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Chris Goumas

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Home advantage and referee bias in European football

CHRIS GOUMAS

School of Public Health, University of Sydney, Sydney, Australia

Abstract
Home advantage is well documented in a wide range of team sports including association football (soccer). Home team crowd support has been shown to be a likely causal factor and its influence on referee decision-making appears to play a significant role. Match data from the 2009/2010 and 2010/2011 seasons of the Union of European Football Associations (UEFA) Champions League and Europa League were used to investigate referee bias in terms of the association between match location (home vs. away) and disciplinary sanctions used by football referees. The adjusted mean number of yellow cards received by home and away teams and the ratios of these means were estimated from Poisson regression models. After controlling for within-match measures of attacking dominance referees in the Champions League and Europa League issued 25% ($p < 0.001$) and 10% ($p = 0.002$) more yellow cards, respectively, to away teams than to home teams. The higher level of home team bias in the Champions League appeared to be mainly due to higher crowd densities. In a combined analysis of both UEFA leagues the magnitude of referee bias increased with increasing crowd density ($p < 0.001$). Crowd size and crowd proximity were not associated with referee bias after controlling for crowd density. These results provide further evidence that crowd support influences referee decisions. Failure to control for within-match team performance may over-estimate the extent of referee bias in terms of the number of disciplinary sanctions used.

Keywords: *Home advantage, referee bias, crowd effects, football, soccer*

Introduction

Home advantage is the tendency for sporting teams to win more matches played at their home ground than those played away from home, and its existence is well established in a wide range of team sports including association football (soccer; Courneya & Carron, 1992; Nevill & Holder, 1999; Pollard & Pollard, 2005). Home advantage in football occurs worldwide, at almost every level of the game, and at the elite level approximately 60% of all competition points gained are at home (Pollard, 2006a). Although home team crowd support appears to play a major role in home advantage the mechanisms through which it operates are unclear (Pollard, 2008). One such mechanism that has received much attention recently is the effect of home team crowd support on officials; that is, football referees may be influenced by the crowd to favour the home team, and this is the focus of the present study.

Studies (described below) into the effect of crowd support on referee decision-making in football have used a variety of measures of potential home team bias including the number of disciplinary sanctions used by referees such as yellow cards (cautions) and red cards (dismissals) and the amount of stoppage time added to the end of matches. All have shown an apparent bias towards the home team and the magnitude of this bias appears to increase with increasing crowd size and/or density. As crowds at almost all professional football matches are composed primarily of home team supporters such correlations suggest that the crowd may be influencing referee decisions.

Studies analysing the frequency of disciplinary sanctions used by referees in domestic football leagues in England (Carmichael & Thomas, 2005; Nevill, Newell & Gale, 1996), Scotland (Nevill et al. 1996), Germany (Unkelbach & Memmert, 2010) and Turkey (Seckin & Pollard, 2008) have

Correspondence: C. Goumas, School of Public Health, The University of Sydney, Queen Elizabeth II Building (D02), University of Sydney, Sydney, NSW, 2006 Australia. E-mail: chris.goumas@sydney.edu.au

consistently found that away teams receive more yellow and red cards than home teams, and those investigating crowd effects have observed an increase in this apparent home team bias with increasing crowd size (Nevill et al., 1996) and crowd density (Unkelbach & Memmert, 2010). However, a difference in the raw number of sanctions issued to home and away teams may be due to factors other than referee bias, for example the more time spent by away teams in defensive situations (Carmichael & Thomas, 2005).

Multivariate statistical analysis has been used in an attempt to control for potential confounders of the association between match location (home vs. away) and disciplinary sanctions used by football referees. Studies of the English Premier League (Boyko, Boyko & Boyko, 2007; Dawson, Dobson, Goddard, & Wilson, 2007) and German *Bundesliga* (Buraimo, Forest, & Simmons, 2010) have modelled the incidence of yellow and red cards adjusting for variables likely to influence within-match team performance such as prior home and away record, match importance, betting odds of winning the match and propensity to receive sanctions in home and away matches. Boyko et al. (2007) found that home team bias increased with increasing crowd size; Dawson et al. (2007) observed a significant overall level of home team bias although it did not appear to be associated with crowd size; and Buraimo et al. (2010) showed that home teams are less likely to receive disciplinary sanctions in stadiums not surrounded by a running track (i.e. where crowds are closer to the field of play and, therefore, more likely to influence the referee). A study of the Italian *Serie A* and *Serie B* football leagues (Petterson-Lidbom & Priks, 2007) found that referees favour home teams when calling fouls and issuing yellow and red cards in matches played in front of spectators but not in those played behind closed doors for disciplinary reasons. These effects appeared to be independent of team performance measures such as shots at goal and ball possession.

Researchers have also investigated the amount of stoppage time football referees add to the end of matches and how this varies depending on the score. In the Spanish *Primera Division,* the amount of stoppage time favoured home teams in that more time was added if the home team was one goal behind than if they were one goal ahead, thus giving them a chance to equalise; this effect remained after controlling for causes of stoppage time (e.g. yellow/red cards and player substitutions), and was positively correlated with crowd size and density (Garicano, Palacios-Huerta, & Prendergast, 2005). Similar results were obtained from the Italian *Serie A* (Scoppa, 2008) and German *Bundesliga* (Dohmen, 2008). In the English Premier League, however, referee bias in terms of stoppage time added was evident prior to, but not after, the introduction of salaried referees (Rickman & Witt, 2008).

Experimental designs have also been used to investigate the effect of crowd support on referee decisions. In two separate studies, Nevill, Balmer and Williams (1999, 2002), had qualified football referees assess the 'legality' of various tackles/challenges on videotape with or without audible crowd noise. In both studies the presence of crowd noise made the observers more likely to decide in favour of the home team, and the 'noise' group's decisions were much closer to those of the actual referee than were the 'no noise' group's. However, the results of each of these studies were based on a single football match so the generalisability of their findings is limited. A similar experiment conducted by Unkelbach and Memmert (2010) used video clips from 56 different matches from the German *Bundesliga*: a 'high crowd noise' group of observers was more likely to award yellow cards than a 'low crowd noise' group.

Only one study to date (Dawson & Dobson, 2010) has investigated the effect of crowd support on referee decision-making in the Union of European Football Associations (UEFA) leagues. An analysis of the 2002/2003 to 2006/2007 seasons of the Champion League and UEFA Cup (now the Europa League) found that although the number of yellow and red cards issued by referees to both home and away teams increased significantly with increasing crowd density the effect was almost twice as strong for away teams, indicating a positive correlation between home team bias and crowd density. Absolute crowd size, however, had no influence on referee decisions when controlling for crowd density.

The aforementioned studies provide evidence that referee decisions in football are influenced by the crowd and tend to favour the home team. The present study differs from these in its attempt to estimate the magnitude of referee bias – in terms of disciplinary sanctions issued to home and away teams – while directly controlling for within-match measures of attacking dominance. This is important as it has previously been shown that away teams find themselves in more defensive situations than home teams (Carmichael & Thomas, 2005) which may result in them committing more fouls and, in turn, receiving more yellow and red cards. Within-match performance is, therefore, a potential confounder of the association between match location and the number referee sanctions used.

To investigate the role crowd support plays in home team bias this study used match data from the UEFA Champions League and Europa League – international club competitions featuring the best teams from over 50 European countries. These

leagues provide a rich source of data for investigating the effect of crowd factors on home advantage as crowd sizes and densities cover a much wider range than in most domestic leagues and many venues are surrounded by running tracks which allow for the effect of crowd proximity to be investigated. The objectives of this study were threefold: 1. to determine the overall level of home advantage in the UEFA leagues; 2. to quantify the extent to which disciplinary sanctions used by referees favour the home team after controlling for within-match measures of attacking dominance; and 3. to investigate how referee bias may vary according to crowd size, density and proximity.

Methods

Data

The data used in this study were all matches from the 2009/2010 and 2010/2011 seasons of the UEFA Champions League ($n = 426$) and Europa League ($n = 958$). Three hundred and twenty-two teams representing 53 countries participated, with entry based on a team's performance in their domestic league the previous season. The Champions League is the 'elite' competition and includes the highest ranked teams from each country involved, whereas the Europa League is a 'second tier' tournament including teams ranked (in their domestic league) just below those qualifying for the Champions League, as well as teams eliminated from the Champions League. Both UEFA leagues consist of a series of qualifying rounds leading up to a group stage. The top two teams in each group progress to a finals stage culminating in two teams competing for the title in a 'final' match. All matches except the final are played in pairs, one at each team's home ground. Each of the group stage matches is decided on their own, whereas matches in the qualifying and finals stages are played as 'two-legged ties' and are won by the team scoring the most goals over the two legs. The final matches in each league ($n = 4$) were excluded from the analysis as they are played at a neutral venue where there is no home advantage.

For each match, the total number of goals scored, shots at goal, corners (free kicks taken from a corner of the field near the opponent's goal) and yellow cards received was available for each team, as well as crowd size. Crowd density was calculated by dividing crowd size by stadium capacity. Crowd proximity was based on whether or not the playing field was surrounded by a running track.

The Union of European Football Associations (UEFA) ranks each European football team based on a coefficient calculated from its performance in UEFA club competitions over the previous five years. The ranking coefficient at the end of each season was used in this study as a measure of team ability during that season.

Match data and team rankings were downloaded from UEFA.com while crowd size, stadium capacity and stadium type (with/without a running track) were obtained from soccerway.com. Details on how UEFA ranking coefficients are calculated can be found at www.uefa.com/memberassociations/uefarankings/.

Analysis

As most matches in the UEFA leagues are decided by the total number of goals scored over two legs, home advantage was calculated as the percentage of all goals scored at home; that is, the total number of goals scored by home teams divided by the total number of goals scored by both home and away teams, multiplied by 100 (Pollard, 1986). To compare home advantage in the UEFA leagues to that reported for domestic European leagues a separate analysis was conducted restricted to the group stage (192 Champions League and 288 Europa League matches) in which each match is decided individually, and home advantage calculated as the percentage of all competition points gained by home teams.

To investigate the association between match location (0 = Home, 1 = Away) and the number of disciplinary sanctions (yellow cards) used by referees, a paired design was adopted whereby each match contributed two observations, one for the home team and one for the away team. A repeated measures regression analysis using log-link Generalised Estimating Equations (Liang & Zeger, 1986) in STATA 11 (2009) was used to estimate the mean number of yellow cards issued to home and away teams, the ratio of 'away' to 'home' means (mean ratio), and their standard errors (SE). Mean ratios were derived by exponentiating the regression coefficient for match location and are interpreted as the percentage difference between home and away teams in the number of yellow cards received. Repeated measures analysis is used when observations occur in pairs or groups and the outcome of interest is likely to be correlated within each group. In the present study, the 'groups' were matches and the 'observations' were the number of yellow cards issued against each of the two opposing teams. As this outcome is a discrete count Poisson errors were specified for the regression model. To adjust for within-match attacking dominance linear terms for the number of shots at goal and corners taken by each team were added to the model.

To determine how the association between match location and disciplinary sanctions used by referees may vary according to crowd size, density and

proximity (0 = No track, 1 = Track) interaction terms between match location and each of these crowd variables were added separately and simultaneously to the model described above. For crowd size and density departure from linearity was tested for using quadratic terms and logarithmic transformations.

To control for the potential confounding effect of league, season and stage of competition (qualifying, group and finals) on the association between home team bias and crowd factors interaction terms between match location and each of these variables were added to the regression model. When comparing match location effects across different levels of crowd factors the home/away balance in the data is lost and team ability becomes a potential confounder (see Clarke & Norman, 1995) and was controlled for by adding a linear term for UEFA team ranking to the models.

All regression analyses were initially performed on both leagues combined. If there was evidence ($p < 0.1$) of heterogeneity of effects between leagues analyses were conducted and results presented separately for each league. Heterogeneity was tested for by adding a two-way interaction term between match location and league to the regression model of overall home-team bias, and a three-way interaction term between match location, league and each crowd variable to the models of home-team bias and crowd effects.

When adding interaction terms to the regression models main effect terms (and lower order interaction terms for three-way interactions) for each variable involved in the interaction were also included. All p-values presented are from two-sided z-tests for statistical significance of the regression parameter of interest. P-values less than 0.05 were considered to be significant.

Results

Four forfeited matches were excluded from the analysis; in order to maintain the home/away balance in the data the 'reverse legs' of each of these matches were also excluded. The results presented are based on the remaining 422 Champions League and 950 Europa League matches.

Table I shows descriptive statistics for crowd size and density. Median crowd size in the Champions League was over twice that in the Europa League, although crowds in both leagues ranged from less than 500 to over 65,000. Median crowd density was also much higher in the Champions League (over three-quarters capacity) than in the Europa League (about half capacity). In the Europa league, 41% of matches were played at a venue with a running track separating the crowd from the field, compared to only 32% in the Champions League.

Table I. Descriptive statistics for crowd size and crowd density in UEFA Champions League and Europa League matches

	N	Median	Inter-quartile range
Crowd size			
Champions League	422	26,469	12,295–42,789
Europa League	950	11,200	4019–19,669
Crowd density			
Champions League	422	0.79	0.53–0.92
Europa League	950	0.51	0.27–0.72

Table II shows descriptive statistics for within-match disciplinary and performance measures. Away teams received more yellow cards than home teams, particularly in the Champions League. In both leagues the average number of goals scored, shots at goal and corners taken was higher for home teams than for away teams.

Home advantage

Home advantage in terms of goals scored was 58.8% in the Champions League and 58.0% in the Europa League. In terms of competition points gained in the group stage of competition home advantage was 57.8% in the Champions League and 59.2% in the Europa League.

Referee bias

Table III shows results of the regression analysis of match location on yellow cards issued by referees. After controlling for within-match attacking dominance referees in the Champions League and Europa League issued 25% ($p < 0.001$) and 10% ($p = 0.002$) more yellow cards, respectively, to away teams than to home teams. The difference between the two UEFA leagues in the effect of match location

Table II. Descriptive statistics for disciplinary and performance measures for home and away teams in 422 Champions League and 950 Europa League matches

	Home teams	Away teams
	Mean (SD)	Mean (SD)
Champions League		
Yellow cards	1.67 (1.26)	2.24 (1.45)
Goals scored	1.58 (1.43)	1.11 (1.20)
Shots at goal	12.20 (5.30)	9.35 (4.35)
Corners	5.44 (3.03)	4.19 (2.73)
Europa League		
Yellow cards	1.82 (1.37)	2.13 (1.43)
Goals scored	1.60 (1.43)	1.16 (1.19)
Shots at goal	12.21 (5.25)	8.71 (4.54)
Corners	5.61 (3.31)	4.03 (2.59)

Table III. Results of regression analysis of match location on yellow cards issued by referees in 422 Champions League and 950 Europa League matches (SE in brackets)

				Adjusted mean		
	Regression coefficient[a]	*z*-score	*p*-value	Home teams	Away teams	Mean ratio[b]
Champions League	0.2226 (0.0498)	4.47	<0.001	1.73 (0.07)	2.17 (0.07)	1.25 (0.06)
Europa League	0.0962 (0.0312)	3.08	0.002	1.88 (0.05)	2.07 (0.05)	1.10 (0.03)

[a]Regression coefficient for match location (0 = Home, 1 = Away) from log-link Poisson regression models adjusted for shots at goal and corners.
[b]Ratio of away to home means (exponentiated regression coefficient).

on yellow cards was statistically significant ($p = 0.007$), although after controlling for crowd density the difference in home team bias between leagues was no longer evident ($p > 0.2$).

Crowd size, density and proximity

In both leagues, the effect of crowd size on the association between match location and yellow cards received was best explained with a logarithmic transformation of crowd size. For crowd density, however, a natural linear term provided the best fit in both leagues. There was little evidence ($p > 0.1$) of heterogeneity between leagues in the effect of crowd size, density or proximity on home advantage and, therefore, both leagues were combined for this part of the analysis.

Table IV shows results of the regression analysis of match location and crowd factors on yellow cards issued by referees in the UEFA leagues. Home team bias increased significantly ($p < 0.001$) with increasing crowd density and this effect did not change appreciably after adjusting for crowd size and proximity (although the SE for crowd size and density were noticeably inflated, suggesting co-linearity). Although home team bias appeared to increase logarithmically with increasing crowd size ($p = 0.05$) and decrease in stadiums with a running track ($p = 0.07$), these effects were no longer evident after adjusting for crowd density. Exponentiating the regression coefficient for crowd density in the model excluding the other crowd factors gives a 4.1% (SE = 1.0%) increase in home team bias for each 0.1 increase in crowd density. Based on this model, referee bias (away/home mean ratio) was 0.94 (SE = 0.05) at 5% stadium capacity, 1.13 (SE = 0.03) at 50% capacity and 1.35 (SE = 0.06) at 95% capacity.

Discussion

The aims of this study were to determine the overall level of home advantage in the UEFA leagues, to quantify the magnitude of referee bias in terms of disciplinary sanctions used after controlling for within-match attacking dominance and to investigate how crowd factors may influence the level of home team bias.

Home advantage in terms of competition points gained in the group stage of competition was 57.8% in the Champions League and 59.2% in the Europa League. These figures are a lower than those reported for top division European domestic leagues including the English Premier League (61.0%; Seckin & Pollard, 2008), Spanish *Primera Division* (62.1%; Sanchez, Garcia-Calvo, Leo, Pollard, & Gomez, 2009) and Turkish *Süper Lig* (61.5%; Seckin & Pollard, 2008).

After adjusting for within-match attacking dominance referees in the Champions League issued

Table IV. Results of regression analysis of match location and crowd factors on yellow cards issued by referees in 1372 UEFA league matches (SE in brackets)

	Adjusted for other crowd factors in table?					
	No[b]			Yes[c]		
Regression parameter[a]	Coefficient	*z*-score	*p*-value	Coefficient	*z*-score	*p*-value
Crowd size	0.0420 (0.0218)	1.93	0.054	−0.0145 (0.0264)	−0.55	0.582
Crowd density	0.0403 (0.0098)	4.11	<0.001	0.0428 (0.0120)	3.55	<0.001
Track	−0.0959 (0.0520)	−1.85	0.065	−0.0690 (0.0522)	−1.32	0.187

[a]Interaction terms between match location (0 = Home, 1 = Away) and log transformation of crowd size, crowd density in units of 0.1 and running track (0 = No, 1 = Yes).
[b]Log-link Poisson regression models adjusted for shots at goal, corners, team ability, league, season and stage of competition.
[c]Log-link Poisson regression model adjusted for shots at goal, corners, team ability, league, season, stage of competition and other crowd factors in table.

25% more yellow cards against away teams than against home teams, adding support to previous studies (Boyko et al., 2007; Buraimo et al., 2010; Dawson et al., 2007) that found significant levels of home team bias in terms of disciplinary sanctions issued by referees after controlling for variables likely to influence within-match performance. Home team bias was considerably lower in the Europa League, with away teams receiving only 10% more yellow cards than home teams. However, the difference in the magnitude of referee bias between the two UEFA leagues appeared to be mainly due to higher crowd densities in the Champion League.

Controlling for attacking dominance noticeably attenuated the effect estimates in this study. Home team bias (away/home mean ratio) for yellow cards decreased from 1.34 to 1.25 in the Champions League and from 1.17 to 1.10 in the Europa league after adding shots at goal and corners to the models. This suggests that within-match measures of attacking dominance need to be controlled for when investigating referee bias in terms of the number of disciplinary sanctions used. It should be noted, however, that the association between attacking dominance and referee sanctions may be bi-directional. That is, as well as influencing the number of sanctions received, attacking dominance may also be influenced by it. Such bi-directionality may have biased the effect estimates in this study towards the null and, therefore, contributed to some of the observed reduction in the estimate of home team bias.

In the combined analysis of both UEFA leagues, there was a strong positive association between home team bias and crowd density; when stadiums were at less than 25% capacity there was no evidence of referee bias, but as density increased so did home team bias with away teams receiving 13% more yellow cards than home teams at half capacity and 35% more at near full capacity. Crowd size and proximity appeared to have no effect on home team bias after controlling for crowd density. These results support those of previous studies which observed positive correlations between the magnitude of referee bias and crowd density (Boyko et al., 2007; Dawson & Dobson, 2010; Garicano et al., 2005). As crowds at UEFA league matches are composed almost entirely of home team supporters these results strongly suggest that crowd support influences referee decisions.

A measure of attacking dominance that this study did not control for was 'time in possession' as it was available for only about 20% of matches. When the analyses were re-run on this subset, adding this covariate to the models had negligible influence on the effect estimates (data not shown), and it is, therefore, unlikely that its omission from the main analysis left any residual confounding. No data were available for the number of tackles made by each team – a factor which may be related to the number of referee sanctions issued – but this has been shown to not vary between home and away teams (Carmichael & Thomas, 2005) and is, therefore, unlikely to be a potential confounder.

A disciplinary sanction used by referees that this study did not investigate was red cards (dismissals). Although data were available for the total number of red cards issued to each team, no distinction was made between 'automatic' red cards and those resulting from a player receiving a second yellow card. As only the automatic red cards would have been of interest, the analysis was restricted to yellow cards only.

A possible alternative explanation for the results of this study is that away teams act more aggressively in response to hostile home crowds (Pollard, 2006b) and, therefore, deserve to be sanctioned more than home teams. This study was not able to explore this hypothesis as it would require objective assessment of individual referee decisions. Studies that have made such an assessment (Dohmen, 2008; Nevill et al., 1999, 2002) show that referees are indeed stricter with the away team, and, therefore, the tendency for away teams to receive more disciplinary sanctions than home teams appears to be at least in part due to referee bias.

Conclusion

This study adds to the growing body of evidence suggesting that football referees show bias towards the home team when making decisions which may affect the outcome of matches and that crowd influence is a likely cause of this bias. In particular, this study found that it is crowd density as opposed to crowd size or proximity that is important in influencing referee decisions. Failure to control for within-match team performance may over-estimate the extent of referee bias in terms of the number of disciplinary sanctions used.

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