Bookmakers’ mispricing of the disappeared home advantage in the German Bundesliga after the COVID-19 break

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ABSTRACT
The outbreak of COVID-19 in March 2020 led to a shutdown of economic activities in Europe. This included the sports sector since public gatherings were prohibited. The German Bundesliga was among the first sport leagues realizing a restart without spectators. Several recent studies suggest that the home advantage of teams eroded for the remaining matches. Our paper analyses the reaction by bookmakers to the disappearance of such home advantage. We show that bookmakers had problems to adjust the betting odds in accordance with the disappeared home advantage, opening opportunities for profitable betting strategies.

I. Introduction

Playing in front of the home crowd is beneficial to team success in all of sports. Home fans use supportive chants to motivate their team and scream and shout at the opponent. Referees also appear to be influenced by the audience as their decisions have repeatedly shown to favour the home team (Dohmen and Sauermann 2016). These impacts can help to explain why chances to win a match are typically higher during home than away games. Such home advantage is also a well-known fact to bookmakers, who price in all information available and hence offer, on average, lower odds for bets on the home than on the away team.

With the outbreak of the COVID-19 pandemic in spring 2020, all professional and amateur sports had to be cancelled because public gatherings were prohibited. About two months later, the German Bundesliga was among the first to resume playing, still in the same stadiums as before, but with fans absent. While the home advantage is driven by different factors such as away team travel and their unfamiliarity with the stadium, several studies provide evidence that the home advantage eroded immediately with games played in empty stadiums (Fischer and Haucap 2020; Reade, Schreyer, and Singleton 2020). While it took some rounds for this change to become pronounceable, it upheld until the season finished at the end of June 2020. With the German Bundesliga being a heavyweight in the betting market, the question emerges whether bookmakers adapt their odds concerning the now reduced home advantage.

This paper investigates betting market (in-)efficiencies in the German Bundesliga for matches behind closed doors after the COVID-19 break in spring 2020. The Bundesliga was the first to resume play and bookmakers had no experience on matches without spectators from other leagues. Our analysis focuses on the 83 matches\(^1\) at the end of the season 2019/2020 in the highest German football division and compares it to previous seasons. We show that bookmakers did not adjust their pricing sufficiently during the period of matches after the start of no-attendance games. This opened highly profitable strategies to bettors with return on investment (ROI) of around fifteen per cent.

The paper is organized as follows: Section 2 provides an overview of the literature on the home advantage in sports as well as the home bias in sports betting. It is proceeded by descriptive statistics of our data in Section 3. Section 4 analyses the efficiency of betting markets before and after the COVID-19 break and strategies generating positive returns for bettors. Finally,

\(^{1}\)In addition to rounds 26–34, two postponed matches were played behind closed doors.

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Section 5 concludes with a discussion of our results.

II. The home advantage and the home bias

Our analysis considers bookmakers’ evaluation of the home advantage in football. We first present the state of research on the home advantage in football, to be followed by the incorporation of the home advantage into betting odds.

The advantage of playing at home

It is well documented in the literature that teams enjoy an advantage when playing at home. In football, teams have higher chances to win when playing at home than playing the exact team in an away game. While the magnitude of such home advantage is more pronounced in football than in other sports (Jamieson 2010) and decreases to some extend over time (Palacios-Huerta 2004), the exact mechanism of why teams have better winning records at home is still not well understood.

As already pointed out in the introduction, research agrees that the home advantage is not caused by a single source, but rather assembled by a combination of different factors, which appear impossible to be disentangled empirically (Pollard and Gómez 2014). Since the away team has to travel, their journey as well as their unfamiliarity with the venue could reduce winning chances (Schwartz and Barsky 1977; Courneya and Carron 1992). Concerning tactical formation, home teams tend towards a more offensive style of play compared to away teams, which could again benefit their chances of winning (Schwartz and Barsky 1977; Carmichael and Thomas 2005). Also, referees have shown to favour home teams, known as the home bias. Such (unintentional) favouritism displays in longer extra-times when the home team is trailing compared to when the home team is winning (Sutter and Kocher 2004; Garicano, Palacios-Huerta, and Prendergast 2005).

The recent COVID-19 pandemic opened the opportunity to determine if the home advantage in football still exists when no spectators are present. The results are unanimous and find the home advantage to disappear once games were played behind closed doors. Bryson et al. (2021) analyse various European football competitions including the German Bundesliga, while Dilger and Vischer (2020) and Fischer and Haucap (2020) focus on Germany only. Cueva (2020) considers a large data set of 41 football leagues stating that the home advantage decreases on average by about one half. Moreover, Bryson et al. (2021) find that the magnitude of such decrease varies across leagues. The studies also agree that the referee bias towards the home teams disappeared, potentially due to less social pressure of home fans on the referee (see also Endrich and Gesche 2020).

(Mis-)Pricing of the home advantage by bookmakers

Following the concept of efficient markets, asset prices (equivalent to betting odds) should contain all available information (Fama 1970). Since bookmakers face uncertainty of events and have to adjust to new information (Deutscher, Frick, and Otting 2018), they keep a risk premium, referred to as margin. Such margins decreased in recent years due to increasing competition between bookmakers (Štrumbelj and Šikonja 2010). Efficient betting markets imply that market participants (bettors) cannot use simple strategies to beat the market and make profit, given the margin kept by bookmakers. Those simple strategies include systematic betting on, e.g., home teams, favourites, popular or recently promoted teams.

As the location of the game has shown to benefit the home team, the betting odds for home teams are on average lower than for away teams. The again so-called home bias refers to increased pay-outs (equivalent to higher odds) for the home team compared to the fair odds. Such biased odds can arise from the bookmakers’ difficulty to assess the exact magnitude of the home advantage, their knowledge that fans are somewhat unable to assess teams’ strength (Na, Su, and Kunkel 2019) or their goal to have a so-called balanced book, which is given if wagers on both outcomes (home and away

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2 For meta-analysis non-exclusive to football see, e.g., Courneya and Carron (1992); Jamieson (2010).

3 See Dohmen and Sauermann (2016) for a review of the literature.

4 Winkelmann, Otting, and Deutscher (2020) present an overview of studies on biases in European betting markets.
win) level out such that bookmakers secure a profit independent of the game outcome (Hodges, Lin, and Liu 2013). Since bettors rather bet on underdogs than favourites, bookmakers offer favourable odds on home wins (Franke 2020). If such bias towards home wins is large enough to exceed the margin kept by bookmakers, a profitable strategy would suggest to systematically bet on the home team. Supporting empirical evidence comes from, e.g., Forrest and Simmons (2008) and Vlastakis, Dotsis, and Markellos (2009).

The COVID-19 pandemic offers a unique natural experiment: The direct effect on the disappearance of the home advantage in the German Bundesliga is strengthened by imperfect information of bookmakers due to a small number of comparable games behind closed doors prior to the pandemic. This leads to the question if and how fast bookmakers responded by adjusting the betting odds. From the bettors’ perspective, this opens the question if mispricing by bookmakers created profitable strategies.

III. Data

Due to spread of the COVID-19 pandemic in early 2020 the German Bundesliga prohibited the attendance of spectators after round 25 on 9 March 2020. By then 223 matches were played and 82 had been rescheduled between the 16th of May and the 27th of June 2020. The Bundesliga was the first of the top European football leagues to restart matches, but without spectators. Match data retrieved from www.football-data.co.uk cover results and pre-game betting odds for all games of the German Bundesliga from season 2014/15 until 2019/20. We focus on data covering the current season while using the five preceding seasons as reference to cover potential within season dynamics. We split the 2019/20 season into two periods, considering matches with and without fans. Previous seasons are separated after round 25 corresponding to the COVID-19 break in season 2019/20 for comparison.

### Descriptive match statistics

Table 1 provides an overview on match results. Prior to the most recent season, home teams won nearly half of their matches, with an almost equal split between away wins (29.42%) and draws (25.60%). At the end of previous seasons, the number of home wins increased by more than four percentage points while games resulting in a draw and away wins were less likely than before. The 2019/20 German Bundesliga season stands out due to a large number of away wins which is almost 20% higher compared to previous seasons – even in rounds with spectators. The proportion of home wins and draws is smaller by 2 and about 3.5 percentage points, respectively. For matches after the COVID-19 break, we find a strong increase in the number of away wins compared to previous rounds in season 2019/20 (+27.44%) and to the end of previous seasons (+65.66%). At the same time the number of home wins decreased and was about 25% lower than before the COVID-19 break and about 35% lower than in previous seasons (see Table 1). These findings confirm previous results which revealed an eroded home effect for the German Bundesliga after the COVID-19 break (see e.g. Dilger and Vischer 2020).

Similar results occur regarding the average number of goals scored by the home and away team. In previous years, the number of total goals increased at the end of the season from 2.82 goals on average to 3.06 goals. However, in 2019/20 considerably more goals were already scored in games with spectators, which mainly origins from the increased number of away goals. While away teams scored even more goals after the COVID-19 break, the number of home goals decreased by nearly 20%.

| Table 1. Proportion of match outcomes before and after the COVID-19 break as well as for previous seasons. |
|---------------------------------------------------------------|
| Matches | Home wins | Draws | Away wins |
| Seasons 2014/15-2018/19 | 1125 | 44.98% | 25.60% | 29.42% |
| Round 1-25 | 405 | 49.63% | 23.46% | 26.91% |
| Seasons 2014/15-2018/19 | 223 | 43.05% | 21.97% | 34.98% |
| Season 2019/20 with spectators | 83 | 32.53% | 22.89% | 44.58% |

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3 Prior to COVID-19.

4 25 rounds with nine games each; two games had been postponed due to other circumstances, one of them has been played on March 12th behind closed doors.
For the first time, the number of away goals surpasses the number of home goals (see Table 2).

In general, the match schedule can influence the proportion of home and away wins during a short period of a season. To investigate teams’ strength in the schedule for our data, Figure 1A in the Appendix shows boxplots on the difference between the market values of the two teams in each match, based on data retrieved from www.transfermarkt.com. These data cover the market values for all teams in each season, and positive differences in Figure 1A indicate higher market values for home teams. For season 2019/20 as well as for previous seasons the boxplots show only minor differences between matches until and after round 25. Therefore, the substantial change in the number of home and away wins as well as goals scored as reported above in Tables 1 and 2 are most likely not caused by the match schedule.

### Implied winning probabilities and bookmaker’s margins

To determine the precision of bookmakers’ forecasts, we first turn our attention to the betting odds. As betting odds contain a margin, they have to be adjusted as follows to obtain the implied winning probability \( \tilde{p}_i \) given by bookmakers (see, e.g., Deutscher et al. 2013; Forrest and Simmons 2008):

\[
\tilde{p}_i = \frac{1/O_i}{1/O_h + 1/O_d + 1/O_a}, \quad i = h, d, a \tag{1}
\]

where \( O_i \) represents the average odds over all bookmakers for home wins \( i = h \), away wins \( i = a \), and draws \( i = d \). The difference in the implied probabilities \( \text{ImpProbDiff} = \tilde{p}_h - \tilde{p}_a \) indicates whether bookmakers denote the home team to be the favourite (\( \text{ImpProbDiff} > 0 \)), whereas \( \text{ImpProbDiff} < 0 \) coincides with a favoured away team. If the (absolute) difference in the implied winning probability between two teams in a specific match is large, one team can clearly declared to be the favourite. In contrast, a small difference indicates that bookmakers assign nearly equal abilities to both teams.

Bookmakers use their margin to account for possible mispricing and to remain profitable (Makropoulou and Markellos 2011). According to the calculation of implied probabilities in Equation (1), bookmakers’ margins are given by (see, e.g., Deutscher et al. 2013; Feddersen, Humphreys, and Soebbing 2017; Forrest and Simmons 2008):

\[
\sum_{i \in \{h, d, a\}} O_{m, i}^{-1} - 1, \text{ for matches } m = 1, \ldots, M.
\]

Table 3 compares margins for season 2019/20 to previous seasons, indicating that margins are lower in the most recent season. This confirms previous results and is in line with decreased margins over time caused by higher market competition as argued by Forrest, Goddard, and Simmons (2005), Constantinou and Fenton (2013), Buhagiar, Cortis, and Newall (2018), and Winkelmann, Ötting, and Deutscher (2020).

Furthermore, margins typically increase as the assessment of teams becomes more difficult, e.g. if bookmakers expect two teams to have nearly equal abilities. Table 4 displays results of a regression model where we explain the margin for a specific match by the absolute difference between the implied winning probability for a home and away win as well as the season. We find significantly

### Table 2. Average home and away goals before and after the COVID-19 break as well as for previous seasons.

|            | Home goals | Away goals | Total goals |
|------------|------------|------------|-------------|
| Seasons 2014/15-2018/19 Round 1–25 | 1.58 | 1.24 | 2.82 |
| Seasons 2014/15-2018/19 Round 26–34 | 1.80 | 1.26 | 3.06 |
| Season 2019/20 with spectators | 1.74 | 1.51 | 3.25 |
| Season 2019/20 without spectators | 1.43 | 1.66 | 3.10 |

### Table 3. Bookmakers’ margins before and after the COVID-19 break as well as for previous seasons.

|            | Margins |
|------------|---------|
| Seasons 2014/15-2018/19 Round 1–25 | 5.09% |
| Seasons 2014/15-2018/19 Round 26–34 | 5.11% |
| Season 2019/20 with spectators | 4.83% |
| Season 2019/20 without spectators | 4.79% |

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1 The data set covers odds of between 30 and 56 bookmakers for each match. The pairwise correlation between betting odds offered by different bookmakers is at least 0.969 for home wins and 0.945 for away wins.
lower margins if this difference increases, i.e. if one team can clearly declared to be the favourite.

For matches behind closed doors, previous experience of bookmakers is fairly low. It could be expected that bookmakers account for increased uncertainty in the assessment of team’s strength by increasing margins. However, according to Table 3, there is only a marginal increase in the margins at the end of previous seasons whereas margins slightly decrease after the COVID-19 break. While increased margins at the end of previous seasons can be referred to the difficulty in the prediction of match outcomes when there are matches with two teams without any possibilities to face promotion to the international competition or are under threat of possible relegation, findings on season 2019/20 are somewhat surprising.

**IV. Analysing market inefficiencies**

Bookmakers had close to no experience on games behind closed doors since only a small number of such games had been played in the past. Nevertheless, as indicated by our findings from the previous section, they did not account for this increased uncertainty by increasing their margins. Our descriptive analysis also reveals a disappeared home advantage, equal to more away wins after the COVID-19 break at the end of season 2019/20 in the German Bundesliga. This opens the question whether bookmakers incorporated increased winning probabilities for away teams in their odds. Otherwise, bettors would have been able to gain positive returns when betting consistently on the away team. In accordance with the home bias as described above, this phenomenon can be denoted as an away bias. In the following, we provide regression analyses to statistically test for increased chances to win a bet when betting on away teams (especially in games played behind closed doors). To further investigate the profitability of such betting strategies, we also present ROIs when consistently betting on the away team (again especially in games played behind closed doors).

**Model**

Our analysis covers bets on home and away teams since margins for draws only vary slightly in football (Pope and Peel 1989). To account for a potential home/away bias, we include the binary variable *Away* indicating whether we bet on the away team (*Away = 1*) or the home team (*Away = 0*). In addition, the covariate *COVID-19* equals one if the match was played behind closed doors. To control for possible dynamic changes during the course of the season, the covariate *Betting after round 25* equals one if we bet after this round. We further include an interaction term between *Away* and *COVID-19*. This term allows for differences in a potential away bias between matches with and without spectators. In the second model, we additionally test for adjustments by bookmakers during the period of matches without spectators, thus including the *Round after round 25* taking value 1 for round 26 up to value 9 for round 34 as well as an interaction term with the *COVID-19* variable.

Efficient markets would imply that neither betting on away teams nor the *COVID-19* variable affects the chance to win a bet significantly. To test if the market considered here is efficient, we fit a logistic regression model to the entire data set to detect whether any variable beyond the implied probability has explanatory power on the binary response variable, which indicates if a bet was Won. The linear predictor with logit(Pr(Won) = 1)) = $\eta_i$ is linked by the logit function and given as:

$$\eta_i = \beta_0 + \beta_1\text{ImpliedProbability}_i + \beta_2\text{Away}_i + \beta_3\text{Bettingafterround25}_i + \beta_4\text{COVID} - 19_i + \beta_5\text{Away}_i \cdot \text{COVID} - 19_i + \beta_6\text{Roundafterround25}_i + \beta_7\text{Roundafterround25}_i \cdot \text{COVID} - 19_i$$

### Table 4. Margins explained by absolute difference in implied winning probabilities, season and round.

| Response variable: | Margin |
|--------------------|--------|
| Absolute difference in implied probabilities | $-0.002^{***}$ (0.0003) |
| Season | $-0.001^{***}$ (0.00004) |
| Constant | $0.056^{***}$ (0.0002) |
| Observations | 1,836 |
| $R^2$ | 0.468 |

*Note:* $p < 0.1$; $^{*}p < 0.05$; $^{***}p < 0.01$
We use maximum likelihood to fit the models to the data using the function glm() in R (R Core Team 2019). This approach follows the concept of various further studies as Forrest and Simmons (2008), Franck, Verbeek, and Nüesch (2011), and Feddersen, Humphreys, and Soebbing (2017).

**Results**

Table 5 displays the estimated coefficients and standard errors of our two regression models fitted to the entire data set. The Implied Probability calculated based on bookmakers’ odds has strong explanatory power on the actual outcome of the game, which is intuitively plausible. The negative and significant effect of Away reveals a home bias for matches with spectators in the German Bundesliga which is in line with the existing literature summarized above. However, there is no significant change in the chances to win a bet in the last quarter of the season as indicated by the insignificant effect of the dummy variable for Betting after round 25. Model 1 allows for a comparison between a bet on a match without spectators and a match at the end of a previous season with equal implied probability by the bookmaker. The estimated coefficients for Away, COVID-19, and the corresponding interaction term in Model 1 indicate a substantial increase (decrease) in the odds to win a bet on the away (home) team at the end of season 2019/20.

Model 2 additionally tests for an adjustment of betting odds by bookmakers during the period of matches behind closed doors. We do not find significant changes in the chances to win a bet for subsequent rounds, thus concluding that the misassessment is not limited to the first rounds after the restart of the German Bundesliga but kept up for the remainder of the season.

We use the results in Model 1 to compare implied probabilities given by bookmakers to winning probabilities as expected under our model (see Figure 1). The estimates for Pr(Won_i = 1) under our fitted model are given by

\[
\text{logit}^{-1}(\hat{\eta}_i) = \text{logit}^{-1}(\hat{\beta}_0 + \hat{\beta}_1 \text{ImpliedProbability}_i + \hat{\beta}_2 \text{Away}_i + \hat{\beta}_3 \text{Bettingafterround25}_i + \hat{\beta}_4 \text{COVID} - 19_i + \hat{\beta}_5 \text{Away}_i \cdot \text{COVID} - 19_i)
\]

with \(\hat{\beta}_0, \ldots, \hat{\beta}_5\) as shown in Table 5 for Model 1. The left panel represents bets on home teams while bets on the away team are illustrated in the right panel. Bets at the end of a previous season (with spectators) are depicted in red while bets on a game behind closed doors are shown in blue colour. An efficient market would correspond to the dashed diagonal line. We find expected winning probabilities to deviate only slightly from the efficient market line for matches with spectators at the end of previous seasons. As indicated by our model, the figure confirms higher expected probabilities to win a bet when betting on away teams after the COVID-19 break, while these chance are lower for bets on home teams (see Figure 1). This underlines that it was difficult for bookmakers to incorporate the eroded home advantage for matches without the attendance of spectators into their odds, potentially opening the possibility for positive returns to bettors who systematically bet on away wins. This confirms the results of our regression model (see Table 5).

**Table 5** Estimation results of our model fitted to the entire data set.

| Response variable | Model 1 | Model 2 |
|-------------------|---------|---------|
| Implied probability | 4.530*** | 4.530*** |
| Away | (0.231) | (0.231) |
| Betting after round 25 | 0.162** | 0.162** |
| COVID-19 | (0.080) | (0.080) |
| Away · COVID-19 | 0.032 | 0.076 |
| Round after round 25 | 0.089 | 0.174 |
| Round after round 25 · COVID-19 | 0.068 | 0.445 |
| Constant | 1.136*** | 1.143*** |
| (0.358) | (0.359) |
| Observations | 3,672 | 3,672 |
| Akaike Inf. Crit. | 4,322.426 | 4,325.643 |

Note: "p < 0.1; **p < 0.05; ***p < 0.01"
strategies. Still, our model indicates significantly higher chances to win a bet when betting on away games after the COVID-19 break. Based on these results, we evaluate a simple betting strategy, namely betting on away teams in each match with an equal wager. The generated ROIs of this strategy are compared to those when betting on home teams (see Table 1).

For previous seasons, we find on average higher returns when betting on the home team (see Table 6). This corresponds to the significant negative effect of the Away covariate in our regression model. As home teams are more often denoted to be the favourite (Winkelmann, Ötting, and Deutscher 2020), some extend this bias can be explained by the favourite-longshot bias, which denotes increased chances to win a bet when betting on the favourite. The favourite-longshot bias has been revealed for different leagues in the past (see, for example, Angelini and De Angelis 2019; Cain, Law, and Peel 2000) while Constantinou and Fenton (2017) state that the favourite-longshot bias naturally occurs in betting markets. However, due to the bookmakers’ margin, for previous seasons the returns until round 25 are negative when consistently betting on the home or away team. The increased number of home wins at the end of previous seasons (see Table 1) leads to positive returns of about 6.24% when betting on the home team at this time (Table 6).

The descriptive analysis shows a considerably higher proportion of away wins also at the beginning of season 2019/20 (see Table 1). Bookmakers were not able to fully include this shift into their odds, leading to positive returns of about 5.53% when betting on away teams until round 25. As the home advantage eroded after the restart of the season, we observe even more away wins, thus leading to substantial returns of almost 15% when betting on away teams in matches behind closed doors. Meanwhile, betting on home teams generates an average return of −33.84% (Table 6).

The results open the question whether these considerable returns are mainly driven by a few bets with high odds, i.e. wins of away teams.
which can be clearly denoted to be the underdog, or several wins in close competitions. As stated above, we denote the difference in percentage points between the implied probabilities given by the bookmaker for a home and an away win by $\text{ImpProbDiff}$. While positive values of this variable indicate higher implied probabilities for the home team, $\text{ImpProbDiff}$ takes negative values if the bookmaker denote the away team to be the favourite. Table 7 displays different ranges for this variable together with the corresponding number of matches and outcomes for each range.

In about 60% of the matches behind closed doors in the German Bundesliga, the home team was
denoted to be the favourite according to bookmakers, i.e. implied winning probabilities for the home team were higher than for the away team (see Table 7).

Considering matches with a large difference of more than 45 percentage points, we find that only 11 of 16 such heavy home favourites could win their game while nine out of ten away teams with considerably larger implied winning probabilities won their game. Focusing on 23 relatively close competitions ($|\text{ImpProbDiff}| \leq 0.15$) we find 11 away wins in contrast to only 5 home wins. Even if bookmakers denote the home team to be the slight favourite, we find more away than home wins in these matches (see Table 7). Accordingly, bookmakers undervalue the strength of away teams for matches behind closed doors, especially for balanced competitions.

### V. Discussion

We analyse the home advantage and its evaluation by bookmakers in Bundesliga games that were played behind closed doors. While the number of home wins increased at the end of previous seasons, it disappeared at least to some extend during the COVID-19 season, equal to considerably more away wins at the end of season 2019/20. Furthermore, the number of home goals decreased as the number of away goals increased, confirming the reduced home advantage. Our analysis shows bookmakers’ difficulties to price such change. Their odds imply that the home advantage remained intact and opened opportunities for bettors to generate a substantial profit of around 15% when betting on away teams in games that were played behind closed doors. A more fine-grained analysis shows that especially in close competitions away teams won considerably more games than expected by bookmakers, confirming their struggle to implement the impact of games without spectators on the home advantage. Returns of presented magnitude are very rare in betting markets and can have a significant impact on bookmakers business as well as other stakeholders.

While our results indicate that bookmakers did not fully incorporate the disappeared home advantage for matches behind closed doors in the German Bundesliga into their betting odds, the analysis covers only 83 matches at the end of season 2019/20. Given that positive returns can be generated even under full market efficiency in the short-run (see Winkelmann, Ötting, and Deutscher 2020), further research is needed to investigate how bookmakers react to such special match characteristics. Furthermore, Pollard (2006) has provided evidence that the magnitude of the home advantage varies across teams and leagues, as it depends on a team’s popularity or the stadium capacity. Therefore, also the decrease in the home advantage may not be the same for all teams and leagues. Bryson et al. (2021) confirm this result by stating that the reduction of the home advantage in the German Bundesliga is fairly comprehensive compared to other European leagues. Furthermore, the

### Table 6. ROIs when betting on the home and away team before and after the COVID-19 break as well as for previous seasons.

|                  | Betting on home wins | Betting on away wins |
|------------------|-----------------------|-----------------------|
| Seasons 2014/15-2018/19 round 1–25 | $-1.37\%$ | $-11.69\%$ |
| Seasons 2014/15-2018/19 round 26–34 | $6.24\%$ | $-15.52\%$ |
| Season 2019/20 with spectators | $-6.64\%$ | $5.53\%$ |
| Season 2019/20 without spectators | $-33.84\%$ | $14.71\%$ |

### Table 7. Match outcomes depending on difference in implied winning probabilities given by the bookmaker.

| ImpProbDiff   | Matches | Home wins | Draws | Away wins |
|---------------|---------|-----------|-------|-----------|
| Heavy home favourite     |         |           |       |           |
| $[0.90; 0.75]$     | 3       | 2         | 1     | 0         |
| $[0.75; 0.60]$     | 6       | 3         | 2     | 1         |
| $[0.60; 0.45]$     | 7       | 6         | 1     | 0         |
| $[0.45; 0.30]$     | 9       | 5         | 2     | 2         |
| $[0.30; 0.15]$     | 12      | 3         | 4     | 5         |
| $[0.15; 0.00]$     | 13      | 4         | 3     | 6         |
| Balanced match     |         |           |       |           |
| $[0.00; -0.15]$    | 10      | 1         | 4     | 5         |
| $[-0.15; -0.30]$   | 4       | 1         | 0     | 3         |
| $[-0.30; -0.45]$   | 9       | 2         | 1     | 6         |
| $[-0.45; -0.60]$   | 6       | 0         | 1     | 5         |
| $[-0.60; -0.75]$   | 4       | 0         | 0     | 4         |

$^a$On average, the home team had implied winning probabilities exceeding the value of the away team by 7.73 percentage points.
Bundesliga was the first league restarting matches behind closed doors. Thus, Bundesliga games may not be fully representative and it would be interesting to analyse whether bookmakers were able to include their experience with Bundesliga ghost games into the assessment of teams in further top European football leagues as the English Premier League, the Spanish La Liga or the Italian Serie A after their restart with matches behind closed doors some weeks after the German Bundesliga. Finally, in some countries spectators returned to the stadium in autumn 2020 with strong restrictions. This opens the possibility for a comparison between matches behind closed doors, a reduced stadium capacity and the full support of spectators.

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**References**

Angelini, G., and L. De Angelis. 2019. “Efficiency of Online Football Betting Markets.” International Journal of Forecasting 35 (2): 712–721.

Bryson, A., P. Dolton, J. J. Reade, D. Schreyer, and C. Singleton. 2021. “Causal Effects of an Absent Crowd on Performances and Refereeing Decisions during Covid-19.” Economics Letters 198: 109664. [https://www.sciencedirect.com/science/article/pii/S0165176520304249](https://www.sciencedirect.com/science/article/pii/S0165176520304249)

Buhagiar, R., D. Cortis, and P. W. S. Newall. 2018. “Why Do Some Soccer Bettors Lose More Money than Others?” Journal of Behavioral and Experimental Finance 18: 85–93.

Cain, M., D. Law, and D. Peel. 2000. “The Favourite-longshot Bias and Market Efficiency in Uk Football Betting.” Scottish Journal of Political Economy 47 (1): 25–36.

Carmichael, F., and D. Thomas. 2005. “Home-field Effect and Team Performance: Evidence from English Premiership Football.” Journal of Sports Economics 6 (3): 264–281.

Constantinou, A., and N. Fenton. 2013. “Profiting from Arbitrage and Odds Biases of the European Football Gambling Market.” Journal of Gambling Business and Economics 7 (2): 41–70.

Constantinou, A., and N. Fenton. 2017. “Towards Smart-data: Improving Predictive Accuracy in Long-term Football Team Performance.” Knowledge-Based Systems 124: 93–104.

Core Team, R. 2019. R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing.

Courneya, K. S., and A. V. Carron. 1992. “The Home Advantage in Sport Competitions: A Literature Review.” Journal of Sport & Exercise Psychology 14 (1): 13–27.

Cueva, C. 2020. Animal Spirits in the Beautiful Game. Testing Social Pressure in Professional Football during the COVID-19 Lockdown. OSF Preprints.

Deutscher, C., B. Frick, and M. Ötting. 2018. “ Betting Market Inefficiencies are Short-lived in German Professional Football.” Applied Economics 50 (30): 3240–3246.

Deutscher, C., B. Frick, O. Gürtler, and J. Prinz. 2013. “Sabotage in Tournaments with Heterogeneous Contestants: Empirical Evidence from the Soccer Pitch.” The Scandinavian Journal of Economics 115 (4): 1138–1157.

Dilger, A., and L. Vischer (2020). “No Home Bias in Ghost Games”. Discussion Paper of the Institute for Organisational Economics.

Dohmen, T., and J. Sauermann. 2016. “Referee Bias.” Journal of Economic Surveys 30 (4): 679–695.

Endrich, M., and T. Gesche (2020). “Home-bias in Referee Decisions: Evidence From’ghost Matches’ during the Covid-19 Pandemic”. Center for Law & Economics Working Paper Series.

Fama, E. F. 1970. “Efficient Capital Markets: A Review of Theory and Empirical Work.” The Journal of Finance 25 (2): 383–417.

Feddersen, A., B. R. Humphreys, and B. P. Soebbing. 2017. “Sentiment Bias and Asset Prices: Evidence from Sports Betting Markets and Social Media.” Economic Inquiry 55 (2): 1119–1129.

Fischer, K., and J. Haucap (2020). “Does Crowd Support Drive the Home Advantage in Professional Soccer? Evidence from German Ghost Games during the COVID-19 Pandemic”. Technical report, DICE Discussion Paper.

Forrest, D., J. Goddard, and R. Simmons. 2005. “Odds-setters as Forecasters: The Case of English Football.” International Journal of Forecasting 21 (3): 51–564.

Forrest, D., and R. Simmons. 2008. “Sentiment in the Betting Market on Spanish Football.” Applied Economics 40 (1): 119–126.

Franck, E., E. Verbeek, and S. Nüesch. 2011. “Sentimental Preferences and the Organizational Regime of Betting Markets.” Southern Economic Journal 78 (2): 502–518.
Pollard, R., and M. A. Gómez. 2014. “Components of Home Advantage in 157 National Soccer Leagues Worldwide.” International Journal of Sport and Exercise Psychology 12 (3): 218–233.

Pope, P. F., and D. A. Peel. 1989. “Information, Prices and Efficiency in a Fixed-odds Betting Market.” Economica 56 (223): 323–341.

Reade, J. J., D. Schreyer, and C. Singleton. 2020. Echoes: What Happens When Football Is Played behind Closed Doors? Available at SSRN 3630130.

Schwartz, B., and S. F. Barsky. 1977. “The Home Advantage.” Social Forces 55 (3): 641–661.

Štrumbelj, E., and M. R. Šikonja. 2010. “Online Bookmakers’ Odds as Forecasts: The Case of European Soccer Leagues.” International Journal of Forecasting 26 (3): 482–488.

Sutter, M., and M. G. Kocher. 2004. “Favoritism of Agents—the Case of Referees’ Home Bias.” Journal of Economic Psychology 25 (4): 461–469.

Vlastakis, N., G. Dotsis, and R. N. Markellos. 2009. “How Efficient Is the European Football Betting Market? Evidence from Arbitrage and Trading Strategies.” Journal of Forecasting 28 (5): 426–444.

Winkelmann, D., M. Ötting, and C. Deutscher (2020). “Betting Market Inefficiencies in European Football – Bookmakers’ Mispricing or Pure Chance?” Universität Bielefeld Working Papers in Economics and Management, 2020(06).