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Investigating the influence of fans on home advantage outcomes in association football across Europe

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ABSTRACT

Fan support has long been stated as one of the major contributors to the home advantage which football teams enjoy across Europe; whereby fans motivate the home team to increase performance levels, and in some cases, inadvertently cause referees to subconsciously make decisions in favour of the home team. With the naturally created experimental design by the COVID-19 pandemic, the unique opportunity arose to analyse the influence of fans on these home advantage outcomes. Mixed-effects models were used while controlling for available confounds. It was observed that home teams won fewer points and were less dominant without the support of their fans; while referees called more fouls against, and produced more yellow cards for home teams without fans present. However, these decisions were dependent on team dominance in a match. The findings reinforced social theories and also provided greater insights into the home advantage phenomenon.

Introduction

The phenomenon of home advantage in sport has been widely recognized over the years.¹ Home advantage has been identified as the tendency for sporting teams to perform better at their home ground than away from home.² Schwartz and Barsky provided the first empirical evidence of home advantage, in which extensive data collection for home and away results in baseball, American football, hockey, and basketball revealed pronounced home advantages for each sport, while Morris provided the first report of home advantage in association football.³ Pollard would later update this research, with the common way of quantifying home advantage given to be the number of points won or goals scored at home expressed as a percentage of the total number of points won or goals scored both home and away.⁴

Schwartz and Barsky initially hypothesized home advantage as a social phenomenon and the discussion by Gelade later supported this claim.⁵ Psychologists and social scientists have long studied the effects of how crowds affect performance. It was suggested that supportive crowds are social representations of their teams, and by displaying a motivational influence, the home team was encouraged to perform better. The literature provides evidence that home advantage was strongest in association football and spectators were a major factor for the home advantage.

The few studies on matches played without fans behind closed doors commonly reported very small samples and thus were filled with uncertainty. The COVID-19 pandemic brought restrictions

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on mass gatherings at sporting events with what became rising public health concerns at that time.⁶ Countries across the world prevented fans from attending live matches. Inadvertently, these conditions created a natural experiment which permitted investigating home advantage in European football with and without fans' influence.⁷ Therefore, this research sought to investigate how the absence of an audience affected the home advantage typically found in football across European domestic leagues based on team performance and refereeing decisions.

Social influence theories

Social influence observes the change in an individual's behaviours as a result of actual or envisaged external pressure. Norman Triplett observed that cyclists recorded faster times when competing with other persons than when practicing on their own, while Pessin, and later, Bond and Titus, found that students performed worse when given arbitrary memory tasks and were under observation.⁸ The variations in performance were attributed to the individual's ambition and strive for satisfaction due to social influence.

In 1965, Robert Zajonc theorized the social facilitation effect, where performing a task in front of a crowd increased an individual's energy to complete the activity.⁹ It leads to an increased probability of reactions being performed because of the expectation attached and the concern of being evaluated by others. Cottrell et al. provided another mechanism for crowd's effect on performers, in which they postulated that an audience was drive-enhancing if the performers believed that the crowd was evaluating their performance.¹⁰ Performance is enhanced or impaired in the presence of individuals who can judge their actions. Furthermore, Emile Durkheim's theory of social community suggested social unity as the cohesive network of relationships among individuals sharing common objectives.¹¹ The theory implies that a supportive community encourages an individual to perform well.

Home advantage in association football

In general, there has been a wide spectrum consisting of five overarching dimensions for home advantage in football, including psychological factors, location, refereeing bias, fan presence and physical aspects.¹² Of these, fan support has been the most dominant and influential contributors to home advantage.¹³

Although home advantage tends to be the major factor in determining the ultimate outcome in many sports, it tends to have a greater impact in association football, particularly European football.¹⁴ Complex in nature, it has been portrayed since the late nineteenth century; firstly, in English football, and has remained a significant phenomenon. The concept in football was represented by the consistency with which teams won more than 50% of their matches at home, provided that the same number of home and away matches are played, and the same opponents were faced.¹⁵ Pollard stated that home advantage in football could be quantified as an average of 0.60 goals more for home teams, while van Ours found a home advantage of 0.33 points and 0.42 goals per match.¹⁶

The role of fans in home advantage

Football fans have been commonly referred to as the '12th man', and constitute a significant part of the sport as they form the basis of the atmosphere in stadia.¹⁷ Regardless of the underlying theory, the argument remained roughly the same, that is, the crowd enhanced the drive of the players, thus improving their performance.

A key limitation to early studies, and one that has been frequently noted by authors is that home advantage could very rarely be investigated without fans present; while fan influence and crowd presence have always been cited as the main contributors to home advantage in football.¹⁸ Almost all sporting competitions welcomed fans, prior to 2020, there was almost no research investigating

crowd-free matches in football across Europe. Studies have shown the home advantage effect in major European football leagues and suggested that the primary relationship was the link between fans' support and how it changes between home and away matches.¹⁹

From the scientific and social perspectives, fans have been viewed as a determinant of sporting success, as well as economic success.²⁰ As such, football has greatly benefitted from fan presence in stadia on match days. These benefits tend to be accompanied by costs, however, emphasis has been placed on the positive contribution of football fans in this research; with home advantage being heavily attributed to the influence of fans during matches.

Several social and psychological factors involving fans have since been established as being critical to home advantage. These included fan proximity to the field, constant, loud and inspiring sounds from the crowd, by which enthusiastic cheers would propel entertaining play and provide encouragement to home players for favourable match outcomes. From early on, it was found that a positive correlation existed between fan presence and home advantage; an advantage that could get as high as 12% over an opponent.²¹ In addition to this, it was observed that crowd noises made referees more uncertain in their decision-making, awarding up to 15.5% fewer fouls against the home team.²² Petterson-Lidbom and Priks and van de Ven analysed a small sample of matches in Italy and observed that refereeing decisions appeared to be sensitive to the lack of fans.²³ Other authors found that the home advantage effect appeared to increase with crowd sizes up to 20,000 spectators.²⁴ CIES Football Observatory examined 63 leagues worldwide between April and August 2020, and observed that without fans present, home win percentage in the majority of the leagues was reduced by an average of 2.1%.²⁵ McCarrick et al. analysed games across European leagues and found that without fans present, the points per game collected by home teams were almost halved.²⁶

Even in earlier studies, it was suggested and identified that the frequencies of penalties and sending-offs in football matches favoured the home teams.²⁷ This was attributed to the pressure placed on referees by the home support, and also their influence on the away players to behave more recklessly. Social psychology posited that human beings tend to adapt to the opinion of the majority since persons unconsciously gravitate towards a group's interpretation of an ambiguous situation.²⁸ Nevill et al. found that referees were influenced by crowd noises towards the home team out of fear as the hostile environment could cause these referees to make the decisions in favour of the home team to avoid adverse reactions.²⁹ Dosseville et al. presented that referees opted to make more decisions in favour of home teams, and were highly susceptible to social influence as these officials unknowingly relied on cues from the crowd when making some of their decisions; including, but not limited to, adding extra stoppage time at the end of the halves, particularly if the home team was a goal behind, and making more decisions against the away team.³⁰ These biases were commonly observed in three of the top five European football leagues, namely the Premier League in England, Bundesliga in Germany and Serie A in Italy.

The COVID-19 pandemic brought restrictions on mass gatherings at sporting events with what became rising public health concerns at that time.³¹ Countries across the world prevented fans from attending live matches. Inadvertently, these conditions created a natural experiment which permitted investigating home advantage in European football with and without fans' influence.³² Germany was one of the first countries in Europe to place restrictive measures on mass public gatherings at football matches. Initial observations revealed mixed evidence for fans' influence on home advantage. The authors reported that home advantage was significantly reduced in matches being played without fans present, with refereeing decisions on fouls and cards were less favourably for home teams, as was also observed in an earlier study.³³ Others argued that this phenomenon might be league-dependent and might only be present in German football.³⁴

As restrictions on public gatherings spread throughout Europe, studies utilized these conditions to present empirical evidence of home advantage across the continent. Bryson et al. and Endrich and Gesche also reported large-sized effects for the absence of fans on refereeing decisions, in which fewer cards were awarded to away teams, and subtle differences emerging when team performance

was considered.³⁵ Reade et al. reported reductions in the percentage of home wins by 2.6% without fans. Scoppa and Ferraresi and Gucciardi also presented cross-league evidence of reduced home advantage in terms of points won and goals scored by home teams.³⁶ However, Almeida and Leite, Wunderlich, and Ramchandani and Millar did not report major changes in home advantage outcomes.³⁷ Analyses over the years were consistent regarding fans' influence in home advantage regarding refereeing decisions, however, results fluctuated when team performance was considered, and the extent of this home advantage was dependent on whether any additional factors were considered.

Significant additional factors that were likely to influence the relationship between the lack of fans' influence and home advantage were not considered in previous studies.³⁸ Schwartz and Barsky, and Carmichael and Thomas alluded that a team's playing style would influence the chance of scoring goals and winning football matches.³⁹ Shots, shots on target, penalties, possession, corner kicks and free kicks were all considered to be direct and indirect determinants of a team's dominance in a match.⁴⁰ An understanding of the home team's strength relative to the opposition and league position, and the difficulty of fixtures were also considered to be confounds which could play significant roles when observing fans' influence in home advantage.⁴¹ Some of which have not been directly explored in existing literature.

Research hypothesis

The literature suggested the evidence that the outcomes of a match were dependent on fans. Therefore, how much of the home advantage can be attributed to the influence of the home team's fans? The unique situation of the COVID-19 pandemic created an unusual scenario for both players and fans, making it highly intriguing for analysis. Part of the difficulty in analysing the specifics of home advantage has been due to the lack of controlled experiments. Following its suspension due to the COVID-19 pandemic, the 2019–2020 football season across Europe resumed with approximately the final quarter of the campaign being played without fans present. This naturally created experimental design in stadia provided a unique opportunity whereby differences in home advantage in terms of team performance and refereeing decisions could be observed with and without the influence of fans. All games from European leagues completing their respective seasons following COVID-19 restrictions were analysed to investigate fans' influence on home advantage. Based on previous and current studies, this research hypothesized that lack of fans in stadia was an inverse example of the social facilitation effect, that is, the lack of fans' influence negatively affected players but was more pronounced for the home team. Therefore, home advantage would be reduced without the direct influence of fans, that is, home teams will score fewer goals, collect fewer points and receive less favourable refereeing decisions in those matches played without fans present. It contributes to the literature on home advantage by applying mixed-effects models to football data.

Methodology

Data description

Using the naturally created experimental design, data from the 2019/20 European league campaigns were considered for analysis. A sample of $n = 3997$ games were extracted from 11 leagues across 7 countries: English Premier League and Championship, German Bundesliga 1 and 2, Greek Super League, Italian Serie A and B, Portuguese Primeira Liga, Spanish La Liga 1 and 2, and Turkish Super Lig. Austrian Bundesliga, Danish Superligaen, Russian Premier League and Swiss Super League were not included in the study due to a lack of data on refereeing decisions, while the French Ligue 1 and 2, Belgium Jupiler Pro League, Dutch Eredivisie and Scottish Premiership chose to abort their

seasons. A total of 2955 matches (73.9%) were played with fans present, while 1042 matches (26.1%) took place without fans in stadia.

Data on the number of goals scored, points won, fouls, yellow and red cards were extracted for each game. These variables were supplemented with latent variables such as dominance which was based on attacking tendencies of teams, team strengths based on the Soccer Power Index (SPI) and the importance of the match for each team relative to their league positions throughout the season. Only matches spanning the regular league campaign were included in the dataset, that is, matches which were played over two legs or involved extra time were excluded. Data relating to match outcomes were extracted from Transfermarkt (<https://www.transfermarkt.com/>), while the additional variables were taken from FiveThirtyEight (<https://projects.fivethirtyeight.com/soccer-predictions/>).

Analysis

Home advantage outcomes

Home advantage outcomes were measured from two perspectives: team performance using goals scored, points won and dominance; and refereeing decisions using fouls, yellow and red cards. In this context, approximately three-quarter of the season, which was played with fans was compared with the final quarter of matches without fans.

Mixed-effects models

A natural hierarchical structure existed within the data as games were nested within each team.⁴² Individual teams are also nested within leagues, which are then nested with countries. Mixed-effects modelling, also referred to as hierarchical modelling or multilevel modelling, facilitated the structure of the data, and also allowed for the inclusion of potential confounds into the analysis.⁴³ Instead of evaluating home advantage by the widely used percentage ratio of home points gained, we investigated home advantage outcomes and their potential factors (particularly the influence of fans) using mixed-effects modelling.

Meaningful patterns were not observed when leagues and countries were included in our mixed-effects models possibly due to the sparse data for individual league matches without fans. Therefore, teams were subsequently used as single units in the mixed-effects modelling, and given the homogenous nature and operating conditions of the leagues across Europe, that is, footballers functioning under similar rules, data were analysed collectively to detect our underlying mechanisms. However, descriptive statistics for home advantage outcomes in the individual leagues were provided in [Tables 1 and 2](#) along with the results of z-tests for proportions of home wins, independent samples t-tests for match dominance and fouls, and Mann-Whitney U tests for goals scored, points won, number of yellow and red cards.

In our experimental design, the focus lies in the influence of fans on home advantage. Therefore, we were interested in the location of the match for each team, that is, home or away, and whether or not fans were present in the stadia. Each match was coded twice, that is, from the perspective of the home team and the away team. This was taken into account by the hierarchical structure of the multilevel models. Particularly important would be the interaction between these two factors. If the influence of fans affected home advantage outcomes, teams would be expected to score fewer goals, win fewer points and receive less favourable refereeing decisions when playing at home without fans present.

To control for differences in the fixtures and significance of the matches, variables relating to team strength and match importance for each team were included. The SPI attempted to account for the randomness present in football by being updated after each game using actual (previous results, market values of players, goals scored) and expected (expected goals) outcomes when measuring team strengths, while the match importance was based on the significance of the match relative to the team's season (challenging for the league title, European

Table 1. Descriptive statistics for home advantage outcomes relating to team performance across Europe with and without the influence of fans.

League	With fans				Without fans				p-values
	No. of games (%)	Home win %	Avg. points at home	Avg. goals at home	No. of games (%)	Home win %	Avg. points at home	Avg. goals at home	
English Premier League	288 (75.8)	44.8	1.59	1.51	92 (24.2)	46.7	1.62	1.54	0.375 ^a 0.922 ^b 0.738 ^c
English Championship	444 (80.4)	42.6	1.55	1.43	108 (19.6)	38.0	1.38	1.34	0.192 ^a 0.170 ^b 0.164 ^c
German Bundesliga 1	223 (72.9)	43.0	1.51	1.74	83 (27.1)	32.5	1.20	1.42	0.047 ^a 0.076 ^b 0.032 ^c
German Bundesliga 2	223 (72.6)	41.7	1.57	1.56	84 (27.4)	41.7	1.58	1.65	0.500 ^a 0.876 ^b 0.612 ^c
Greek Super League	182 (75.8)	48.4	1.71	1.51	58 (24.2)	32.8	1.36	1.16	0.019 ^a 0.091 ^b 0.063 ^c
Italian Serie A	256 (67.4)	40.2	1.43	1.54	124 (32.6)	44.4	1.55	1.79	0.218 ^a 0.443 ^b 0.038 ^c
Italian Serie B	279 (73.4)	45.9	1.65	1.42	101 (26.6)	41.6	1.51	1.36	0.230 ^a 0.377 ^b 0.695 ^c
Portuguese Primeira Liga	216 (70.6)	39.8	1.45	1.28	90 (29.4)	44.4	1.59	1.50	0.227 ^a 0.409 ^b 0.133 ^c
Spanish La Liga 1	270 (71.1)	47.8	1.71	1.51	110 (28.9)	40.9	1.50	1.26	0.111 ^a 0.137 ^b 0.064 ^c
Spanish La Liga 2	340 (73.8)	39.4	1.54	1.28	121 (26.2)	43.8	1.62	1.26	0.198 ^a 0.677 ^b 0.887 ^c
Turkish Super Lig	234 (76.5)	43.2	1.57	1.61	72 (23.5)	45.8	1.61	1.63	0.348 ^a 0.886 ^b 0.338 ^c
Overall	2955 (73.9)	43.2	1.57	1.48	1042 (26.1)	41.5	1.51	1.45	0.171 ^a 0.155 ^b 0.435 ^c

^aProportion of home wins.^bPoints won.^cGoals scored.

qualification, avoiding relegation). The team strength and match importance variables were based on scores which facilitated cross-league comparisons. The difference between team strengths and also match importance were calculated for each match and standardized for interpretability before including in the models for home advantage outcomes.⁴⁴ Interactions of these variables with the location of the match and whether or not fans were present were also considered, as significant findings would indicate disparities in fixture difficulties for matches played with and without fans.

The variables included in the mixed-effects models were: match location (home/away), fans present (yes/no), standardized differences between team strengths, standardized differences between match importance, and their interactions. Higher order interactions (between three and four variables), and the second-order interaction between having fans present, match importance and team strengths were not found to be statistically significant in preliminary analyses, and were not included in the final models. The final model comprised a set of *i* observations (matches) at level 1 nested within *j* participants (teams) at level 2, giving a two-level model.

Table 2. Descriptive statistics for home advantage outcomes relating to refereeing decisions across Europe with and without the influence of fans.

League	With fans				Without fans				p-values
	No. of games (%)	Avg. fouls at home	Avg. yellow cards at home	Avg. red cards at home	No. of games (%)	Avg. fouls at home	Avg. yellow cards at home	Avg. red cards at home	
English Premier League	288 (75.8)	10.28	1.63	0.06	92 (24.2)	11.13	1.46	0.05	0.023 ^d 0.488 ^e 0.586 ^f
English Championship	444 (80.4)	11.55	1.48	0.04	108 (19.6)	12.76	1.35	0.6	<0.001 ^d 0.405 ^e 0.333 ^f
German Bundesliga 1	223 (72.9)	11.01	1.8	0.05	83 (27.1)	12.75	2.12	0.10	<0.001 ^d 0.122 ^e 0.181 ^f
German Bundesliga 2	223 (72.6)	12.02	1.87	0.12	84 (27.4)	13.67	2.26	0.05	0.001 ^d 0.023 ^e 0.085 ^f
Greek Super League	182 (75.8)	15.85	2.48	0.10	58 (24.2)	16.24	2.57	0.16	0.261 ^d 0.776 ^e 0.239 ^f
Italian Serie A	256 (67.4)	13.78	2.56	0.13	124 (32.6)	13.62	2.18	0.10	0.356 ^d 0.018 ^e 0.525 ^f
Italian Serie B	279 (73.4)	15.45	2.48	0.16	101 (26.6)	15.47	2.48	0.19	0.489 ^d 0.764 ^e 0.909 ^f
Portuguese Primeira Liga	216 (70.6)	15.66	2.42	0.11	90 (29.4)	17.20	2.69	0.20	0.002 ^d 0.131 ^e 0.199 ^f
Spanish La Liga 1	270 (71.1)	13.66	2.57	0.09	110 (28.9)	13.68	2.48	0.12	0.478 ^d 0.717 ^e 0.401 ^f
Spanish La Liga 2	340 (73.8)	15.74	2.61	0.14	121 (26.2)	15.59	2.73	0.15	0.460 ^d 0.271 ^e 0.707 ^f
Turkish Super Lig	234 (76.5)	13.74	2.38	0.15	72 (23.5)	13.43	2.38	0.14	0.270 ^d 0.722 ^e 0.802 ^f
Overall	2955 (73.9)	13.40	2.17	0.10	1042 (26.1)	14.11	2.24	0.12	<0.001 ^d 0.121 ^e 0.303 ^f

^aFouls called.
^bYellow cards.
^cRed cards.

Home advantage outcomes relating to goals scored and points won were discrete occurrences, therefore, mixed-effects modelling using the Poisson distribution were implemented.⁴⁵ A mixed-effects model using the normal distribution was considered for the latent dominance variable. For home advantage outcomes relating to refereeing decisions, further mixed-effects models using the Poisson distribution were considered for the number of yellow and red cards, while we applied a model using the normal distribution for fouls. Since a team’s dominance in a match tends to influence refereeing decisions, our dominance variable was included as a confound in these models for refereeing decisions.

For models using the Poisson distribution, exponentiated coefficients, that is, incident rate ratios (IRR) were presented, while for models using the normal distribution, raw coefficient estimates were used, along with 95% confidence intervals (CI) and standard errors. Tables 3-8 present parsimonious mixed-effects models for the home advantage outcomes considered. The models and analyses were conducted using the following packages in

Table 3. Mixed-effects models for home advantage relating to points won in matches across Europe.

Predictor	IRR	95% CI	Std. error	p-value
Fixed effects				
Intercept	1.11	1.07–1.14	0.02	<0.001
Home match	1.38	1.32–1.45	0.02	<0.001
Fans absent	1.05	0.99–1.12	0.03	0.129
Team strength	1.40	1.35–1.44	0.02	<0.001
Match importance	1.05	1.03–1.08	0.01	<0.001
Home match * Fans absent	0.91	0.84–0.99	0.04	0.032
Home match * Team strength	0.93	0.90–0.97	0.02	<0.001
Team strength * Match importance	0.97	0.95–0.98	0.01	<0.001
Random effects				
σ^2	0.56			
τ_{00Team}	0.00			

Table 4. Mixed-effects models for home advantage relating to goals scored in matches across Europe.

Predictor	IRR	95% CI	Std. error	p-value
Fixed effects				
Intercept	1.14	1.10–1.19	0.02	<0.001
Home match	1.25	1.19–1.30	0.02	<0.001
Fans absent	1.05	0.99–1.12	0.03	0.122
Team strength	1.24	1.21–1.27	0.01	<0.001
Match importance	1.03	1.01–1.06	0.01	0.002
Home match * Fans absent	0.93	0.86–1.02	0.04	0.118
Random effects				
σ^2	0.57			
τ_{00Team}	0.01			

Table 5. Mixed-effects models for home advantage relating to team dominance in matches across Europe.

Predictor	β	95% CI	Std. error	p-value
Fixed effects				
Intercept	-0.24	-0.28 - -0.20	0.02	<0.001
Home match	0.52	0.48–0.57	0.02	<0.001
Fans absent	0.06	-0.00–0.12	0.03	0.063
Team strength	0.33	0.30–0.36	0.02	<0.001
Match importance	0.04	0.01–0.06	0.01	0.001
Home match * Fans absent	-0.33	-0.42 - -0.24	0.04	<0.001
Home match * Team strength	0.06	0.02–0.10	0.02	0.004
Team strength * Match importance	0.02	0.00–0.04	0.01	0.018
Random effects				
σ^2	0.77			
τ_{00Team}	0.03			

Table 6. Mixed-effects models for home advantage outcomes relating to fouls called by referees across Europe.

Predictor	β	95% CI	Std. error	p-value
Fixed effects				
Intercept	13.96	13.63–14.28	0.17	<0.001
Home match	-0.35	-0.55 - -0.15	0.10	0.001
Fans absent	-0.22	-0.49–0.05	0.14	0.110
Team strength	0.50	0.35–0.65	0.08	<0.001
Match importance	-0.08	-0.18–0.03	0.05	0.147
Team dominance	-0.34	-0.44 - -0.25	0.05	<0.001
Home match * Fans absent	0.70	0.32–1.09	0.20	<0.001
Home match * Team strength	-0.28	-0.45 - -0.11	0.09	0.001
Team strength * Match importance	-0.15	-0.23 - -0.08	0.04	<0.001
Random effects				
σ^2	14.61			
τ_{00Team}	4.70			

Table 7. Mixed-effects models for home advantage outcomes relating to yellow cards called by referees across Europe.

Predictor	IRR	95% CI	Std. error	p-value
Fixed effects				
Intercept	2.45	2.36–2.54	0.02	<0.001
Home match	0.88	0.85–0.91	0.02	<0.001
Fans absent	0.83	0.79–0.87	0.02	<0.001
Team strength	1.01	0.98–1.03	0.01	0.521
Team dominance	0.95	0.94–0.97	0.01	<0.001
Home match * Fans absent	1.21	1.13–1.29	0.03	<0.001
Home match * Team strength	0.94	0.91–0.96	0.01	<0.001
Random effects				
σ^2	0.37			
τ_{00Team}	0.04			

Table 8. Mixed-effects models for home advantage outcomes relating to red cards called by referees across Europe.

Predictor	IRR	95% CI	Std. error	p-value
Fixed effects				
Intercept	0.12	0.11–0.13	0.06	<0.001
Home match	0.86	0.74–1.00	0.08	0.047
Fans absent	0.82	0.66–1.00	0.10	0.052
Team dominance	0.75	0.69–0.80	0.04	<0.001
Home match * Fans absent	1.30	0.97–1.75	0.15	0.077
Random effects				
σ^2	2.29			
τ_{00Team}	0.11			

R: lme4 for multilevel models, sjstats for extracting fit statistics, sjPlot, and dplyr for some data manipulation.⁴⁶ P-values <0.05 were considered statistically significant.

Results

Match outcomes

Statistically significant differences were not observed in the proportions of home wins ($p = 0.171$), points won ($p = 0.155$), and the number of goals scored ($p = 0.435$) at home with and without fans present in stadia. However, clear conclusions on home advantage outcomes based on team performance from these preliminary tests would be premature since a number of factors were not yet simultaneously considered along with the influence of fans.

Our mixed-effects models indicated that the interaction effect of playing at home and not having fans present was significant ($p = 0.032$). Though the size of the effect was small, in the model for points won, the playing at home and not having fans present resulted in fewer points per game (IRR = 0.91, 95% CI: 0.84–0.99), compared to the same home teams with their fans present, while controlling for the effects of team strength and match importance. The difference in team strength while playing at home was also found to be significantly associated with points won ($p < 0.001$). Fewer points were won at home as the difference in team strengths increased in favour of the away team (IRR = 0.93, 95% CI = 0.90–0.97). This was not dependent on fans being present in stadia.

When goals scored were considered as the home advantage outcome in a mixed-effects model, the interaction effect of playing at home without fans was not found to significantly influence the number of goals scored ($p = 0.118$), while controlling for the effects of team strength and match importance. However, team strength (IRR = 1.24, 95% CI: 1.21–1.27, $p < 0.001$) and match importance (IRR = 1.03, 95% CI: 1.01–1.06, $p = 0.002$) on their own were found to be significantly

associated with goals scored in a match, though the size of the effect relating to match importance was relatively small.

Our mixed-effects model also revealed that playing matches at home without fans present significantly negatively affected the team's dominance in a match ($p < 0.001$), while considering team strength and match importance. The home team's dominance was reduced by $\beta = -0.33$ (95% CI: $-0.42 - -0.24$) without their fans' influence. Sizeable variability between teams was not observed when random effects were examined for team performance outcomes.

Referee behaviour

Statistically significantly more fouls called by referees against the home team ($p < 0.001$) were observed without fans present in stadia. No significant differences were observed for the number of yellow ($p = 0.121$) and red ($p = 0.303$) cards given by referees. However, clear conclusions on home advantage outcomes based on refereeing decisions from these tests would also be premature since once again, a number of factors were not yet simultaneously considered with the influence of fans. Mixed-effects models for home advantage based on refereeing decisions saw significant interaction effects from playing at home without fans when considering yellow cards given by referees ($p < 0.001$) and fouls called ($p < 0.001$), while controlling for team strength, match importance and also team dominance in the match. Home teams playing without their fans received more yellow cards when compared to the same home teams playing with a crowd in the stadia (IRR = 1.21, 95% CI: 1.13–1.29), while home teams had more fouls called against them when playing without their fans ($\beta = 0.70$, 95% CI: 0.32–1.09). The number of red cards produced by referees were not influenced by home teams having fans present in the stadia. However, it was observed that refereeing decisions were influenced by a team's dominance in a match ($p < 0.001$). Some variability between teams was observed when random effects were examined for fouls called, however this was not evident for other refereeing decision outcomes.

Discussion

Influence of fans on home advantage outcomes

The natural experimental design created across football leagues in Europe by the COVID-19 pandemic provided the opportunity to explore factors, particularly the influence of fans, on the home advantage phenomenon. This research explored the influence of fans on home advantage outcomes in football from two perspectives, that is, based on team performance and refereeing decisions by observing three-quarter of the regular season with fans present in stadia and the final quarter without fans. This was done using mixed-effects models, while controlling for factors such as team strengths, match importance and team dominance (when observing refereeing decisions). Overall, having no fans present adversely affected some aspects of a team's home advantage. Teams appeared to win fewer points and be less dominant when playing at home without fans, while referees produced more yellow cards and called more fouls against the home team without their fans in the stadia. However, the absence of fans' influence did not affect the number of goals scored nor the number of red cards produced by the referee.

Some of the earlier studies by Nevill et al. suggested that home teams benefitted from having fans present.⁴⁷ Even recent studies by Martins et al., Scoppa and Cueva shared this conclusion.⁴⁸ However, the prominence of this home advantage varied across studies focusing on football, depending on the additional factors and data that were considered.

With the conditions created by the pandemic, authors such that Wunderlich, Sanchez, Benz, Matos and Almeida found that there were no significant differences in the match results with or

without a crowd present.⁴⁹ Some suggested that home advantage might be league-dependent and also based on the statistical methodology used and factors considered when examining these effects.⁵⁰

On the other hand, using these experimental conditions, Hill and van Yperen, Correia-Oliveira, Tilp and Cross presented that home advantage outcomes including points, goals and shots on target were dependent on fans' influence as these measures were significantly reduced for home teams without their fans during the period without fans present in the stadia.⁵¹ The findings of our research supported the general view that the lack of fans decreased the chances of the home team receiving favourable outcomes during a match. Points won and team dominance were reduced for home teams when playing in stadia without their fans, with team strength and match importance included as confounders. This also supported the claims of Hill and van Yperen and Correia-Oliveira.⁵²

From a social theoretical perspective, spectators in football exert significant influences to support players during their performances through visual characteristics and auditory functions. Our findings were consistent with Durkheim's theory of social coherence. Supportive crowds are social representatives of their teams and provide a motivational influence for the home side to perform well. Therefore, the absence of fans adversely impacted home teams as without their fans' influence, home teams appeared to no longer benefit from the motivation which the crowd offered, resulting in dwindling match outcomes for home teams. Our data also emphasized Zajonc's conceptualization of social facilitation and Cottrell et al.'s belief that an audience was drive-enhancing.⁵³ Therefore, home advantage can be considered as a situational condition that is cognitively evaluated by players. Without the presence of fans to evaluate the players, there was a lack of willingness to respond to the actions of the opposition, with the source and goals of social influence no longer operationalized to facilitate the supportive and emotional ties between the players and the crowd.

Our findings also extended previous literature that fans biased refereeing decisions. It was important that team dominance was accounted for when applying mixed-effects modelling to refereeing decisions. These decisions could be consequences of the attacking tendencies of teams as more passive teams tend to commit more fouls and receive more cards from referees. We observed that a team's dominance in a home match was reduced without the influence of their fans. Therefore, introducing this factor into our models for refereeing decisions was necessary before assessing how these decisions were affected by the lack of fan support for the home team.

Bryson et al. demonstrated that referees produced significantly fewer yellow cards against away teams in matches played without home fans, while Sors found large significant effects on the number of yellow cards without the influence of fans, implying to the authors that reduced social pressure contributed to more neutral decisions by referees.⁵⁴

Our research further supported this notion that home advantage by means of refereeing decisions were affected by fans' influence, but revealed that these decisions were also sensitive to the match situation. It was noted that while home teams received fewer decisions in terms of fouls and were given more yellow cards without fans present, these decisions were also consequences of a team's dominance in the match. It was suspected that some teams tend to be more defensive and as a result, tend to commit more fouls and receive more cards. Therefore, referees may sometimes be subconsciously influenced by the reaction of the crowd, especially in ambiguous situations. The subsequent decisions would then favour the home team. Their behaviour also seems to be reactive to the match situation. This supported the hypothesis of Pollard who believed that match context played a more profound role in the relationship between home advantage and fans' influence on refereeing decisions.⁵⁵ Although these findings supported that referees were implicated in home advantage, it is also important to understand the objectivity in their decisions by observing whether the decisions were considered correct by governing football bodies in future studies.

For earlier studies by Dosseville et al., Dohmen and Boyko et al., and even more recent research by Reade et al., Scoppa, Bryson et al., Cueva and Endrich and Gesche which used match outcome data with and without fans, large effects were reported for yellow cards, while there were smaller effects regarding red cards.⁵⁶ Our research did not observe

a significant effect on the number of red cards given by referees when teams played at home without fans. However, previous authors did not consider a team's attacking tendency or propensity to defend in their analyses.

With the natural experimental design created by the COVID-19 pandemic, matches considered in the final quarter were expected to carry greater importance in the context of the league campaign, that is, challenging to win the league, qualification for European competitions or avoiding relegation. Examining random effects suggested that the majority of the variability in home advantage outcomes lies within teams and between matches after controlling for factors such as team strength and match importance. Based on these mixed-effects models, it was observed that home advantage outcomes were not significantly affected by the interaction of team strengths and the presence of fans, and the reduced performance of the home teams without spectators was not a result of unbalanced fixtures during the COVID period (therefore, these factors were not included in the final models presented). Knowing that teams would not have their home support could potentially encourage away teams to take the opportunity presented to get a favourable result from the match. Away teams may be more offensive during the early stages with the awareness that a home crowd is not present to motivate the opposition. Additionally, knowing that team dominance and refereeing decisions are linked, coaches may explore alternative tactics for their payers to exploit.

Limitations

This research was not without some limitations. Other variables, which could potentially affect match outcomes were not controlled. These included factors such as player-specific outcomes (for example fitness, suspensions, decision-making on the field), additional fixtures (domestic cups and European competition), crowd sizes when fans were present and distance travelled by teams to away matches; while there were some variables which could not be controlled, like the mental state of players and other psychological factors on match days, environmental familiarity and the evident element of luck which is present in a complex and unpredictable sport as football. Although country and league effects were not found to be significant in this research, with more data and further statistical modelling, fans' influence on home advantage outcomes at the country and league levels could be further explored.

Conclusion

Our research examined the influence of fans on home advantage outcomes in football across Europe from two perspectives, that is, based on team performance and refereeing decisions. With the naturally created experimental design, we were able to examine the home advantage phenomenon from a unique perspective. The application of mixed-effects models confirmed the influence of fans on team performance while playing at home, as home teams won fewer points, and were less dominant in matches without their fans present. This reinforced Emile Durkheim's theory of social coherence and Robert Zajonc's concept of social facilitation. The number of goals scored at home without fans present were not greatly influenced. Analyses of home advantage relating to referee behaviour was more complex. While fewer fouls were called and more yellow cards were given to the home team by referees when home support was not present, these decisions were also influenced by the team's dominance in a match. The effects of fans present for home matches on the number of red cards were not found to be significant. Overall, the findings of this research provided a greater inferential view on home advantage in European football, as it demonstrated the significant effect the absence of fans had when teams played at home once other team and match factors were controlled.

Notes

1. Bilalić, Gula and Vaci, 'Home Advantage Mediated (Ham) by Referee Bias and Team Performance During Covid'; Pollard, 'Home Advantage in Football: A Current Review of an Unsolved Puzzle'; Nevill and Holder, 'Home Advantage in Sport'; Schwartz and Barsky, 'The Home Advantage'.
2. Courneya and Carron, 'The Home Advantage in Sport Competitions: A Literature Review'.
3. Schwartz and Barsky, 'The Home Advantage'; Morris, 'The Soccer Tribe'.
4. Pollard, 'Home Advantage in Soccer: A Retrospective Analysis'.
5. Schwartz and Barsky, 'The Home Advantage'; Gelade, 'National Culture and Home Advantage in Football'.
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19. Benz and Lopez, 'Estimating the Change in Soccer's Home Advantage During the COVID-19 Pandemic Using Bivariate Poisson Regression'; Leitner and Richlan, 'No Fans-No Home Advantage'; Leitner, and Richlan, 'Analysis System for Emotional Behavior in Football (Aseb-F): Matches of Fc Red Bull Salzburg without Supporters During the COVID-19 Pandemic'.
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