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How (absent) fans influenced football during the COVID 19 pandemic?

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The fact that home football teams win more games than away teams has been largely discussed in the literature. Crowd factors appear to be the most dominant cause of this *home advantage*. At the end of the 2019–2020 season, the COVID-19 pandemic forced European football teams to close their stadium to fans, allowing researchers to exploit this natural experiment to analyze the effects of crowd on match outcomes and referees' decisions. To answer to this question, we used match data played in the top two divisions of four of the main national professional leagues in European countries and Portugal in the 2018–19 and the 2019–20 seasons. We find that the total absence of a generally supportive crowd has a significant effect on home advantage. This results in a reduction of the chances of a home win, a poorer performance by the home team's players, and more severe refereeing decisions toward the home team and less severe toward the away team.

KEYWORDS

COVID-19, football, home advantage, referee bias, social pressure

JEL Classification: C90, D91, L83

1 Introduction

The "twelfth man" effect is often put forward in football to explain improbable victories. In this spirit, the fact that home teams win more games than away teams—especially in football—has been largely discussed in the literature. Home advantage is not guided by a single source. The main factors include crowd support and size, travel fatigue, field condition, climate, altitude or the newness of stadiums, etc. Crowd factors appear to be the most dominant cause of the home advantage.

At the end of the 2019–2020 season, the COVID-19 pandemic forced European football teams to close their stadium to fans, allowing researchers to exploit this natural experiment to analyze the effects of crowd on match outcomes and referees' decisions. What were the consequences of "The sound of silence"? The economic and psychological literature on this subject is already abundant.

Leitner et al. (2022) lists 20 peer-reviewed articles on home advantage during the COVID-19 pandemic (up to December 2021). The majority of the current studies find a significant reduction in the home advantage effect during the ghost matches of the COVID-19 pandemic, but this reduction does not always appear to be significant. The two main reasons for this effect examined are the so-called "referee bias" (fewer yellow cards and fewer red cards for the visiting team behind closed doors...) and the "motivations and/or emotions" emerging from the crowd. More recently, Wang and Qin (2023) identified 28 articles published before December 2022 dealing with this issue. Many of these studies concluded that the absence of spectators reduced the victory rate of home teams and that

home advantage was weakened or even disappeared. In terms of technical and tactical performance, the lower the score, the worse the home teams' attacking indicators, such as the number of goals, shots, shots on target, and ball possession, as well as the number of dangerous situations for the visiting team, whereas away teams perform better. As far as "referee bias" is concerned, numerous studies have shown that referees are more tolerant of punishing away teams without the pressure of spectators.

In our paper, we want to replicate these results by analyzing 6,864 matches played in the main divisions of five European countries (England, Spain, Italy, Germany, and Portugal) during the 2018–2019 and the 2019–2020 seasons. Among them, 935 (around 14% of the total sample) were "crowdless" due to the sanitary situation.

Controlling for teams' characteristics, previous performance and for in-match information, our main results confirm negative statistically significant effects on the home advantage phenomenon, in terms of chances of winning, number of fouls and yellow cards booked, number of shots made, and number of expected goals.

The remainder of the article is organized as follows. In Section 2, we briefly review the home advantage in football and the studies about the effect of closed doors during the COVID-19 pandemic. In Section 3, we describe the data. Section 4 and 5 present the empirical strategy and the results. Section 6 concludes.

2 Home advantage in football: a review

Schwartz and Barsky (1977) is one of the first studies to address and document the superior performance of teams in several sports (baseball, American football and hockey, and basketball) in the United States and Canada, competing at home as opposed to away. They showed that home advantage exists in these sports, but its intensity varies from one sport to another. A meta-analysis done by Jamieson (2010) incorporating ten distinct individual and collective sports determined that home advantage was the highest in association football. For example, Reade et al. (2022), considering matches in seven European competitions that took place in the 2011/12–2020/21 seasons, found that 46% ended in a home win, 28% in a draw and 26% in an away win.

2.1 The crowd effect

Courneya and Carron (1992) proposed a theoretical and conceptual framework designed to "highlight and organize the major components involved in the home advantage process," revisited over a decade after by Carron et al. (2005). This framework incorporates five major components: (a) game location, (b) game location factors, (c) critical psychological states, (d) critical behavioral factors, and (e) performance outcomes.

Game location, representing the site (home or away) for the competition, defines the game location factors, which, in turn, are considered to influence first the critical psychological states and then the critical behavioral states of the three groups involved in the performance outcomes: coaches, competitors, and officials.

The game location factors represent four "major conditions that differentially impact teams competing at their venues vs. an opponent's venue." These are: (i) crowd support, (ii) familiarity factors, (iii) travel factors, and (iv) rule factors. The first three have been commonly recognized and empirically analyzed in the literature and proposed as explanations for why a home team tends to have an increased probability of winning a match, whereas the latter has been questioned if it should be retained, especially in football. These factors are considered to systematically interact with each other (Pollard and Pollard, 2005).

Out of the above mentioned factors that could affect the home advantage phenomenon, crowd factors appeared to be the most dominant cause of the home advantage (Nevill and Holder, 1999). Home fans present in the bleachers, typically the vast majority of the supporters at the stadium, tend to give their support to the home team by cheering, chanting, and screaming. This could stimulate the home team players' effort and energy and push them to perform better and/or could influence the referee's decisions in favor of the home team. Ponzo and Scoppa (2018) analyzed the existence of home advantage in same-stadium Italian football derbies over 22 seasons, expecting to neutralize the familiarity and travel factors and to identify the "pure" effect of the crowd support. They showed that the "crowd support effect contributes for about 60% to the home advantage, whereas both familiarity and travel fatigue account for the remaining 40%." Moreover, in these games, the home teams scored nearly 0.45 goals more than the visiting teams and their probability of winning was approximately 13 percentage points higher.

One mechanism through which crowd support could influence the outcomes of a football match is the number of supporters present in the stadium. Whereas some studies have shown a direct association between an increased home advantage and increased crowd sizes (Schwartz and Barsky, 1977; Nevill et al., 1996; Coates and Humphreys, 2010; Inan, 2020), others show no difference in the magnitude of the home advantage despite differences in crowd size (Pollard, 1986; Pollard and Pollard, 2005; Goumas, 2014; Pollard and Gómez, 2014). Nevill et al. (1996), who analyzed English football matches, showed that the greatest home advantage was not in the top tier division, but rather in the second-tier division, where crowd sizes were significantly less. This could suggest that once the audience reaches a certain number, a peak in the home advantage is observed.[1]

The crowd affects the referee's decisions for the home team [see the literature review made by Dohmen and Sauermann (2016)]. For instance, Pettersson-Lidbom and Priks (2010) estimated the bias for the home team to be 23% for fouls, 26% for yellow cards, and 70% for red cards for Italian football. Downward and Jones (2007) showed significantly more first yellow cards awarded against the away team than the home team in English football, and this referee bias would increase as crowd size increase. Dohmen (2008) showed that questionable or wrongly awarded penalties mostly favored home teams, in particular when the home team was one goal behind. Nevill et al. (1996) found a similar result, as referee's decisions concerning penalty kicks tend to favor home teams in

1 Fans' presence has also been measured as 'crowd density' (the percentage of the stadium capacity filled by supporters) and the results are also mitigated (Schwartz and Barsky, 1977; Agnew and Carron, 1994; Pollard, 1986; Inan, 2020).

English and Scottish professional football matches. Garicano et al. (2005) found a clear referee bias at the end of the game: in Spanish football matches, when the home team is behind by one goal, the injury time is 35% above average, whereas when it is ahead by one goal, the injury time is 29% below average (see also Dohmen and Sauermann, 2016).

2.2 The COVID-19 natural experiment of "ghost games:" "the sound of silence"

The total absence of supporters in stadiums during the COVID pandemic allows isolating the effect of crowd support on home advantage in football.

Reade et al. (2022) consider all the 161 matches played without spectators since 2002 in several European competitions in the "pre-COVID-19 era." They showed that on average the home team won 36% of the matches played in empty stadiums, compared with 46% when fans were present, which was mirrored by a significant increase of nearly 8 percentage points in the proportion of matches won by the away team. In line with this, there was a lower goal difference, and away teams received 20% fewer cards when playing behind closed doors, compared with having fans in attendance. They suggest that the lack of social pressure from the crowd affect referees' decisions, with fewer fouls called for the team playing away.

Reade et al. (2022) made the first attempt of a literature review of the published and unpublished articles concerning the effects of playing football behind closed doors due to the COVID-19 pandemic. As expected, some showed a reduction in the number of yellow cards awarded to the away team (Bryson et al., 2021; Endrich and Gesche, 2020; Scoppa, 2021), whereas others showed a change in the foul ratio to the disadvantage of the home team (Endrich and Gesche, 2020). Fischer and Haucap (2021) showed a significant reduction of home advantage in the Bundesliga after the Corona break, as "away teams have even outperformed home teams and collected more points than their hosts in Bundesliga ghost games." However, this negative effect seems to be only temporary during the first matches played behind closed doors, as the home advantage "recovered" over time, possibly due to players becoming more used to playing without fans.

This review of the empirical literature can be supplemented with more recent research examining the effects of fan absence on home-field advantage and referee decision-making in professional football during the COVID-19 pandemic. The papers of McCarrick et al. (2021), Wunderlich et al. (2021), Wolaver and Magee (2022), and Bhagwandeen et al. (2024) analyzed data across top European leagues and observed a consistent decline in home advantage when stadiums lacked spectators. Specifically, home teams scored fewer goals, earned fewer points, and created fewer attacking opportunities in empty stadiums. Referee biases favoring home teams—such as awarding fewer fouls, yellow and red cards, and granting more penalty kicks—diminished without fan presence. Additionally, "ghost games" saw a significant improvement in away teams' in "technical efficiency" (offensive and defensive), further reducing the typical home advantage (Destefanis et al., 2022).

This body of research underscores the influence of crowds in shaping both team performance and referee behavior, suggesting that fan presence amplifies home-field advantage by impacting both player dynamics and referee judgments.[2]

3 The data: *Big Four* and Portugal

Our dataset contains 6,864 matches played in the top two divisions of four of the main national professional leagues in European countries (and Portugal Primeira Liga) in the 2018–19 and the 2019–20 seasons: German Bundesliga 1 and 2, English Premier League and Championship, Spanish La Liga 1 and 2, Italian Serie A and B. They involve 197 football teams. The dataset contains 935 matches played behind closed doors from mid-May 2020 to the end of the season, 13.6% of the whole dataset. The dataset is composed of within-match information (goals, yellow and red cards, penalties, shots, and shots on target, expected goals…) and, as we analyze two different consecutive seasons, we control for potential between-season team differences (market value, final position in season…). Finally, to isolate the crowd support effect, we control for the other factors that could influence the home advantage phenomenon, such as travel fatigue. The variables come from different sources: the specialized website wyscout.com, an Italian company that supports football scouting, match analysis and transfer dynamics; secondary sources of information as Wikipedia, GoogleMaps, and transfermarkt, in particular for team-specific information.

Table 1 provides a first snapshot of the home advantage phenomenon on the games in our sample, comparing matches played with crowd (first column) and behind closed doors (second column). The third column represents the mean differences between the two first columns and their significance. Most variables show a significant difference demonstrating that the absence of the public has an impact on matches leading to a reduction in home advantage.

4 Empirical strategy

For six different "home" outcome variables (home advantage, yellow cards received, red cards received, fouls committed, shots, and expected goals) whose mean difference is significant we estimate the following equation:

$$Y_{ims} = \beta_1 HOME_{im} + \beta_2 COVID_m + \beta_3 HOME_{im} * COVID_m + \delta X_{ims} + h_i + t_s + \varepsilon_{ims}$$

where Y denotes the selected individual match outcome for: team i, match m, and season s. *HOME* is a dummy variable that

2 Concerning women's football, Krumer and Smith (2023) investigate matches in Swedish Damallsvenskan women's soccer league. Comparing games in the 2019 and 2020 seasons, they find a slight, but not statistically significant reduction in home advantage in games without crowds in terms of goals scored and points won. However, unlike in most studies on men's soccer, they find that away teams received significantly more yellow cards in games without crowds compared to games with crowds.

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TABLE 1 Statistics for matches with and without fans.

	With crowd	Behind closed doors	Mean difference
Home win share	43.9	41.8	−2.1
Away win share	28.6	32.7	4.1**
Home yellows	2.037	2.175	0.138***
Home reds	0.090	0.124	0.034***
Away yellows	2.327	2.033	−0.294***
Away reds	0.127	0.113	−0.014
Goals difference (Home - Away)	0.315	0.204	−0.111*
Total goals	2.678	2.700	0.022
Home Points	1.592	1.509	−0.082*
Home Xgoals	1.503	1.377	−0.126***
Home Shots	13.118	11.794	−1.324***
Home Penalties	0.180	0.198	0.018
Home Fouls	13.349	14.077	0.728***
Away Points	1.133	1.235	0.102**
Away Xgoals	1.191	1.239	0.048*
Away Shots	10.726	10.853	0.127
Away Penalties	0.137	0.183	0.046***
Away Fouls	13.715	13.800	0.085
Home ball possession share	51.382	50.577	−0.805**

***, **, * indicate significance at 1%, 5%, and 10% levels, respectively.

takes the value of one if the team plays at home and *COVID* is a dummy variable that takes the value of one if the match is played behind closed doors; h is a fixed effect capturing team specific effects, t is fixed effect capturing the season-specific effects. X is a set of control variables. This specification counts each match m twice, once with i referring to the home team and once to the away team. This allows us to estimate the coefficients in a differences-in-differences framework so that β_3 captures how the match outcomes were affected by playing a match without supporters at home as opposed to playing at home pre-pandemic in front of a crowd.

The X-vector collects additional independent variables, which vary depending on the Y variable in question. We include proxies for the teams' relative strength (such as the differences between the average player value of the home and the away team, and between the performance of the home and the away team in their last 9 matches), controls for in-match player behavior (such as shots, tackles, passes, ball possession…), a dummy variable for the use of the *VAR* system and a proxy for the distance between the stadiums of the home and the visiting teams.

We estimate the equation with OLS for the five numeric variables (*fouls, yellow cards, red cards, shots, and expected goals*), and with a probit model for the binary variable (home) *Win*. As suggested in Benz and Lopez (2023), count data models would be more appropriate for estimating the numeric variables, at least the number of yellow cards. We tested our specification with a Poisson and a negative binomial model and the results are the same in terms of change of variation and significance. This is in line with Wooldridge (2023) who shows that linear and non-linear models produce similar estimates on average when using Difference-in-difference methodologies. Of course, the range of the estimates is different because of the distribution functions which are not the same. In Table 2, we only present the core of the estimations, that is β_1, β_2, *and* β_3 to focus on the effects of ghost games.

5 Classic results of ghost games: a declining home advantage and less referee bias

Table 2 shows the estimated effects of playing behind closed doors for the home team on winning, fouls, yellow cards, red cards, shots, and expected goals. Our estimates of interest are on the fourth row for each of the outcomes (β_3, Home-Covid interaction). Even if the interaction term in a probit model is more difficult to interpret quantitatively than in OLS, the advantage of playing at home is significantly reduced (−0.24) when playing without a crowd during the COVID-19 pandemic.

The estimates of columns 2, 3, and 4 show how referee decisions were affected by playing a match at home without fans. In this case, home teams are significantly charged with more fouls, more yellow cards and more red cards than their opponent (0.65 for foul, 0.39 for yellow cards and 0.04 for red cards). This change in the relative difference of fouls and yellow/red cards could be due to a change

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TABLE 2 Effect of "Covid" games on match outcomes.

	Win	Fouls	Yellow cards	Red cards	Shots	Expected goals
Intercept	3.58*** (0.4)	18.63*** (1.05)	1.42*** (0.34)	0.19*** (0.06)	8.37*** (1.00)	1.39*** (0.18)
HOME	0.47*** (0.04)	−0.39*** (0.07)	−0.25*** (0.02)	−0.01 (0.01)	1.16*** (0.08)	0.22*** (0.02)
COVID	0.19*** (0.06)	0.504*** (0.12)	−0.37*** (0.05)	−0.01 (0.01)	−0.11 (0.13)	0.03 (0.03)
HOME*COVID	−0.24*** (0.09)	0.65*** (0.16)	0.39*** (0.06)	0.04** (0.02)	−0.479*** (0.18)	−0.10*** (0.04)
Team controls	Yes	Yes	Yes	Yes	Yes	Yes
Match controls	Yes	Yes	Yes	Yes	Yes	Yes
In-match controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11,812	11,812	11,812	11,812	11,812	11,812

OLS standard errors clustered on the match level on parentheses. ***/**/*: significant at 1%/5%/10%.

in players' in-match behavior, which varies differently by whether they play at home or away and whether an audience is present. As Endrich and Gesche (2020), we control for such an explanation by including, as previously mentioned, a range of in-match behavior variables and fixed effects. We know that, nevertheless, these in-match variables do not control perfectly for the style of play of each team or the aggressiveness of the players.

Table 2 also shows the estimated effects of playing behind closed doors on the performance of the teams' players, in particular on the shots made and the expected goals. Home teams made significantly more shots than away teams and had significantly more expected goals in the pre-COVID-19 matches. Teams playing at home had around 16.4% more expected goals and made almost 10% more shots during these games. Both tendencies are significantly mitigated in the matches played behind closed doors. Although home teams continue to make more shots and have more expected goals, the differences with the visiting teams during the pandemic are less important than in the pre-COVID-19 games, narrowing the gap to almost half of the original difference: by 41.2% concerning the shots and by 45.5% concerning the expected goals. Otherwise, the fact of playing behind closed doors does not appear to have by itself a significant effect.

6 Conclusion

We find that the total absence of a generally supportive crowd has a significant effect on home advantage. This results in a reduction of the chances of a home win, a poorer performance by the home team's players, and more severe refereeing decisions toward the home team and less severe toward the away team.

Our results discarded a commonly named factor of the home advantage phenomenon, the visiting team's travel fatigue. In all of our regressions, it has a negligible and statistically non-significant effect. We significantly showed that both referees and home players changed their usual behavior when playing without a supportive crowd due to the pandemic. Further research could try to explain the sources of these alterations. In the case of home players, is it due to a lack of familiarity in playing in their stadium without their fans? Or is it due to a lower self-esteem and/or confidence in their skills? Do referees act differently without the social pressure of the home team supporters?

In any case, we have established that individual behavior, in this case, is notably driven by its social environment.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

LA: Writing – original draft. RD: Writing – original draft. BF: Writing – original draft.

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References

Agnew, G. A., and Carron, A. V. (1994). Crowd effects and the home advantage. *Int. J. Sport Psychol.* 25, 53–62.

Benz, L. S., and Lopez, M. J. (2023). Estimating the change in soccer's home advantage during the Covid-19 pandemic using bivariate Poisson regression. *AStA* 107, 205–232. doi: 10.1007/s10182-021-00413-9

Bhagwandeen, B., Mohammed, A., and Dialsingh, I. (2024). Investigating the influence of fans on home advantage outcomes in association football across Europe. *Soccer Soc.* 25, 1093–1109. doi: 10.1080/14660970.2024.2333487

Bryson, A., Dolton, P., Reade, J. J., Schreyer, D., and Singleton, C. (2021). Causal effects of an absent crowd on performances and refereeing decisions during Covid-19. *Econ. Lett.* 198:109664. doi: 10.1016/j.econlet.2020.109664

Carron, A. V., Loughhead, T. D., and Bray, S. R. (2005). The home advantage in sport competitions: Courneya and Carron's (1992) conceptual framework a decade later. *J. Sports Sci.* 23:4, 395–407. doi: 10.1080/02640410400021542

Coates, D., and Humphreys, B. R. (2010). Week to week attendance and competitive balance in the National Football League. *Int. J. Sport Finance* 5, 239–252. Available at: https://EconPapers.repec.org/RePEc:jsf:intjsf:v:5:y:2010:i:4:p:239-252

Courneya, K. S., and Carron, A. V. (1992). The home advantage in sport competitions: a literature review. *J. Sport Exer. Psychol.* 14, 13–27. doi: 10.1123/jsep.14.1.13

Destefanis, S., Addesa, F., and Rossi, G. (2022). The impact of COVID-19 on home advantage: a conditional order-m analysis of football clubs' efficiency in the top-5 European leagues. *Appl. Econ.* 54, 6639–6655. doi: 10.1080/00036846.2022.2074361

Dohmen, T. (2008). The influence of social forces: evidence from the behavior of football referees. *Econ. Inq.* 46, 411–424. doi: 10.1111/j.1465-7295.2007.00112.x

Dohmen, T., and Sauermann, J. (2016). Referee bias. *J. Econ. Surv.* 30, 679–695. doi: 10.1111/joes.12106

Downward, P., and Jones, M. (2007). Effects of crowd size on referee decisions: analysis of the FA Cup. *J. Sports Sci.* 25, 1541–1545. doi: 10.1080/02640410701275193

Endrich, M., and Gesche, T. (2020). Home-bias in referee decisions: evidence from 'Ghost Matches' during the Covid19-Pandemic. *Econ. Lett.* 197:109621. doi: 10.1016/j.econlet.2020.109621

Fischer, K., and Haucap, J. (2021). Does crowd support drive the home advantage in professional football? Evidence from german ghost games during the COVID-19 pandemic. *J. Sports Econ.* 22, 982–1008. doi: 10.1177/15270025211026552

Garicano, L., Palacios-Huerta, I., and Prendergast, C. (2005). Favoritism under social pressure. *Rev. Econ. Stat.* 87, 208–216. doi: 10.1162/0034653053970267

Goumas, C. (2014). Home advantage and referee bias in European football. *Eur. J. Sport Sci.* 14, S243–S249. doi: 10.1080/17461391.2012.686062

Inan, T. (2020). The effect of crowd support on home-field advantage: evidence from European football. *Ann. Appl. Sport Sci.* 8, 7–16. doi: 10.29252/aassjournal.806

Jamieson, J. P. (2010). The home field advantage in athletics: a meta- analysis. *J. Appl. Soc. Psychol.* 40, 1819–1848. doi: 10.1111/j.1559-1816.2010.00641.x

Krumer, A., and Smith, V. A. O. (2023). The effect of COVID-19 on home advantage in women's soccer: evidence from Swedish Damallsvenskan. *Am. Behav. Sci.* 67, 1168–1178. doi: 10.1177/00027642221118259

Leitner, M., Daumann, F., Follert, F., and Richlan, F. (2022). The cauldron has cooled down: a systematic literature review on home advantage in football during the COVID-19 pandemic from a socio-economic and psychological perspective. *Manag. Rev. Quart.* 73:10. doi: 10.31234/osf.io/qjp27

McCarrick, D., Bilalic, M., Neave, N., and Wolfson, S. (2021). Home advantage during the COVID-19 pandemic: analyses of European football leagues. *Psychol. Sport Exer.* 56:102013. doi: 10.1016/j.psychsport.2021.102013

Nevill, A. M., and Holder, R. L. (1999). Home advantage in sport: an overview of studies on the advantage of playing at home. *Sports Med.* 28, 221–236. doi: 10.2165/00007256-199928040-00001

Nevill, A. M., Newell, S., and Gale, S. (1996). Factors associated with home advantage in English and Scottish Soccer matches. *J. Sports Sci.* 14, 181–186. doi: 10.1080/02640419608727700

Pettersson-Lidbom, P., and Priks, M. (2010). Behavior under social pressure: Empty Italian stadiums and referee bias. *Econ. Lett.* 108, 212–214. doi: 10.1016/j.econlet.2010.04.023

Pollard, R. (1986). Home advantage in soccer: a retrospective analysis. *J. Sports Sci.* 4, 237–248. doi: 10.1080/02640418608732122

Pollard, R., and Gómez, M. A. (2014). Comparison of home advantage in men's and women's football leagues in Europe. *Eur. J. Sport Sci.* 14, S77–S83. doi: 10.1080/17461391.2011.651490

Pollard, R., and Pollard, G. (2005). Home advantage in soccer: a review of its existence and causes. *Int. J. Soccer Sci.* 3, 28–44.

Ponzo, M., and Scoppa, V. (2018). Does the home advantage depend on crowd support? Evidence from same-stadium derbies. *J. Sports Econ.* 19, 562–582. doi: 10.1177/1527002516665794

Reade, J. J., Schreyer, D., and Singleton, C. (2022). Eliminating supportive crowds reduces referee bias. *Econ. Inq.* 60, 1416–1436. doi: 10.1111/ecin.13063

Schwartz, B., and Barsky, S. F. (1977). The home advantage. *Soc. Forces* 55, 641–661 doi: 10.2307/2577461

Scoppa, V. (2021). Social pressure in the stadiums: do agents change behavior without crowd support? *J. Econ. Psychol.* 82:102344. doi: 10.1016/j.joep.2020.102344

Wang, S., and Qin, Y. (2023). The impact of crowd effects on home advantage of football matches during the COVID-19 pandemic—A systematic review. *PLoS ONE* 18:e0289899. doi: 10.1371/journal.pone.0289899

Wolaver, A. M., and Magee, C. (2022). Ghost games: Crowds, referee bias, and home advantage in European football leagues. *J. Sport Behav.* 45:91.

Wooldridge, J. M. (2023). Simple approaches to nonlinear difference-in-differences with panel data. *Econ. J.* 26, C31–C66. doi: 10.1093/ectj/utad016

Wunderlich, F., Weigelt, M., Rein, R., and Memmert, D. (2021). How does spectator presence affect football? Home advantage remains in European top-class football matches played without spectators during the COVID-19 pandemic. *PLoS ONE* 16:e0248590. doi: 10.1371/journal.pone.0248590