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The Twelfth Man? Refereeing Bias in English and German Soccer

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Abstract

This paper investigates potential bias in awards of player disciplinary sanctions, in the form of cautions (yellow cards) and dismissals (red cards) by referees in the English Premier League and the Bundesliga. Previous studies of behaviour of soccer referees have not adequately incorporated within-game information. Descriptive statistics from our samples clearly show that home teams receive fewer yellow and red cards than away teams. But biases may be wrongly identified where the modeller has failed to include within-game events such as goals scored and recent cards issued. What appears as referee favouritism may actually be excessive and illegal aggressive behaviour by players in teams that are behind in score. We deal with these issues using a minute-by-minute bivariate probit analysis of yellow and red cards issued in games over six seasons in the two leagues. The significance of a variable to denote score difference at the time of sanction suggests that excessive effort, induced by a losing position, is an important influence on award of yellow and red cards. Controlling for a number of pre-game and within-game variables, we find evidence of home team favouritism in Germany as home teams with running tracks in their stadia attract more yellow and red cards than teams playing in stadia with separation of fans from pitch. This is indicative of referee response to social pressure. Separating the competing teams in matches by favourite and underdog status, as perceived by the betting market, yields further evidence, this time for both leagues, that the source of home teams receiving fewer cards is not just that they are disproportionately often the favoured team. Rather, there appears to be pure referee bias in relative treatments of home and away teams.

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"It was like playing against 12 men"- Sir Alex Ferguson on the performance of referee Herbert Fandel after Manchester United's 2-1 defeat, away to Roma in a UEFA Champions' League match, April 2007.

1. INTRODUCTION

In professional soccer, referees are appointed to regulate matches under the Laws of Association Football, which are determined by the governing body of world soccer, FIFA. In applying these laws referees have sanctions in the form of cautions (henceforth 'yellow cards') and expulsions of players from the field ('red cards'). Although yellow cards are issued for less heinous offences, such as dissent, deliberate handball, persistent fouling, obstruction and shirt-pulling, this sanction offers an important disincentive to persist in illegal behaviour as a second caution to the same player is accompanied by dismissal ('second yellow card'). A red card results from serious misconduct such as hitting a player or a dangerous tackle or the so-called 'professional foul' where a player deliberately prevents a clear goal-scoring opportunity for an opponent by unfair means. Red cards are relatively infrequent.

Fans, players and head coaches worldwide often complain about both inconsistent application of rules by referees and alleged bias against their team. Critical refereeing decisions can be pivotal for a team's prospects of winning championships, qualifying for lucrative European competition or avoiding relegation. As revenue streams, especially sales of broadcast rights, have grown in European football, so criticism of referee behaviour has intensified. This has begun to be reflected in academic research and a number of papers have investigated particular sources of

bias, inconsistency and favouritism offered by football referees in various European leagues, including England, Germany and Spain.

One strand of literature examines the amounts of time added on by referees at the end of each half of games. Referees will stop their clocks immediately if they perceive a player to be sufficiently injured to warrant treatment on the field. They also receive official guidance on amounts of time to add on for substitutions and are instructed to resist attempts at timewasting, with cautions if necessary. But the referee takes sole responsibility for time-keeping and does have some discretion over amounts of time played. An influential paper by Garicano *et al.* (2005) presented evidence from the Spanish top division that referees awarded less added time after 90 minutes in games where the home team was ahead and more added time when the home team was behind. These results were obtained after controlling for numbers of substitutions, cautions and injuries that would tend to interrupt a match. Subsequently, other authors offered broad support for home team favouritism in terms of added time. Lucey and Power (2005) were able to replicate the results of Garicano *et al.* for Italian and US Major League Soccer. Dohmen (2005) and Sutter and Kocher (2004) found that Bundesliga referees added more time on in games where the home team was behind.

Dohmen strengthened the findings of referee bias by also investigating 'disputable' and 'incorrect' decisions as determined by an independent panel of consultants (appointed by the German Football Federation, DFB) after matches. It appeared that home teams were more likely to benefit from disputable or incorrect goals and penalties awarded. Intriguingly, though, bias was more evident in grounds where a running track did not separate crowd from pitch. Referees

did not offer superfluous extra time in grounds with running tracks and this suggests that the extent and effectiveness of social pressure on referees depends on stadium design.
The supposed mechanism is that referees respond (presumably subconsciously) to the preferences of the crowd when the physical proximity of the crowd is close.

Another strand of literature examines impacts of changes in the rules of the game and referees' contractual status on award of sanctions. In the 1998/99 season, FIFA issued a toughened rule on dangerous tackles by stipulating that a deliberate tackle made from behind an opponent should be punished by a red card. The principle behind this rule change was that defenders had been making such tackles in an intimidatory manner and that attackers henceforth would be less constrained in their forward moves. FIFA felt that the rule change would deter defenders and might contribute to more attacking play, with presumed benefits in terms of greater gate attendance and TV audiences. Witt (2005) found, looking at the 1997/98 and 1998/99 English Premiership seasons, that, after the rule change was imposed, the number of red cards did not increase but the number of yellow cards did. This suggests that the rule change acted as an effective deterrent to illegal tackles but also players tended to substitute more minor yellow card offences for red card offences. In North America, Allen (2002), Heckelman and Yates (2002) and Levitt (2002) examined the case of the National Hockey League where two referees, rather than one, were randomly assigned to games in a season. Both sets of authors found that a higher number of referees was not associated with a reduction in the number of fouls. But as Witt (2005) notes, it does not follow that deterrence theory is rejected in this case. The number of fouls recorded depends on the behaviour of both players and officials. With more policemen, as many crimes as before may be noticed even if fewer are committed.

In 2001/02 another significant change occurred in English football, this time involving referees' terms of employment rather than the Laws of the Game. In contrast to all other European leagues, the English Premiership changed its referee reward system away from a match fee (plus expenses) and towards a full-time salary. A Premiership list was devised of top referees who would earn this salary. In exceptional cases of poor performance, a referee could be demoted from this list and replaced, but generally the referee panel was renewed and set at the beginning of each season. The rationale for this new payment scheme was that referees would become 'more professional'. Released from the pressures of work in their regular occupation, referees could train with Premiership teams, become fitter and take part in fuller discussion with peers (and clubs) over aspects of recent performance. The intended effects of annual salary contracts were to reduce bias and inconsistency among 'professional' referees. Rickman and Witt (2005) examined discretionary time added on by referees at the end of English Premiership games and found evidence of home team bias in the 1999/2000 season; but in the 2002/03 season, after the change in contract, this bias was removed. They interpret this result as suggesting that the incentives built into annual salary contracts were sufficient to remove this particular form of bias. However, this finding is based on only one season's data subsequent to the change.

A small number of papers directly address sources and extent of referee bias. Dawson *et al.* (2007) offer a comprehensive analysis of various possible forms of referee bias in the English Premiership covering seven seasons. Whereas Witt (2005) focuses on *total* cautions and dismissals in games, regardless of whether the perpetrators are from home or away team, Dawson *et al.* distinguish between home and away team cautions and dismissals in a bivariate negative binomial model. They do this by amalgamating yellow and red cards into a discrete

points measure. Although the results from the yellow cards regression are stated to be similar to those from the points measure, they do not offer an explicit separate analysis of yellow and red card offences. Their findings are indicative of bias in favour of home teams (fewer cards given to home teams, more cards awarded to away teams, after controlling for relative team strengths and importance of fixtures for league outcomes). Supporting evidence of referee bias in favour of home teams is offered by Boyko *et al.* (2007). They examine yellow card awards and penalty decisions in 5244 Premiership games and find that there was inconsistent and favourable treatment of home teams across the 50 referees considered.

The literature on sanctions and penalties reviewed so far uses the match as unit of observation and this raises issues about controlling for within-game effects. The award of sanctions will most likely depend on the dynamics of previous sanctions; casual inspection of the data suggests that yellow cards tend to be clustered in groups close together in time, so award of one card is followed by award of another. This is arguably a consequence both of a rising temperature of a game in which illegal activity escalates and of increased monitoring as referees try to retain control of the match. Also, it is clear that the incidence of yellow cards is greater for away teams than for home teams. This is not necessarily attributable to referee bias. Home teams have home advantage, a feature that is prominent in most major team sports. Consequently, away teams are generally expected to defend more than home teams because, typically, the phenomenon of home advantage makes them underdogs (see Carmichael and Thomas (2005) for a study of home advantage in English football; Pollard and Pollard (2005) and Stefani (2007) survey the extent of home advantage in team sports across North America and England). This extra emphasis on defence often spills over into illegal activity.

An additional factor is that teams that are behind in score may resort to more physical play in order to get back on even terms and this too may result in illegal aggression. This will generate more cards for away teams in the aggregate than for home teams in the aggregate because away teams are more frequently behind in a game than are home teams. Failure to control for within-game dynamics, especially the goal difference prior to a card being issued, leaves investigators open to omitted variable bias and mistaken inferences over extent of bias. What is attributed as referee bias may simply result from excessive effort by the offending teams. Away teams may receive more yellow cards in the aggregate just because, on average, they spend more of the game trailing their opponents in score and therefore resort to more foul play.

Our contribution to the study of referee bias in European football departs from the existing literature in two key respects. First, acknowledging the potential importance of within-game dynamics noted above, we switch from match to minute of game as unit of observation. Rather than model the number of cautions and dismissals as count variables (as in Witt, 2005 and Dawson *et al*., 2007), we model the *probability of a caution or dismissal within a specific minute of a match*. This permits us to introduce a full set of relevant within-game covariates such as number of yellow and red cards issued up to the minute and score difference at the start of the minute. Specifically, we set up a bivariate probit model in which the likelihood of a card being issued is determined for home and away teams jointly. Our second innovation is to compare results from two leagues over the same time period. The literature to date reads as a set of cases, with one league analysed at a time. Here, we make a direct comparison of yellow and red cards for the English Premiership and the Bundesliga. Our sample period covers the 2000/01 to 2005/06 seasons and over this time there were no radical changes in the rules of football.

2. DATA AND MODEL

We propose two pairs of dependent variables. The first pair comprises binary indicators of the award of a specific type of card to home and away teams in a given minute of a match. We estimate probability of a card being awarded, focussing on the Bundesliga. Unlike the Premiership, some Bundesliga stadia have running tracks separating crowd from pitch. Following Dohmen (2005), we hypothesise that social pressure on referees will decrease when a track is present. We construct a dummy variable, *track*, to capture presence of a running track in a stadium. Then, the hypothesis to be tested is that home teams have lower probability of receipt of a card and/or away teams have a higher probability of receipt of a card when a track is present. Data on tracks in stadia, kindly provided by Joachim Prinz of Witten/Herdecke University, show that the number of team-seasons with tracks is 39 out of 108. Three teams actually changed their ground structure during our sample period. Schalke, in 2001, and Bayern Munich, in 2005, moved to a new stadium without a running track. Hannover, in 2003, renovated their old stadium, removing the existing running track. Hence, *track* is not conflated with team-specific effects and does permit identification of favourable treatment by referees.

The second pair of dependent variables consists of probability of a card being awarded to *favourite* and *underdog* teams, as assessed by the bookmaker betting market for match results. We can address the issue of home team bias directly by modelling the probability that a team will be awarded a yellow card in the next minute of a match with a specific dummy variable included to reflect whether a team is home or away. Of course, this requires a departure from defining the two teams in a match as the home club and the away club: for each equation to be

estimated, there has to be a mix of home and away teams in each subsample if a home dummy is to be included. Accordingly we need to adopt an alternative perspective on each match from that taken earlier. A convenient dichotomy is between teams that were favourites or underdogs in the betting market. A small number of matches had equal win probabilities for the two teams (i.e. there was no favourite) and these games were excluded from the sample.

As noted above, the use of minute of game as unit of observation allows us to control for within-game influences on award of yellow cards. We have data on times of yellow and red cards and goals scored for the English Premiership and Bundesliga 1 obtained from www.11v11.co.uk and www.bundesliga.de. The former site offers identity of referee. In general, the two sites offer consistency in timing of cards and goals although www.bundesliga.de is more comprehensive in its coverage of German cards. This site does have a peculiar feature in that it records minute zero as the beginning and minute 89 as the end of a match. We added one minute on for each card and goal taken from the German site to provide consistency with the English data. There are occasions where more than one card is issued to the same team in a particular minute and, when that happens, we simply record ‘one’; there is therefore an extent to which this recording of cards slightly understates the total.

Our sources permit us to separate the data into yellow card, second yellow card and red card categories. Table 1 below shows some descriptive statistics for yellow cards, red cards and second yellow cards by referee for the two leagues in our study. Clearly, yellow cards occur much more frequently than red cards. The rarity of dismissals, relative to cautions, is itself a consequence of incentives. When a player receives a red card, his team plays with 10 men and

some literature shows that teams with 11 men have a greater chance of winning against 10 men compared to 11, although this depends on the timing of dismissal and hence how much time there is left for the team with full strength to exploit its advantage (Ridder *et al.*, 1994, Torgler, 2004, Caliendo and Radic, 2006). If the depleted team loses the game then the dismissed player may receive blame from fans and coaches for the defeat (in press conferences head coaches sometimes speak of 'unnecessary dismissal' when a player performs a reckless act that induces a red card). Unless the dismissal is found to be unfair on appeal, the player will also serve a suspension (of a minimum of three games for a straight red card) and may receive a fine if the offence was very serious. The suspension has career implications for the player in that a replacement may claim and retain the player's place, even when the suspended player becomes available again. As a result, the kind of severe offences found in amateur football, such as fighting between players, are far less prevalent in the professional game.

We distinguish between control variables for within-game and pre-game influences. In the former category, we include *minute* and *minute squared* as covariates since it appears that the longer the match continues, the more likely it is that a card will be issued. Also, we should note that neither web site records time added on at the end of each half and so the 45^{th} and 90^{th} minutes will typically last longer than others because they include 'injury time'. We account for this feature of the data by using dummy variables, *45^{th} minute* and *90^{th} minute*. The dynamics of previous yellow cards are included by separating numbers of cards issued to home and away teams in the preceding three minutes (*home yellow cards last 3*, *away yellow cards last 3*) from numbers of cards issued earlier in the game than the preceding three minutes (*home yellow cards prior*, *away yellow cards prior*). Numbers of straight red cards (without previous yellow) issued

in the game prior to the subject minute are captured by *home red* and *away red*. Numbers of second yellow cards issued previously in the match are similarly captured by *home 2nd yellow* and *away 2nd yellow*. The impacts of these within-game dynamic effects cannot be signed *a priori*. On the one hand, an extra card issued in the preceding three minutes, or prior to that, to a team may reduce the probability of a further card being issued to the same team, a deterrence effect. On the other hand, an extra card in the previous three minutes may be part of an escalation in illegal conflict between teams and so the sign of effect on probability of a card in the present minute may then be positive. Observers sometimes claim that referees have a tendency to 'even out' decisions so that a caution given to one team is followed by another to its opponent, but we are unable to distinguish this from conflict escalation generated by the players themselves. Our set of variables covering previous yellow and red cards serves to control for dynamics of conflict during a game.

Illegal activity may also increase as teams fall behind and we register the *goal difference* as match status (home team current score minus away team current score) at any point in time. Teams that are behind in score, which are more often away than home teams, are hypothesised to generate extra effort in an effort to negate the deficit and some of this extra effort will spill over into illegal activity, punishable by cautions or dismissals. This illegal effort is characterised by Garicano and Palacios-Huerta (2006) as 'sabotage in tournaments', where players attempt to reduce the effectiveness of opponents by unfair means. The propensity to undertake sabotage activity will be enhanced for a team that is behind in score.

Some football matches are notable for the intense rivalry they generate amongst supporters and players, the result of tradition and independent of current team league standings and prospects. These matches are generally played between two local teams a short distance apart. Witt (2005) used distance between (stadia of) competing teams to capture the impact of local rivalry. Here we nominate a particular set of rivalrous games denoted by *derby* and predict that these will generate a higher probability of a caution or dismissal for each team. In Germany, there is typically much greater average distance between teams than in England and so there are far fewer local derbies to be found in the Bundesliga, which has just six team pairs following the list provided by Brandes and Franck (2007).

The extent of social pressure exerted by fans may be positively related to size of crowd and we proxy crowd intensity by (log) match attendance (*log attendance*). Dawson *et al.* (2007) use this measure as a covariate in their analysis of disciplinary points.

We also include a measure of *ex ante* relative team strength. Dawson *et al.* used an elaborate forecasting model to generate win probabilities for the respective teams in a match. An alternative is to derive a relative team strength measure from betting odds. This has the advantage that odds will incorporate not only information from previous matches, as in the statistical model, but also fresh news such as that pertaining to player absences from injury or suspension. Of course, reliance on bookmaker odds to capture relative team strengths (as modified by home advantage) depends on the betting market being efficient. In the sample period employed by Dawson *et al.*, there is evidence that it was not fully so (Forrest and Simmons, 2002) and a statistical model may indeed have been a more appropriate basis for

deriving win probabilities. However, since the abolition of betting tax in 2001, and as the growth of internet competition has put pressure on bookmaker margins, there is evidence (Forrest and Simmons, 2004) that the betting market has moved strongly towards displaying efficiency, i.e. towards odds capturing accurately all factors relevant to the outcome of a match. Accordingly we choose to exploit odds data, from Ladbrokes, the largest UK bookmaker, and include in our model *difference in bookmaker probability* (home win probability minus away win probability) and, to capture non-linearity, its square. This variable proxies *ex ante* relative team strengths. The larger the value of this variable, the stronger the relative strength of the home side and, we predict, the less (more) likely the home (away) team is to be awarded yellow cards.

Armed with this set of covariates we model home and away probabilities of receipt of yellow (red) card as:

Probability of home team yellow (red) = f(*minute, minute squared, 45th minute, 90th minute, home yellow cards last 3 minutes, away yellow cards last 3 minutes, home yellow cards prior, away yellow cards prior*, (*home 2nd yellow*), (*away 2nd yellow*), *home red, away red*, *goal difference, track, log attendance, derby, difference in bookmaker probability, difference in bookmaker probability squared*) (1)

Probability of away team yellow (red) = f(*minute, minute squared, 45th minute, 90th minute, home cards last 3 minutes, away cards last 3 minutes, home cards prior, away cards prior*, *home 2nd yellow*), (*away 2nd yellow*) *home red, away red, goal difference, track, log attendance, derby, difference in bookmaker probability, difference in bookmaker probability squared*) (2)

We model favourite and underdog probabilities as:

Probability of favourite team yellow (red) = f(minute, minute squared, 45th minute, 90th minute, favourite yellow cards last 3 minutes, underdog yellow cards last 3 minutes, favourite yellow cards prior, underdog yellow cards prior, home 2nd yellow, away 2nd yellow, home red, away red, goal difference, home underdog, derby, difference in bookmaker probability) (3)

Probability of underdog team yellow (red) = f(minute, minute squared, 45th minute, 90th minute, favourite yellow cards last 3 minutes, underdog yellow cards last 3 minutes, favourite yellow cards prior, underdog yellow cards prior, home 2nd yellow, away 2nd yellow, home red, away red, goal difference, home underdog, derby, difference in bookmaker probability) (4)

In our estimation, we assume independence of error terms across matches but control for interdependence of error terms within matches by clustering of residuals. The resulting error terms are then robust to heteroskedasticity.

3. EMPIRICAL RESULTS

We begin with a descriptive analysis of referee propensity to award yellow and red cards in the Bundesliga and the Premiership. The matches in our samples were officiated by 35 referees in the Bundesliga and 36 referees in the Premiership. Some referees were in charge of small numbers of games, just one in some instances. The average number of games officiated is 52 in

the Bundesliga and 63 in the Premiership but the difference between the samples is not statistically significant. Standard deviations are 36 and 47 respectively. In each league, referees are obliged to retire at the age of 48, so our sample includes some referees who had just begun careers at the top level and others who retired or were demoted during the sample period. An analysis of career duration and referee performance in the Bundesliga is presented by Frick and Prinz (2007).

From the data shown in Table 1, and focussing on referees who have officiated at least 25 games, we consider the mean number of each type of card for home and away teams. There are two immediate results from t-tests, conducted with samples of unequal variance. First, with just one exception, referees in each league awarded fewer cards per game to home teams than to away teams. This was not necessarily due to referee bias as away teams tend to be more involved in defensive play as they struggle to overcome home advantage. The exception noted is straight red cards in England where the null hypothesis of equality of cards per game for home and away teams is not rejected (p = 0.31). Second, English referees tended to award fewer yellow cards per game than their German colleagues, irrespective of whether the team was home or away (p = 0.00 for both home and away comparisons). For red cards though (and for home team second yellow cards) English referees are no less severe than German referees. Differences in incidence of cards across leagues could reflect different degrees of aggression; the industry stereotype is that the Premiership is faster-paced, more physical and more attack-oriented than the Bundesliga. But differences in interpretation of the Laws of the Game may also play a part. Offences meriting straight red cards involve more clear-cut decisions by referees compared to yellow cards, where there is greater scope for discretion.

In Table 2, bivariate probit estimates of equations (1) and (2) are shown for probability of a yellow card, for each league, while Table 3 reports estimates of probability of red card in each league.

Our control variables show plausible and important effects from within-game dynamics in both leagues. An extra yellow card received by the home (away) team previously in the match, whether in the immediately preceding three minutes or prior to that, is associated with reduced probability of a home (away) team yellow card in the current minute. This is consistent with the intended deterrent effect of cautions.

An extra yellow card received by the away (home) team previously in the match, whether in the immediately preceding three minutes or prior to that, is associated with *increased* probability of a home (away) team yellow card in the current minute. This result may reflect both conflict escalation within a match and a possible tendency for referees to 'even up' decisions. These effects are significant and similar in sign across both leagues.

An extra goal scored by the home team, with away score constant, is shown to lead to a reduced probability of a home team yellow card in each league. It also leads to an increased probability of an away team yellow card though this effect is statistically significant only for the Premiership. The results therefore confirm that controlling for goal supremacy during the match is an important feature of our model.

Turning to pre-game covariates, we note that derby matches in England generate increased probability of cautions for each team, but this effect is absent in Germany where there are far fewer fixtures of intense local rivalry. Attendance is not a significant predictor of the likelihood of caution in either league. The lack of significance may arise from the consideration that increases in attendance from the mean may come from an increase in the number of either home or away supporters with different implications for the degree of social pressure exerted on referees on behalf of home teams.

An increase in difference in bookmaker win probability of the home team relative to the away team is found to be associated with a reduced likelihood of the home team receiving a yellow card and a higher likelihood of an away team receiving a yellow card, in each league (for away teams, the positive level effect dominates the negative quadratic effect within the sample range). Given efficiency in the bookmaker betting market for match results, these results suggest that *ex ante* relative team strength is a significant predictor of the likelihood of cautions for the competing teams in a match. The greater the likely superiority of the home team, as signalled by betting odds, the fewer yellow cards the home team is predicted to receive and the more yellow cards the away team is predicted to receive.

We can test for the presence of refereeing bias in the Bundesliga through the exploitation of information about presence of running track in stadia (Dohmen, 2005). The inclusion of the dummy variable *track* accounts for whether the crowd was or was not separated from the field of play by a running track. This is an irrelevant consideration for the Premiership. The results in Table 2 show that home teams face an increased probability of a yellow card where there is a

track, with a coefficient that is significant at five per cent. We also find that *track* has a positive, and marginally significant ($p = 0.052$) impact on home team's probability of red cards. The marginality of significance may be attributed to the much lower frequency of home red cards relative to home yellows. That it makes a difference whether there is a track is suggestive that German referees are not immune to social pressure when the crowd is in close proximity to the action. Referees are the likely source of what we observe here as bias since home players are, if anything, likely to be more aggressive if stirred up by a close-up crowd and this factor would tend to lead to fewer, not more, home cards being offered where there is a track. We should stress that this form of bias is systematically offered towards home teams and is not idiosyncratic to specific referees. Moreover, although we include referee fixed effects in the regressions reported in Tables 2 and 3, we cannot use these to ascertain existence of bias as the inferences will depend on the selection of the baseline referee, who may or may not be biased himself. It is the case that referee fixed effects are jointly significant in the regressions in Tables 2 and 3, but this can only be taken to imply inconsistency and not necessarily any form of systematic bias.

The findings on refereeing bias in the Bundesliga here are consistent with those of Dohmen (2005) who examined data from independent consultants, appointed by the DFB, on correctness of referees' decisions to award penalty kicks. More penalties were awarded to home teams in stadia without a running track. This suggests, reinforced by our result, that, given equal revenue-generating potential, removal of running track was a rational decision by the three Bundesliga 1 clubs that did so in our sample period. Dohmen also found that, given that an award of a penalty, penalty decisions were more likely to be 'correct' in matches played in stadia with a running track separating fans from pitch.

Behind all these findings may be that social pressure is exerted through volume of noise. Nevill *et al.* (2002) performed an experiment in which two sets of referees viewed a videotape of a Premiership match under different conditions and were asked to nominate award of free kicks. One set viewed the replay with the sound of fan noise eliminated while the other group watched with sound retained. The latter group offered more decisions in favour of the home team.

We turn next to results based on estimation of equations (3) and (4) for probability of card issue to favourite and underdog teams. In this exercise, team and referee fixed effects are excluded. However, it should be noted that *difference in bookmaker probability* is retained. Of course, this variable is now constrained to the positive range in the case of the 'favourite' equation and to the negative range for 'underdogs' (since the favourite, by definition, has the higher win probability). Continuing to control for win probabilities is key here. As in Dawson *et al.*, it should be recognised that the reason for greater incidence of yellow cards for visiting teams might be that *typically* they are underdogs and may therefore attempt to employ more foul play as an extra input in the absence of sufficient talent. If this is the reason for differential yellow card totals for home and away teams, then a visiting team that has similar prospects of victory as a typical home team should not face a different expected number of yellow cards from that typical home team. So long as we control for win probabilities in the equations for team yellow cards, the inclusion of a dummy variable to indicate which is the home team should not add significant explanatory power to the model. If the coefficient on the home team dummy were significant this would be evidence that there is differential treatment of home and away teams that could not be explained away by the correlation between home/away status and the teams' prospects of winning.

In Tables 4 to 6, the variable *home underdog* distinguishes matches where the underdog is the team playing at home and the favourite is the team playing away. We estimate ordered probit models of probability of yellow card, straight red card and any red card (including second yellow). In Table 4, the coefficient estimate on *home underdog* is negative and statistically significant in the underdog equation for yellow cards for each league. Hence, controlling for how large the difference in win probabilities is as well as for within-game factors, underdog teams are less likely to receive yellow cards when playing at home rather than away. Similarly, for the Premiership (but not this time for the Bundesliga where the coefficient estimate was statistically insignificant), the chance of a yellow card is higher for the favourite playing away rather than at home. Therefore, this pattern of results clearly supports the finding in Dawson *et al.* (2007) that the tendency of away teams to receive relatively more yellow cards cannot be fully explained by the fact that, because of home advantage, they are more often than not the team more likely to win the match.

From the results shown in Table 5, we observe a positive and (highly) significant coefficient on *home underdog* for probability of favourite team receiving a red card in each league. Controlling for degree of favourite status in the odds, match score and within-game dynamics of yellow and red cards, we find that favourites face a higher probability of a red card when playing away rather than at home. Hence, referees generally exhibit bias in their treatment of red cards in favour of home teams, and not just in their behaviour with respect to less severe cautionable offences. This finding is reinforced by the results shown in Table 6 for all red cards, including second yellow cards and not just straight red cards. In each league, away teams that are favourites receive a significantly higher probability of a red card, of either type, when it is

playing away and the underdog is playing at home. For the Bundesliga only, we find that underdog teams have a lower probability of a red card, *ceteris paribus*, when they are playing at home.

We have, then, found a number of indications of home team bias on the part of referees in both Germany and England. This may be a source of concern to the respective governing bodies. However, it cannot be assumed that neutrality would be socially preferable to any given degree of home team bias. If referees indeed exhibit systematic bias towards home teams, then this may help reinforce home advantage and help smaller teams win more home games. This may in turn raise competitive balance which is alleged by many sports economists to raise audience interest in the competition. Assuming that reluctance to issue cautions to home teams has a bearing on match outcome, then small home teams are more likely to win games then hitherto.

4. CONCLUSIONS

We have presented a novel disaggregated analysis of bias and favouritism practiced by soccer referees, in which the unit of observation is minute of play in a match. This disaggregated approach allows us to control for within-game factors of fluctuating scores and dynamics of award of cards in a match. With these additional controls in place, inferences on bias and favouritism are more robust and more compelling than those derived from analyses that use the match as unit of observation. It appears, though, that the previous literature, such as Dawson *et al.* (2007) and Dohmen (2005), was correct in detecting signs of bias in application of disciplinary sanctions in English and German football.

We have two primary exhibits for referee bias in favour of home teams in the award of yellow and red cards:

- From the Bundesliga we find evidence of favouritism against away teams in that home teams playing in stadia without running tracks have lower probabilities of yellow and red card than home teams playing in grounds without running tracks. This is indicative of a successful impact of fans' 'social pressure' as proposed by Dohmen (2005). The fact that three teams switched stadium design with track removal in our sample period suggests that this is more than just a specific team effect.
- When matches in our two sample leagues are re-specified as favourite versus underdog, rather than home versus away, we obtain evidence, via significant coefficients on the *home underdog* dummy variable, of biased treatment of teams in both the Premiership and the Bundesliga, in the award of both yellow and red cards.

Clearly, it would be desirable to assess whether our results are supported by analysis from other European football leagues, and other sports leagues where sanction design and refereeing technology may differ. Most importantly, further research is needed to assess the implications of referee bias for league design and corporate governance of sports leagues. Is the bias that we have detected harmful to stakeholders in the sport? Are audiences (at the stadium and in front of television sets) deterred both by increased sanctions applied by referees and referee bias in these sanctions? And what exactly are the impacts of measures to reduce referee bias on match uncertainty of outcome and competitive balance in football leagues? These are deeper research

questions that demand attention. For now, the strong findings of referee favouritism towards home teams obtained in this paper are an essential precursor for these investigations.

References

Allen, W.D. (2002), Crime, punishment and recidivism: Lessons from the National Hockey League, *Journal of Sports Economics*, **3**, 39-60.

Boyko, R. Boyko, A. and M. Boyko (2007), Referee bias contributes to home advantage in English Premiership football, *Journal of Sports Sciences*, **25**.

Brandes, L. and E. Franck (2007), Spending too much on a good thing already? How less uncertainty of outcome would foster fan demand, mimeo, University of Zurich.

Caliendo, M. and D. Radic (2006), Ten do it better, do they? An empirical analysis of an old football myth, *IZA Discussion Paper* No. 2158.

Carmichael, F. and D. Thomas (2005), Home-field effect and team performance: Evidence from English Premiership football, *Journal of Sports Economics*, **6**, 264-281.

Dawson, P., Dobson, S., Goddard, J. and J. Wilson (2007), Are football referees really biased and inconsistent? Evidence from the English Premier League, *Journal of the Royal Statistical Society, Series A*, forthcoming.

Dohmen, T. (2005), Social pressure influences decisions of individuals: Evidence from the behavior of football referees, *IZA Discussion Paper* No. 1595.

Forrest, D. and R. Simmons (2002), Outcome uncertainty and attendance demand in sport: The case of English soccer, *The Statistician*, **51**, 229-241.

Forrest, D. and R. Simmons (2004), Sentiment in the soccer betting market, University of Salford, mimeo.

Frick, B. and J. Prinz (2007), Monitoring the monitor: Performance evaluation and remuneration of professional referees in German professional soccer, University of Witten/Herdecke, mimeo.

Garicano, L. and I. Palacios-Huerta (2006), Sabotage in tournaments: Making the beautiful game less beautiful, mimeo, University of Chicago.

Garicano, L., Palacios-Huerta, I. and C. Prendergast (2005), Favoritism under social pressure, *Review of Economics and Statistics*, **87**, 208-216.

Heckelman, J. and Yates, A. (2003), And a hockey game broke out: Crime and punishment in the NHL, *Economic Inquiry*, **41**, 705-712.

Levitt, S. (2002), Testing the economic model of crime: the National Hockey League's two-referee experiment, *Berkeley Electronic Journals in Economic Analysis and Policy*, **1**, 1-19.

Lucey, B. and D. Power (2004), Do soccer referees display home team favouritism?, mimeo, Trinity College Dublin.

Nevill, A., Balmer, N. and A. Williams (2002), The influence of crowd noise and experience upon refereeing decisions in football, *Psychology of Sport and Exercise*, **3**, 261-272.

Pollard, R. and G. Pollard (2005), Long-term trends in home advantage in professional team sports in North America and England (1876-2003), *Journal of Sports Sciences*, **23**, 337-350.

Rickman, N. and R. Witt (2005), Favouritism and financial incentives: A natural experiment, *Centre for Economic Policy Research Discussion Paper* No. 4968.

Ridder, G., Cramer, J. and P. Hopstaken (1994), Down to ten: Estimating the effect of a red card in soccer, *Journal of the American Statistical Association*, **89**, 1124-1127.

Stefani, R. (2007), Measurement and interpretation of home advantage, in J. Albert and R. Koning (eds.), *Statistical thinking in sports*, CRC Press, 203-216.

Sutter, M. and M. Kocher (2004), Favouritism of agents- the case of referees' home bias, *Journal of Economic Psychology*, **25**, 461-469.

Torgler, B. (2004), The economics of the FIFA football World Cup, *Kyklos*, **57**, 287-300.

Witt, R. (2005), Do players react to sanction changes? Evidence from the English Premier League, *Scottish Journal of Political Economy*, **52**, 623-640.

Table 1a Referees' awards of cards per game in Bundesliga 1

Referee	*Games*	*Home yellow*	*Away yellow*	*Home 2nd yellow*	*Away 2nd yellow*	*Home red*	*Away red*
Albrecht	59	1.92	2.34	0.051	0.034	0.034	0.034
Aust	47	1.87	2.23	0.021	0.106	0.021	0.043
Berg	32	1.44	1.88	0	0	0	0
Brych	32	1.78	1.84	0.031	0.031	0	0.031
Fandel	124	1.79	2.23	0.032	0.113	0.040	0.048
Fleischer	83	1.93	1.98	0.024	0.036	0.060	0.048
Frohlich	81	1.77	2.02	0.037	0.049	0.062	0.111
Gagelmann	63	2.08	2.51	0.048	0.095	0.063	0.032
Grafe	30	2.07	2.13	0.067	0.033	0.033	0.100
Jansen	61	1.52	2.05	0.016	0.066	0.066	0.016
Kemmling	60	1.72	2.40	0.067	0.100	0.083	0.117
Kessler	53	1.83	2.26	0.019	0.057	0.057	0.151
Kinhofer	57	2.26	2.46	0.035	0.053	0	0.070
Kircher	70	1.61	1.89	0	0	0	0.043
Koop	33	1.70	2.33	0.061	0.121	0	0.061
Krug	68	1.75	2.26	0.029	0.074	0.044	0.074
Merk	135	1.67	2.17	0.030	0.044	0.059	0.074
Meyer	94	2.10	2.37	0.032	0.011	0.064	0.106
Sippel	73	1.74	1.90	0.014	0.027	0.014	0.082
Stark	100	1.65	2.32	0.030	0.080	0.030	0.080
Steinborn	60	1.38	1.75	0.017	0.017	0	0.050
Strampe	47	1.47	2.11	0.021	0.191	0.085	0.064
Wack	97	1.84	2.19	0.031	0.062	0.031	0.052
Wagner	83	1.49	2.14	0	0.072	0.072	0.048
Weiner	85	1.95	2.36	0.012	0.118	0.012	0.082
Mean	69	1.77	2.16	0.029	0.064	0.037	0.065

Note: In Tables 1a and 1b the minimum number of games for a referee is 25.

Table 1b Referees' awards of cards per game in Premiership

Referee	*Games*	*Home yellow*	*Away yellow*	*Home 2nd yellow*	*Away 2nd yellow*	*Home red*	*Away red*
Barber	81	1.51	2.00	0.049	0.062	0.037	0.049
Barry	96	1.07	1.68	0	0.031	0.042	0.042
Bennett	132	1.43	1.89	0.038	0.114	0.045	0.068
Clattenburg	33	1.73	1.45	0.030	0.030	0.030	0
Dean	108	1.54	1.74	0.019	0.028	0.056	0.093
Dowd	79	1.59	2.08	0.025	0.076	0.038	0.101
Dunn	99	1.20	1.56	0	0.030	0.030	0.040
Durkin	88	0.92	1.26	0.023	0.011	0	0.057
D'Urso	98	1.29	1.90	0.061	0.082	0.071	0.061
Elleray	55	1.05	1.64	0	0	0.073	0.109
Foy	57	1.04	1.63	0.018	0.070	0.035	0.018
Gallagher	112	1.11	1.50	0.045	0.063	0.027	0.054
Halsey	129	0.91	1.43	0.016	0.008	0.078	0.047
Jones	30	1.47	1.87	0	0.033	0.067	0
Knight	63	1.22	1.81	0.016	0.032	0.159	0.079
Messias	45	1.38	1.93	0.044	0.044	0	0.044
Poll	155	1.36	1.66	0.045	0.052	0.032	0.026
Rennie	93	1.23	1.18	0.011	0	0	0.075
Riley	132	1.60	2.16	0.045	0.061	0.091	0.053
Styles	128	1.45	1.94	0.047	0.094	0.094	0.055
Walton	34	1.21	1.53	0	0	0.029	0.029
Webb	61	1.21	1.67	0	0.033	0.049	0.049
Wiley	140	1.41	1.59	0.043	0.029	0.007	0.057
Wilkes	29	1.24	2.14	0	0.034	0.069	0.069
Winter	83	0.80	1.57	0	0.048	0.012	0.012
Mean	86	1.28	1.71	0.023	0.043	0.047	0.051

Table 2 Bivariate Probit Regression Results for Yellow Card

Variable	Bundesliga home team	Bundesliga away team	Premiership home team	Premiership away team
Within-game				
Minute	0.015	0.015	0.015	0.015
	(11.80)	(12.83)	(11.15)	(12.75)
Minute squared	-0.00010	-0.000097	-0.00010	-0.00010
	(7.62)	(7.98)	(7.43)	(8.43)
45^{th} minute	0.346	0.273	0.438	0.534
	(6.55)	(5.24)	(9.00)	(12.65)
90^{th} minute	0.524	0.551	0.638	0.734
	(10.32)	(11.66)	(13.83)	(17.88)
Home yellow	-0.246	0.122	-0.030	0.197
last 3 minutes	(6.82)	(4.42)	(0.85)	(7.13)
Away yellow	0.105	-0.172	0.159	-0.099
last 3 minutes	(3.87)	(6.10)	(5.54)	(3.50)
Home yellow	-0.088	0.016	-0.042	0.051
prior	(8.33)	(1.80)	(4.28)	(5.59)
Away yellow	0.024	-0.086	0.048	-0.065
prior	(2.68)	(9.97)	(5.38)	(7.05)
Home red	0.049	0.110	0.005	0.063
	(0.87)	(2.07)	(0.11)	(1.55)
Away red	0.035	-0.038	-0.026	-0.034
	(0.71)	(0.83)	(0.48)	(0.65)
Goal difference	-0.032	0.007	-0.031	0.017
	(5.10)	(1.31)	(4.48)	(2.77)
Pre-game				
Track	0.105	0.040		
	(2.48)	(0.95)		
Log attendance	0.041	-0.011	-0.008	-0.020
	(1.06)	(0.30)	(0.10)	(0.29)
Derby	-0.005	0.061	0.074	0.112
	(0.10)	(1.60)	(3.02)	(4.90)
Difference in bookmaker probability	0.043	0.245	-0.0075	0.106
	(0.69)	(4.00)	(0.15)	(2.16)
Difference in bookmaker probability squared	-0.429	-0.342	-0.351	-0.237
	(3.20)	(2.99)	(3.68)	(2.84)
N	159,210	159,210	204,480	204,480
LL	-32929	-32929	-32871	-32871

Note: Dependent variable is probability of team receiving a yellow card in a given minute. Coefficients are reported with *t*-statistics in parentheses, computed using robust standard errors clustered by match. Equations are estimated jointly for home and away teams but separately for Bundesliga and Premiership. Models in Tables 2 and 3 include fixed effects for referees and home and away teams and year dummies.

Table 3 Bivariate Probit Regression Results: Red card

Variable	Bundesliga home team	Bundesliga away team	Premiership home team	Premiership away team
Within-game				
Minute	0.012	0.018	0.010	0.006
	(2.07)	(3.07)	(2.24)	(1.16)
Minute squared	-0.000078	-0.00014	-0.000063	-0.00001
	(1.20)	(2.48)	(1.32)	(0.26)
45th minute	0.111	0.242	0.188	0.172
	(0.39)	(1.40)	(0.89)	(0.85)
90th minute	0.724	0.679	0.331	0.540
	(4.55)	(5.51)	(2.03)	(4.45)
Home yellow	-0.246	0.161	0.116	-0.049
last 3 minutes	(6.82)	(1.71)	(1.09)	(0.39)
Away yellow	0.105	0.121	0.014	0.255
last 3 minutes	(3.87)	(1.36)	(0.12)	(2.50)
Home yellow	-0.088	0.067	-0.020	-0.028
prior	(8.33)	(2.21)	(0.55)	(0.82)
Away yellow	0.024	0.017	0.068	0.055
prior	(2.68)	(0.62)	(2.21)	(1.65)
Home 2nd	-4.591	0.369	-4.544	0.178
yellow	(19.27)	(2.17)	(27.01)	(0.88)
Away 2nd	-0.033	0.174	0.103	-4.798
yellow	(0.17)	(1.23)	(0.55)	(31.73)
Home red	0.049	0.226	-0.156	0.271
	(0.87)	(1.46)	(1.35)	(2.31)
Away red	0.035	-0.298	0.312	-0.168
	(0.71)	(2.08)	(2.43)	(1.27)
Goal difference	-0.032	0.064	-0.110	0.032
	(5.10)	(3.02)	(4.27)	(1.56)
Pre-game				
Track	0.293	0.169		
	(1.94)	(1.15)		
Log attendance	-0.250	-0.419	0.383	0.302
	(1.54)	(2.84)	(1.18)	(1.03)
Derby	-0.065	0.062	0.073	0.027
	(0.35)	(0.40)	(0.73)	(0.31)
Difference in bookmaker probability	-0.607	-0.248	0.449	0.154
	(2.57)	(1.25)	(1.97)	(0.81)
Difference in bookmaker probability squared	-0.182	-0.190	-1.150	-0.231
	(0.35)	(0.39)	(2.59)	(0.68)
N	159,210	159,210	204,480	204,480
LL	-1354	-1354	-1669	-1669

Table 4 Bivariate probit model of yellow card with favourites and underdogs

Variable	Bundesliga favourite team	Bundesliga underdog team	Premiership favourite team	Premiership underdog team
Within-game				
Minute	0.013	0.015	0.014	0.014
	(10.55)	(12.33)	(11.11)	(11.93)
Minute squared	-0.000088	-0.00011	-0.00010	-0.00010
	(6.77)	(8.70)	(7.68)	(8.24)
45th minute	0.329	0.284	0.457	0.518
	(6.13)	(5.44)	(9.45)	(11.90)
90th minute	0.503	0.561	0.636	0.730
	(10.03)	(11.70)	(13.59)	(17.47)
Favourite	-0.128	0.118	0.012	0.187
yellow last 3	(4.01)	(4.28)	(0.33)	(6.70)
Underdog	0.145	-0.144	0.190	-0.036
yellow last 3	(5.39)	(4.85)	(6.67)	(1.23)
Favourite	-0.046	0.024	-0.013	0.054
yellow prior	(4.71)	(2.82)	(1.38)	(6.19)
Underdog	0.035	-0.054	0.055	-0.033
yellow prior	(4.03)	(6.48)	(6.11)	(3.59)
Favourite 2nd	-0.062	0.162	0.026	0.020
yellow	(0.67)	(2.33)	(0.37)	(0.26)
Underdog 2nd	0.038	-0.051	0.043	0.033
yellow	(0.78)	(1.03)	(0.70)	(0.59)
Favourite red	0.109	0.132	0.041	0.051
	(2.08)	(2.38)	(0.78)	(1.22)
Underdog red	0.018	-0.039	0.028	-0.031
	(0.35)	(0.86)	(0.60)	(0.67)
Goal difference	-0.042	-0.003	-0.056	-0.003
	(6.97)	(0.57)	(8.41)	(0.52)
Pre-game				
Home underdog	0.019	-0.109	0.104	-0.097
	(0.98)	(5.80)	(6.32)	(5.73)
Derby	0.041	0.034	0.061	0.110
	(0.99)	(0.85)	(2.58)	(5.06)
Difference in bookmaker probability	-0.185	-0.013	-0.138	-0.008
	(3.86)	(0.30)	(3.17)	(0.20)
N	159,750	159,750	198,180	198,180
LL	-32581	-32581	-32035	-32035

Note: Dependent variable in Tables 4-6 is probability of team receiving a stated card in a given minute. Coefficients are reported with *t*-statistics in parentheses, computed using robust standard errors clustered by match. Equations are estimated jointly for favourite and underdog teams but separately for Bundesliga and Premiership. Models include year dummies

Table 5 Bivariate probit model of straight red card with favourites and underdogs

Variable	Bundesliga favourite team	Bundesliga underdog team	Premiership favourite team	Premiership underdog team
Within-game				
Minute	0.014	0.012	0.016	0.005
	(5.22)	(2.19)	(7.03)	(0.96)
Minute squared	-0.000092	-0.000078	-0.00012	-0.00002
	(3.31)	(1.42)	(5.13)	(0.41)
45th minute	0.202	0.173	0.464	0.278
	(1.69)	(0.82)	(5.95)	(1.54)
90th minute	0.610	0.500	0.666	0.437
	(6.49)	(3.78)	(8.61)	(3.18)
Favourite	-0.008	0.176	-0.044	-0.048
yellow last 3	(0.14)	(1.91)	(0.87)	(0.38)
Underdog	0.182	0.115	0.189	0.326
yellow last 3	(3.29)	(1.24)	(3.88)	(3.82)
Favourite	-0.070	0.058	-0.037	0.002
yellow prior	(3.63)	(1.92)	(2.18)	(0.05)
Underdog	0.059	0.030	0.067	0.055
yellow prior	(3.00)	(1.19)	(4.31)	(1.71)
Favourite 2nd	0.065	0.169	-0.018	0.323
yellow	(0.63)	(0.80)	(0.13)	(1.85)
Underdog 2nd	0.133	0.010	0.087	-4.550
yellow	(1.89)	(0.06)	(0.79)	(37.24)
Favourite red	0.097	-0.054	0.137	0.298
	(1.07)	(0.26)	(1.55)	(2.63)
Underdog red	0.164	0.029	0.171	-0.021
	(1.36)	(0.25)	(2.55)	(0.16)
Goal difference	-0.066	0.062	-0.070	0.043
	(5.14)	(3.20)	(6.22)	(2.23)
Pre-game				
Home underdog	1.392	-0.043	1.226	0.043
	(28.77)	(0.52)	(31.69**)**	(0.70)
Derby	0.020	-0.009	0.107	-0.046
	(0.27)	(0.05)	(2.77)	(0.51)
Difference in bookmaker probability	-0.102	-0.154	-0.117	-0.184
	(0.86)	(0.87)	(1.49)	(1.21)
N	159,750	159,750	198,180	198,180
LL	-4311	-4311	-5840	-5840

Table 6 Bivariate probit model of red card (including 2nd yellow) with favourites and underdogs

Variable	Bundesliga favourite team	Bundesliga underdog team	Premiership favourite team	Premiership underdog team
Within-game				
Minute	0.014	0.017	0.016	0.006
	(5.38)	(4.14)	(6.97)	(1.40)
Minute squared	-0.000088	-0.00012	-0.00012	-0.00002
	(3.33)	(2.91)	(5.01)	(0.56)
45th minute	0.171	0.167	0.472	0.413
	(1.47)	(1.03)	(6.25)	(3.17)
90th minute	0.579	0.510	0.687	0.460
	(6.52)	(4.81)	(9.34)	(4.56)
Favourite	0.002	0.176	0.006	0.033
yellow last 3	(0.04)	(2.43)	(0.13)	(0.37)
Underdog	0.157	0.193	0.187	0.411
yellow last 3	(2.95)	(2.77)	(3.91)	(6.35)
Favourite	-0.055	0.054	-0.001	0.001
yellow prior	(3.06)	(2.39)	(0.05)	(0.05)
Underdog	0.055	0.029	0.059	0.170
yellow prior	(3.09)	(1.40)	(4.01)	(8.41)
Favourite all	0.075	0.256	0.076	0.225
red	(1.10)	(2.66)	(0.98)	(2.69)
Underdog all	0.151	-0.079	0.108	-0.207
red	(2.31)	(0.91)	(2.08)	(1.95)
Goal difference	-0.065	0.056	-0.065	0.032
	(5.46)	(3.71)	(6.15)	(1.87)
Pre-game				
Home underdog	1.243	-0.139	1.106	-0.045
	(31.61)	(2.20)	(33.56**)**	(0.87)
Derby	0.004	0.049	0.125	-0.091
	(0.05)	(0.43)	(3.42)	(1.21)
Difference in bookmaker probability	-0.045	-0.359	-0.130	-0.172
	(0.42)	(2.70)	(1.78)	(1.44)
N	159,750	159,750	198,180	198,180
LL	-5332	-5332	-6824	-6824