	9.00	5.00	26.00	8.00	13.00
partybets	81.00	11.00	11.00	10.00	5.50	21.00	7.00	10.00
skybet	67.00	13.00	17.00	9.00	5.00	26.00	8.00	11.00
sportingbet	101.00	13.00	15.00	10.00	4.50	21.00	7.00	11.00
stanjames	101.00	13.00	15.00	9.00	5.00	21.00	7.00	11.00
totesport	101.00	13.00	15.00	9.00	4.50	26.00	7.50	13.00
vcbet	81.00	11.00	13.00	9.00	4.50	26.00	8.00	13.00
hill	81.00	11.00	12.00	10.00	5.00	26.00	8.00	13.00
pinalesports	83.82	12.24	15.33	10.13	5.10	29.88	7.37	12.35
expekt	67.00	12.00	13.00	9.00	5.00	26.00	7.50	10.00
gamebookers	81.00	11.00	11.00	10.00	5.00	21.00	7.00	10.00
betathome	90.00	12.00	15.00	10.00	5.00	25.00	8.00	14.00
gera	81.00	12.00	13.00	10.00	4.75	23.00	7.00	13.00
sunmarker	100.00	13.00	15.00	9.00	5.00	25.00	7.50	13.00
noxwin	100.00	13.00	15.00	9.00	5.00	25.00	7.50	13.00
betway	81.00	11.00	13.00	10.00	5.00	23.00	8.00	13.00
betsafe	100.00	12.00	13.00	10.00	5.00	26.00	8.00	13.00
betboo	81.00	13.00	15.00	8.00	4.25	21.00	6.50	11.00
intertops	101.00	12.00	15.00	9.00	4.00	26.00	8.00	14.00
unibet	100.00	12.50	15.00	10.00	5.00	33.00	8.00	12.50
mybet	81.00	13.00	13.00	9.00	5.00	26.00	7.50	13.00
betsson	100.00	12.00	15.00	8.00	5.00	30.00	8.00	10.00
nordicbet	75.00	12.00	15.00	10.00	5.40	25.00	5.50	12.00
digibet	100.00	13.00	15.00	9.00	5.00	27.00	7.50	13.50
betclick	80.00	14.00	16.00	10.00	5.00	25.00	8.00	14.00
admiralbet	100.00	12.00	15.00	10.00	5.00	20.00	8.00	12.00
interwetten	100.00	12.00	16.00	7.50	5.00	30.00	7.50	12.00
bet24	100.00	12.50	15.00	10.00	5.35	30.00	7.50	12.50

Table 7: Published long term odds of 45 international bookmakers for the teams of group A (Czech Republic, Portugal, Switzerland, and Turkey) and of group B (Austria, Croatia, Germany, and Poland) for winning the EURO 2008 (source: Webpages of the bookmakers, online, accessed 2008-04-21).

	PL	PT	RO	RU	ES	SE	CH	TR
bwin	41.00	8.50	34.00	29.00	7.00	29.00	23.00	41.00
X888	29.00	9.00	41.00	29.00	7.50	26.00	15.00	41.00
bet365	41.00	8.50	41.00	34.00	7.00	29.00	21.00	34.00
betdirect	51.00	8.00	41.00	21.00	7.00	26.00	17.00	34.00
bet1128	42.00	9.00	41.00	35.00	7.50	28.00	23.00	37.00
betChronicle	43.00	8.30	39.00	41.00	7.10	31.00	27.00	50.00
betfred	34.00	8.00	51.00	34.00	7.00	34.00	21.00	41.00
betinternet	41.00	8.50	41.00	34.00	7.00	29.00	21.00	41.00
better	51.00	8.00	41.00	21.00	7.00	26.00	17.00	34.00
bluesq	29.00	9.00	41.00	29.00	7.50	26.00	15.00	41.00
boylesports	41.00	8.00	29.00	26.00	7.00	34.00	21.00	34.00
canbet	46.00	8.00	26.00	31.00	6.00	34.00	26.00	41.00
centrebet	29.00	8.50	51.00	34.00	7.20	34.00	23.00	41.00
coral	51.00	9.00	29.00	34.00	7.00	29.00	23.00	34.00
ladbrokes	34.00	9.00	41.00	29.00	7.00	26.00	21.00	34.00
lasseters	41.00	8.50	34.00	31.00	7.00	31.00	21.00	41.00
paddypower	34.00	8.50	41.00	29.00	7.00	26.00	19.00	34.00
pagebet	51.00	8.50	41.00	29.00	7.00	29.00	23.00	41.00
partybets	34.00	8.50	29.00	26.00	7.00	29.00	19.00	29.00
skybet	41.00	8.00	51.00	26.00	7.00	26.00	21.00	34.00
sportingbet	51.00	8.50	34.00	34.00	6.50	34.00	21.00	41.00
stanjames	51.00	8.00	41.00	21.00	7.00	26.00	17.00	34.00
totesport	41.00	9.00	51.00	34.00	7.00	26.00	21.00	34.00
vcbet	41.00	8.50	34.00	26.00	6.50	26.00	17.00	34.00
hill	41.00	8.00	41.00	26.00	7.00	26.00	21.00	34.00
pinalesports	41.40	8.97	41.40	36.11	7.17	35.57	23.46	41.40
expekt	29.00	9.00	34.00	29.00	7.00	26.00	21.00	29.00
gamebookers	34.00	8.50	29.00	26.00	7.00	29.00	19.00	29.00
betathome	40.00	8.50	40.00	30.00	7.00	30.00	22.00	34.00
gera	39.00	8.50	34.00	29.00	7.00	29.00	21.00	34.00
sunmarker	45.00	8.00	40.00	45.00	6.00	30.00	25.00	45.00
noxwin	45.00	8.00	40.00	45.00	6.00	30.00	25.00	45.00
betway	34.00	8.50	34.00	26.00	7.00	26.00	21.00	34.00
betsafe	45.00	8.50	40.00	32.00	7.00	32.00	22.00	40.00
betboo	41.00	8.50	34.00	31.00	6.50	26.00	21.00	34.00
intertops	41.00	8.50	41.00	34.00	6.50	29.00	23.00	51.00
unibet	40.00	8.50	45.00	35.00	7.00	33.00	27.00	45.00
mybet	41.00	8.00	34.00	29.00	6.80	29.00	26.00	41.00
betsson	40.00	9.00	50.00	30.00	8.00	25.00	22.00	35.00
nordicbet	40.00	9.00	40.00	30.00	7.00	25.00	25.00	30.00
digibet	50.00	8.00	50.00	40.00	6.50	33.00	27.00	50.00
betclick	40.00	8.00	40.00	35.00	7.00	30.00	20.00	40.00
admiralbet	40.00	8.00	40.00	30.00	8.00	30.00	20.00	20.00
interwetten	50.00	10.00	50.00	30.00	7.50	30.00	20.00	30.00
bet24	50.00	9.25	50.00	35.00	7.00	35.00	25.00	40.00

Table 8: Published long term odds of 45 international bookmakers for the teams of group C (France, Italy, Netherlands, and Romania) and of group D (Greece, Russia, Spain, Sweden) for winning the EURO 2008 (source: Webpages of the bookmakers, online, accessed 2008-04-21).