

Diskussionspapier des
Instituts für Organisationsökonomik

7/2020

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Discussion Paper of the
Institute for Organisational Economics

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Instituts für Organisationsökonomik
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Juli 2020

ISSN 2191-2475

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Abstract

Because of the COVID-19-pandemic the men's first German football league (Bundesliga) had to finish the season 2019/20 with ghost games as spectators were not allowed in the stadiums. Comparing these games with the regular ones between the same teams before, we find that the normal advantage for the home team disappears. One reason for this is the disappearances of the home bias of the referees whereas changes in the sportive performance of the teams seem to be irrelevant in this regard.

JEL Code: Z20

Kein Heimspielvorteil bei Geisterspielen

Zusammenfassung

Wegen der COVID-19-Pandemie musste die erste deutsche Bundesliga der Männer die Saison 2019/20 mit Geisterspielen beenden, da Zuschauer in den Stadien nicht zugelassen waren. Wenn wir diese Spiele mit den regulären Spielen zwischen denselben Teams vergleichen, stellen wir fest, dass der normale Vorteil für die Heimmannschaft verschwindet. Ein Grund dafür ist das Verschwinden des Bias der Schiedsrichter für die Heimmannschaft, während Änderungen in der sportlichen Leistung der Mannschaften in dieser Hinsicht irrelevant zu sein scheinen.

Im Internet unter:

http://www.wiwi.uni-muenster.de/io/forschen/downloads/DP-IO_07_2020

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No Home Bias in Ghost Games

1. Introduction

Ernst Happel once said “a day without football is a lost day” (Deutscher Fußball-Bund 1999, 456). The COVID-19 pandemic has had a massive impact on the professional sports industry, in addition to broad social restrictions, and has led to unplanned days without football. As a result, the first German football league (Bundesliga) of men was temporarily suspended on 16 March 2020 and reopened on 16 May 2020 with significant restrictions as the first major sports league to do so. The most striking restriction on the restart of the Bundesliga was the exclusion of the public in the stadium. In addition, the German football league association (DFL) has published a comprehensive hygiene concept, which includes pre-match quarantine of the teams, rules of conduct for players and officials and a maximum number of people, such as doctors, officials and reporters, in the stadium (DFL 2020). The fact that the current 2019/20 season was interrupted and then resumed with the same team compositions and the same preparation time before the restart opens up unique research opportunities.

In particular, the influence of the spectators on the outcome of the game can be investigated. Home bias is considered to be one of the best documented phenomena across all sports (e.g. Courneya & Carron 1992, Pollard & Pollard 2005). It is “the consistent finding that home teams in sport competitions win over 50 % of games played under a balanced home and away schedule” (Courneya & Carron 1992). A relative advantage exists if the probability of winning a home game is higher than that of losing. Although the home bias diminishes over the years (Biermann 2011, 79-82) and may vary from league to league, it is not to be dismissed. Not the fact of but only the reasons for the home bias are discussed such as the journey of the away team, the familiarity of the home ground, the influence of the spectators, the tactical orientations or the refereeing behaviour (Sutter & Kocher 2004). The unique experiment, which was carried out involuntarily, in the season that finished on 27 June 2020 enables to concentrate on the spectators as the object of research.

In contrast to a study already conducted on ghost games by Reade, Schreyer and Singleton (2020), the ghost games in this season are neither individual cases in different competitions nor spread over several years nor the result of a punishment leading to spectator exclusion. It is advantageous that teams with relatively equal playing strength in the same competition can be compared first with and then without spectators. Certainly, factors that cannot be considered in this paper play a role, too, such as the return of injured key players through the Covid-

19 break, while others were suspended after positive virus tests, different incentives at the end of the season by fixed table positions, differences in the game schedule before and after the break as well as different preparations in the lockdown. However, despite these limitations, there has never been such comparability of matches with and without spectators.

Due to the almost identical conditions, we have therefore decided to examine the home bias only in the 306 matches of the 2019/20 season for the first German football league. This resulted in 223 games with spectators and 83 games without spectators. We also compared the 83 ghost games with only the 83 matches with spectators between the same teams before where the home advantage was switched. In addition to the final results of the games, we collected various indicators such as the duel quota, the pass quota, and the finishes on goal. The influence of the referee on the course of the game with and without spectators was examined by using the indicators cards and length of extra time.

In the following, we discuss the literature relevant to this topic in Section 2, form hypotheses based on the literature in Section 3, describe the data we have collected in Section 4, analyse these data in section 5, and discuss the results in Section 6. We conclude and present a short outlook in Section 7.

2. Literature Review

Initial research on the home bias was carried out by Schwartz and Barsky (1977), who found that this bias existed in selected American team sports over long periods of time. Biermann (2011) speaks of an existing home advantage but one that dwindles over time, based on the results of a study by Palacios-Huerta (2004) of English football. Between 1888 and 1915 the home advantage was 56.6 % and between 1983 and 1996 it was only 47.4 % (Palacios-Huerta 2004). Biermann (2011) attributes this to the increasing professionalization of football as well as the differentiable economic possibilities of the clubs and the resulting performance. Specifically for the first German Bundesliga, Strauß and Höfer (2001) determined a distribution of 53.3 % victorious matches of the home team from the 1963/64 to the 1997/98 season compared to 26 % draws and 20.7 % away wins.

In the literature several reasons are discussed for the home bias. Schwartz and Barsky (1977) mention the journey of the away team, the familiarity of the environment (see also Loughhead, Carron, Bray & Kim 2003 and Moore & Brylinsky 1995) and the spectators. Courneya and Carron (1992) add competition rules to these factors and Wallace, Baumeister and Vohs

(2005) add refereeing behaviour (see also Sutter & Kocher 2004). In addition to the factors listed above, other factors such as the tactical orientation of the teams can also play a role. Differences were also found between countries (Pollard 2006).

The factor of travel in the first investigations seems more questionable now in view of the ever increasing professionalization of the teams and the rising convenience of travel. Accordingly, Clarke and Norman (1995) have found already in the 1990s that travel factors no longer played a practical role in determining the home advantage. Competition rules are more likely to be important in other sports, whereas in football they seem to favour the home team only in tournaments such as world championships where the home team usually does not have to expect very tough opponents in its group (Strauß & MacMahon 2019) or is automatically qualified for the group stage. The familiarity of the playing ground should not play a major role in the outcome of the game, too, given that the conditions on the fields and their surroundings, such as the booths, benches and so on are now almost identical for the professional teams.

The influence of the spectators remains as a potentially important factor. The same is true for the refereeing decisions that seem to be more benign when the home team commits fouls compared to away teams (Sapp, Spangenburg & Hagberg 2018). Frondel and Schubert (2016) found a correlation between the card spread and a decreasing chance of winning. Moreover, there could be interactions between the audience (including its noise) and the number of fouls as well as the cards and the resulting standard possibilities, e.g. penalties and free kicks (Nevill, Balmer & Williams 2002). Another result could be inhibitions in duels of a player already cautioned (Nevill & Holder 1999). Dohmen (2008) has found that referees tend to give more extra time when the home team only needs one goal to win. If the home team is already ahead, less extra time is given, which could also be influenced by the spectators. Riedl, Strauß, Heuer and Rubner (2015) confirmed this, too, and determined a longer extra time of on average 18 seconds. Perhaps better referee training over time is also the reason for the declining home advantage over recent years (Nevill, Webb & Watts 2013). However, it has not been determined as yet whether influencing referees has a causal influence on the home advantage.

Tactical play is also influenced by the location of the playing ground. In home games, players are more effective in offensive actions and less inclined to take defensive actions due to support from the ranks (Schwartz & Barsky 1977) since teams want to win in front of home crowds and offensive play is conducive to the achievement of this goal (Carmichael & Thomas 2005). Furthermore, the audience itself has a direct impact on the players. For example, the

volume of the audience is perceived in a negative way to be louder by away teams than by home teams (Barnard, Porter, Bostron, ter Meulen & Hambric 2011). Furthermore, players have higher self-confidence and conviction before home matches and less fear of the game (Bray, Jones & Owen 2002). This could become a self-fulfilling prophecy. Athletes go into a home or away game with different expectations (Fothergill, Wolfson, Neave & Moss 2012, Jurkovic 1985). When teams perceive a home advantage or an away disadvantage, their performances may differ even if no (other) advantage or disadvantage exists (Strauß & MacMahon 2019). Home teams have also been perceived to have higher resistance forces, e.g. by measuring the level of testosterone, seeing the away teams as intruders into their territory (Carre, Muir, Belanger & Putnam 2006).

An elementary influence on the result besides external factors is the real strength of a team. This results in particular from the monetary possibilities of clubs. Only financially strong clubs can bring in superstars who possess extraordinary abilities and therefore cost more in salaries and transfer fees. Teams with several such players have a higher market value and also win more matches. The same reasoning can be applied to younger talented players who are not yet superstars but for whom such teams offer greater incentives (Garcia-del-Barrio & Pujol 2007). This may even lead to a self-reinforcing effect at home matches, as there are more home fans in the stadium at matches where the superiority of one's own team is assumed to be due to its higher market value (Buraimo & Simmons 2008). Serrano, García-Bernal, Fernández-Olmos and Espitia-Escuer (2015) also examined the greater influence of more spectators at teams with higher market value. The largest factor for success in national leagues is the composition of the team and its related market value. If the financial imbalance of a league decreases, this effect also decreases (Gerhards & Mutz 2017).

Reade, Schreyer and Singleton (2020) analysed 160 European ghost matches and thirty-three thousand matches with spectators in various national and international competitions from the 2002/03 season until April 2020, just before the ghost games analysed by us. They found that 36 % of home matches were won in empty stadiums compared to 46 % of home matches in full stadiums. Taking into account the strength of the teams, this difference is not statistically significant. Most of these matches were played as ghost games because misconduct by one of the teams or its fans took place before. Furthermore, they showed that differences in refereeing behaviour could be observed. Away teams generally received more yellow cards than home teams but in matches without an audience this difference was significantly lower. In June, they added to their research the ghost games that have taken place so far in the EU,

compared them with games before the Covid-19 break since 2016 and found a decline in home wins without going into details as for the ghost games before or as we do here.

Fischer and Haucap (2020) have also produced a study on ghost games and examined the first three leagues in Germany. They found a decline in the home advantage in the first league but no significant change in the second and third league by ghost games. Their main explanation is the reduction in the number of spectators that is higher in the first league. Other relevant factors in their investigation are tracks in the stadium, the travel distance, derbies and matches within the week. We take another look at the influence of the spectators and different factors in the first league.

3. Hypotheses

On the basis of the literature review and our own considerations, we formulate three hypotheses that can be tested empirically. As shown in Section 2, the home advantage can depend on various factors, with spectators usually being the main factor. So our first hypothesis is (in accordance with Reade, Schreyer & Singleton 2020 and Fischer & Haucap 2020):

1) The home bias disappears in ghost games.

Further we try to examine the influence of the spectators not only directly on the result but also on parameters influencing this result. As explained in Section 2, the referee plays a role in the outcome of the game while the performance of the referee is influenced by the presence of spectators.

2) The referee's decisions no longer benefit the home team without spectators.

The teams' performance plays the main role in the outcome, so we survey various performance parameters like distance run in km, passes accuracy, possession, tackles won and shots needed to score a goal to test our third hypothesis:

3) The performance of the home teams without spectators becomes weaker and at the same time that of the away team becomes stronger with the following parameters: distance run in km, passes accuracy, ball possession, won tackles and shots necessary to score.

4. Data

Our data is made up of the total of all 306 matches in Germany's first football league (of men) in the season 2019/20. The first 223 games were played under normal conditions with spectators. These were mainly the matches of the match days 1 to 25. Only two matches of these match days took place later without spectators. One was the game between Borussia Mönchengladbach and the FC Köln of the 21st match day, which was played on 11 March 2020 immediately before the break by Covid-19 because it was cancelled on the original date due to a storm warning by the German Weather Service and resulting safety concerns. The other match between Werder Bremen and Eintracht Frankfurt of the 24th match day was initially delayed only shortly due to a tight schedule because of Eintracht Frankfurt's participation in the Europa League, but was postponed longer to 3 June 2020 due to the Covid-19 break. From 16 August 2019 to 8 March 2020 Bundesliga matches were played under regular conditions. The matches continued on 16 May 2020 with the 26th match day. From that date until the 34th match day on 27 June 2020, all matches were played with spectators excluded. Together with the two matches mentioned above, 83 matches were played without spectators. Our observation period is therefore exactly one football season. Furthermore, only Bundesliga matches are taken into account and not matches of other competitions like German cup games or the Champions League, as these competitions have their own dynamics and teams from different leagues participate.

We have collected various data for the match days. For the question of the extent of the home bias during the current Bundesliga season, we recorded the final results for goals scored and the distribution of home wins, draws and away wins. Further indicators of the teams' playing style are the number of scored goals, the distance run in kilometres, the passes accuracy, the ball possession, the tackles won and the fouls committed. The fouls committed are just as decisive for the assessment of the referee's behaviour as the cards dealt to each team. The score in the 90th minute and the given extra time also play a decisive role in assessing the behaviour of the referee. For the extra time, the actual extra time and not the displayed extra time was used as these can sometimes vary considerably and the referee can especially influence the former. We have collected all data relevant to our research with one exception from kicker.de, the homepage of the leading football magazine in Germany.

The exception is the data on market values that we have collected at transfermarkt.de for different moments in time. This seems necessary to evaluate whether a possible disappearing home advantage in the ghost games is merely due to a random distribution of the better teams

as away teams. Therefore, it makes sense to choose different points in time to collect these data to take into account the changes in the strengths of the teams during the period and possible transfer activities. This appears to be a better indicator than the table position because the results to be investigated are directly fed into the table. Accordingly, we have chosen the value of the teams on transfermarket.de on 15 August 2019 for match days 1 to 7. From match day 8 to the end of the first half, the 17th match day, we have taken the values on 15 October 2019. The team values on 15 January 2020 are the reference values for match days 18 to 25, the last match day before the Covid-19 break. Major changes are expected at this value due to the transfer phase in winter. The transfer values from the restart of the league on 16 May 2020 are taken for the match days 26 to 34. They are lower than before the Corona break due to the changed financial possibilities of the clubs but only the relative values of playing teams are relevant for us.

5. Empirical Results

For a broader measure of the usual home advantage, we document in Figure 1 the development of the home advantage in the last ten Bundesliga seasons before the current season, which is from the 2009/10 season up to the 2018/19 season, using data from dfb.de, the homepage of the German football federation.

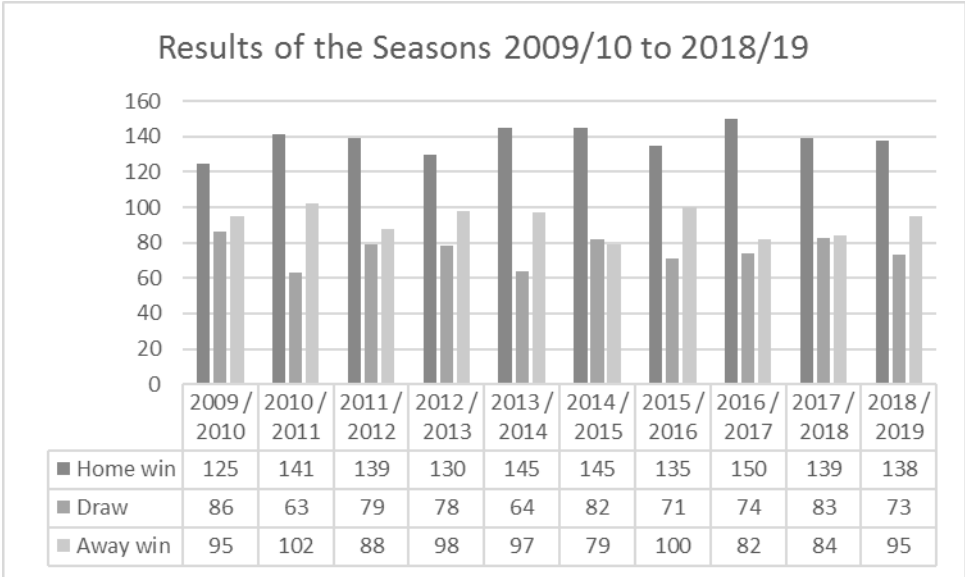


Figure 1: Results of the Seasons 2009/10 to 2018/19

According to these data, there is an average probability of victory for the home team of 45.33 % while 58.32 % of the points are scored at home. On average, away wins occurred in 30.07 % of matches and draws accounted for the remaining 24.61 %.

In the following, we examine the data of the season 2019/20 regarding differences between matches played under normal conditions and ghost games. To do this, we will first look at descriptive statistics in Subsection 5.1., then use various statistical test procedures in Subsection 5.2., and finally present results of regression models in Subsection 5.3.

5.1. Descriptive Statistics

We investigated the entire season as well as only the mirrored games together with the ghost games. The latter reduces the data set of matches under regular conditions (RG) from 223 to 83 but has the advantage that the same teams play against each other and matches between other teams are not considered. Accordingly, the results were somewhat stronger (but similar and those with all games of the season are available upon request). Table 1 shows a comparison of the descriptive statistics of the 83 games under regular conditions and the 83 ghost games (GG) without spectators.

Looking at Table 1, a decline in home wins from 48 % before the Covid-19 break to 33 % home wins after the break can be observed. In combination with the draws, which increased from 19 % to 23 %, this results in on average 0.44 points less at home. In addition, the difference in goals from the home team's point of view is reversed from a positive value of 0.43 to a negative value of -0.23. On a purely descriptive level, our first hypothesis could be confirmed but other tests are needed to establish this. Conspicuously, the market values of both the home and away teams are declining sharply, which is due to presumably changed financial conditions including reduced earnings for all teams and a decline in the market value of individual players during a longer break from training. Although the difference in market values from the home team's point of view is reversed from a positive to a (very small) negative value.

Variables	N		Minimum		Maximum		Mean (M)		Std. Deviation (SD)	
	RG	GG	RG	GG	RG	GG	RG	GG	RG	GG
Home win	83	83	0	0	1	1	0.48	0.33	0.503	0.471
Draw	83	83	0	0	1	1	0.19	0.23	0.397	0.423
Away win	83	83	0	0	1	1	0.33	0.45	0.471	0.500
Home points	83	83	0	0	3	3	1.64	1.20	1.367	1.314
Away points	83	83	0	0	3	3	1.17	1.57	1.333	1.345
Diffpoints	83	83	-3	-3	3	3	0.47	-0.36	2.670	2.625
Market value in Mio. € (H)	83	83	27.60	26.53	882.65	756.58	262.57	228.20	219.123	195.097
Market value in Mio. € (A)	83	83	27.60	26.53	882.65	756.58	257.57	231.75	215.261	196.101
Market value difference (H-A)	83	83	-798.00	-716.13	846.65	687.80	4.99	-3.56	311.049	282.023
Goals (H)	83	83	0	0	8	6	1.86	1.43	1.466	1.390
Goals (A)	83	83	0	0	5	6	1.42	1.66	1.308	1.391
Goals difference (H-A)	83	83	-5	-5	8	5	0.43	-0.23	2.142	2.216
Extra time 2nd half (min)	83	83	0	0	10	7	3.73	3.23	1.994	1.727
Shots on target (H)	83	83	4	4	29	34	15.98	13.33	5.280	5.310
Shots on target (A)	83	83	2	4	24	26	11.88	11.83	4.715	4.520
Shots/Goals (H)	83	83	0	0	29	22	7.64	6.08	6.259	5.455
Shots/Goals (A)	83	83	0	0	24	18	6.04	5.95	5.737	4.67
Distance run in km (H)	83	83	104.10	105.38	127.95	126.39	116.58	115.20	4.368	4.691
Distance run in km (A)	83	83	103.64	105.74	129.35	124.21	116.11	115.19	5.061	4.411
Passes accuracy % (H)	83	83	64	65	94	89	78.55	79.67	6.453	6.165
Passes accuracy % (A)	83	83	60	57	92	90	75.86	78.34	7.148	7.307
Possession % (H)	83	83	29	27	76	72	53.05	51.25	11.244	11.261
Possession % (A)	83	83	24	28	71	73	46.95	48.75	11.244	11.261
Tackles won % (H)	83	83	39	37	63	60	50.67	50.65	4.859	4.723
Tackles won % (A)	83	83	37	40	61	63	49.33	49.35	4.859	4.723
Fouls committed (H)	83	83	6	4	23	22	11.82	12.14	3.700	3.693
Fouls committed (A)	83	83	5	3	22	20	12.07	11.89	3.780	4.150
Yellow cards (H)	83	83	0	0	6	6	1.72	2.00	1.193	1.538
Yellow cards (A)	83	83	0	0	6	4	2.23	1.87	1.364	1.102
Red cards (H)	83	83	0	0	1	1	0.04	0.02	0.188	0.154
Red cards (A)	83	83	0	0	1	1	0.08	0.02	0.280	0.154
Cards (H)	83	83	0	0	7	6	1.8	2.1	1.266	1.551
Cards (A)	83	83	0	0	6	5	2.41	1.95	1.344	1.168
Cards difference (H-A)	83	83	-4	-3	5	4	-0.61	0.14	1.681	1.639

Table 1: Descriptive Statistics of the Season 2019/20

For the descriptive assessment of our second hypothesis that refereeing behaviour is less favourable to the home team in ghost games, we have to take into account not only overtime at the end of the game but also the cards given to the teams. The extra time at the end of the game decreases from 3.73 to 3.23 minutes, which initially supports our hypothesis. The same applies to the number of cards. By the way, we only considered the cards for the teams and

not those for the officials. Furthermore, we have only counted the number of cards, not the reasons such as fouls, complaints or taking off the jersey after scoring a goal. The number of (all) cards for the home team increases for ghost games and decreases for away teams. The variable “Cards difference (H-A)” of the difference in cards shows this clearly by its negative value of -0.61 for regular games and its positive value of 0.14 for ghost games. However, the tendency towards more cards for the home team and fewer cards for the away team is also clearly visible in the individual types of cards (yellow cards and red cards) in a direct comparison of the total. Only the number of red cards for the home team is also decreasing but the cards for the away teams are decreasing more. All of this is in accordance with our second hypothesis but also requires further investigation.

For our third hypothesis, that of less pronounced performance indicators for the home team and simultaneously a stronger away team in ghost games, it can be stated that fewer shots are fired by the home team. However, the home team needs 1.56 fewer shots to score a goal in ghost games than before. For the away team both values are almost unchanged. Likewise, no large differences can be found in the duels won. For both teams, the mileage decreases slightly during the game but it decreases more for the home team than for the away team. In any case, the accuracy of passes and the distribution of ball possession have developed in the direction of our hypothesis, since the first one increases more for the away time while the second one decreases for the home team and increases for the away team. All in all, our third hypothesis can be partially confirmed just looking at the descriptive statistics. More meaningful statistic tests are presented in Subsection 5.2.

5.2. Tests of Significance

To examine our hypotheses further, we use tests of statistical significance. First, Chi-square tests are performed for the distribution of home wins, draws and away wins as shown in Table 2. The types of result are shown in the rows and the type of match day, whether regular (RG) or ghost (GG), is shown in the columns, along with other relevant indicators. There are significantly less home wins while the increases in draws and away wins are not statistically significant.

Direct comparison of the match days	RG			GG			Pearson Chi-square	df	Asympmtotic Significance (2-sided)	
	M	SD	N	M	SD	N				
Home win	0.4819	0.5027	83	0.3253	0.4713	83	4.229	1	0.040	**
Draw	0.1928	0.3969	83	0.2289	0.4227	83	0.326	1	0.568	
Away win	0.3253	0.4713	83	0.4458	0.5001	83	2.543	1	0.111	

Table 2: Chi-square Tests for the Different Types of Games

As a check of these results and for the other variables to be tested, t-tests with independent samples are used. All variables were tested, but apart from home win, draw and away win, only those are listed in Table 3 that are statistically significant with the usual error probabilities of less than 10 % (*), 5 % (**) and 1 % (***). Otherwise, no new information is provided compared to Table 1.

Direct comparison of the match days	RG			GG			Sig. (2-tailed)	
	M	SD	N	M	SD	N		
Home win	0.4819	0.5027	83	0.3253	0.4713	83	0.040	**
Draw	0.1928	0.3969	83	0.2289	0.4227	83	0.571	
Away win	0.3253	0.4713	83	0.4458	0.5001	83	0.112	
Home points	1.6386	1.3667	83	1.2048	1.3137	83	0.039	**
Away points	1.1687	1.3327	83	1.5663	1.3452	83	0.058	*
Diffpoints	0.4698	2.6702	83	-0.3614	2.6252	83	0.045	**
Goals (H)	1.8554	1.4661	83	1.4337	1.3898	83	0.059	*
Goals difference (H-A)	0.4337	2.1424	83	-0.2289	2.2159	83	0.052	*
Extra time 2nd half	3.7349	1.9944	83	3.2289	1.7273	83	0.082	*
Shots on target (H)	15.9759	5.2799	83	13.3253	5.3102	83	0.002	***
Shots/Goals (H)	7.6445	6.2597	83	6.0819	5.4558	83	0.088	*
Distance run in km (H)	116.5799	4.3680	83	115.1982	4.6915	83	0.051	*
Passes accuracy (A)	75.8554	7.1485	83	78.3373	7.3073	83	0.028	**
Yellow cards (A)	2.2289	1.3644	83	1.8675	1.1018	83	0.062	*
Red cards (A)	0.0843	0.2796	83	0.0241	0.1543	83	0.088	*
Cards (A)	2.4100	1.3440	83	4.0500	2.2030	83	0.020	**
Cards difference (H-A)	-0.6144	1.6810	83	0.1445	1.6390	83	0.004	***

Table 3: t-Tests with Independent Random Sampling (Grouped by Type of Game)

The decrease in home wins is again statistically significant while the increases in draws and away wins are not. This, along with the significant decreases in home goals and the goal difference from the home team's point of view, supports our hypothesis 1. Also the significant decrease in home points and significant increase in away points show that the home advantage disappears without spectators. Moreover, the variable "Diffpoints", which shows the differ-

ence of the scored points from the point of view of the home team, is significant in favour of our hypothesis.

Regarding hypothesis 2 on the change in referee behaviour, the variable “Extra time 2nd half (min)” is significant. The difference between the cards of the home and away teams is even more significant. The change in the number of cards for away teams as well as their yellow and red cards are significant, too.

For hypothesis 3, there are significantly less shots fired on target by the home team, while there is a significantly higher pass accuracy of the away team. Furthermore, the home team runs significantly less during the ghost games. However, as mentioned above, all other variables listed in Table 1 but not in Table 3 have no significant difference between regular games and ghost games.

For the differences in goals, cards and market values between home and away teams, additional t-tests are carried out on one sample in each case to check whether these differences are significantly different from 0.

	Type	t	df	Sig. (2-tailed)	M	N	
Market value difference (H-A)	RG	0.146	82	0.884	0.5421	83	
	GG	-0.115	82	0.909	-3.555	83	
Goals difference (H-A)	RG	1.844	82	0.069	0.4337	83	*
	GG	-0.941	82	0.349	-0.2289	83	
Cards difference (H-A)	RG	-3.331	82	0.001	-0.6144	83	***
	GG	0.804	82	0,424	0.1445	83	

Table 4: t-Tests on One Sample

Table 4 shows that the home advantage of goals scored is statistically significant before the Covid-19 break but not after the break. Likewise, the home advantage regarding the distribution of cards is significant before but not after the break. The difference in the market values of the two teams is not significant in either case.

5.3. Regression Results

To test our hypotheses further, we use regressions that control the influence of several variables at the same time. We regress home wins, the difference in cards and the length of extra time. Concerning hypothesis 3, the performance variables have not provided significant regression results such that they are not discussed further in this section.

For home wins as the dependent variable, a binary logistic regression is suitable. First, we have included in the regression all variables listed in Table 1 that are not interdependent, such as market value difference (H-A) that is calculated from market value (H) and market value (A). Then we removed all insignificant variables, like the performance variables, from the regression.

Independent variables	B	Exp(B)	Sig.	
Type of game	-0.828	0.437	0.018	**
Market value difference (H-A)	0.002	1.002	0.001	***
Extra time 2nd half (min)	-0.210	0.810	0.027	*

Table 5: Binary Logistic Regression for Home Wins

Table 5 shows the remaining variables that have a statistically significant impact on home win without directly influencing it like the variable “Goal difference (H-A)”. Ghost games are significantly negative for home wins, confirming our hypothesis 1. The variable “Market value difference (H-A)” has a significantly positive influence on home wins that is not surprising (see also Section 2). Furthermore, the length of extra time has a significantly negative influence on home wins. However, this could be a case of reverse causality if the referee gives more overtime in case the home teams is one goal behind or has the chance to win a tied game.

There are different regression models that could be used for “Cards difference (H-A)” as independent variable. As Figure 2 shows, the variable is sufficiently normally distributed such that a multiple linear regression is possible with the following equation:

$$\gamma = \alpha + \beta_1x_1 + \beta_2x_2 + \dots + \beta_nx_n$$

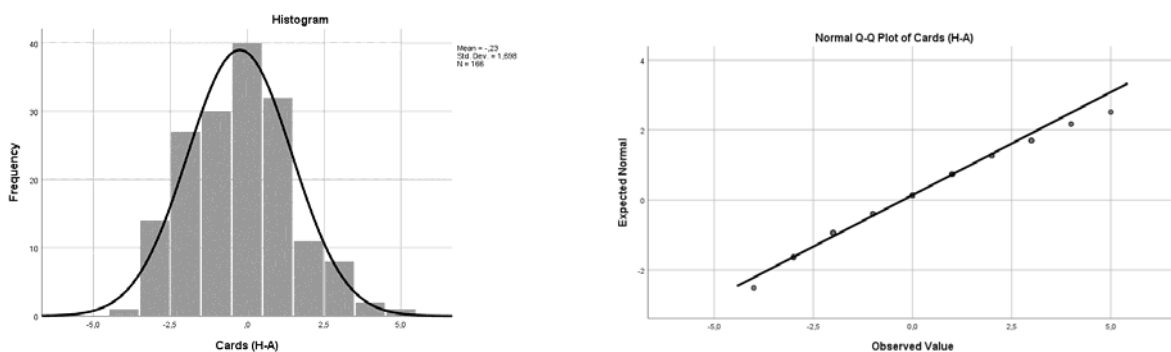


Figure 2: Distribution of the Cards Difference

To include independent variables in the model, we proceeded as before, starting with all of them without interdependencies and then repeating the regression with the significant ones only. Four of them remain in the model as shown in Table 6. The adjusted R^2 as a quality measure of the linear regression is 0.219. That means 22 % of the variance is explained by this model.

Independent variables	B	Std. Error	T	Sig.	
Type of game	0.603	0.239	2.526	0.013	**
Goal difference (H-A)	-0.136	0.054	-2.490	0.014	**
Fouls committed (H)	0.126	0.033	3.868	0.000	***
Fouls committed (A)	-0.136	0.030	-4.473	0.000	***
Constant	-0.406	0.509	-0.797	0.427	

Table 6: Multiple Linear Regression for Cards Difference

The most important result is that the type of game has a significantly positive influence on the difference of cards between home and away teams. Given the fact that home teams get less cards in regular games, this confirms our hypothesis 2 that the home team bias in the distribution of cards disappears in ghost games. The difference in goals reduces the difference in cards, meaning that the leading team gets fewer cards. It is not surprising that fouls by the home team have a significantly positive effect on the difference of cards for the home and away team while the fouls of the away team have conversely a significantly negative effect.

For the analysis of „Extra time 2nd half“ as dependent variable, the appropriate regression has to be considered again. Figure 3 shows that the deviations from the normal distribution are larger than those for the cards difference but not too large such that a multiple linear regression model can be used again. The variables are chosen as before such that only two independent ones remain in the final regression. The results are shown in Table 7. The adjusted R^2 of this regression is 0.068.

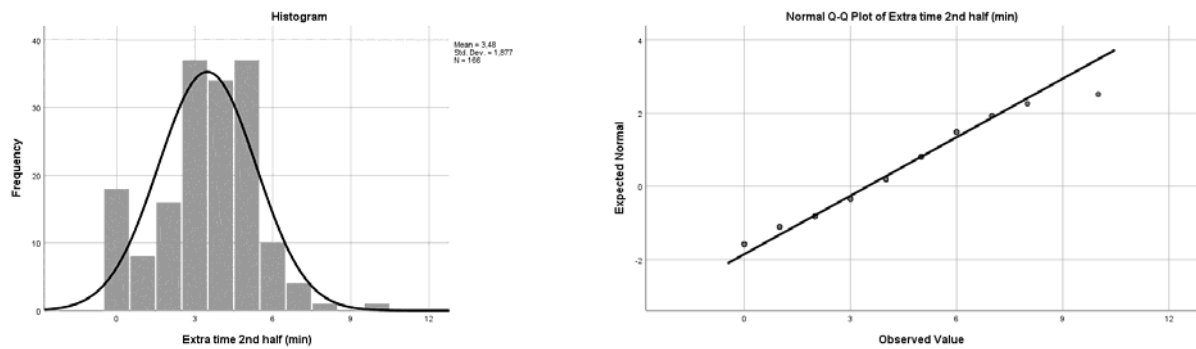


Figure 3: Distribution of the Extra Time

Independent variable	B	Std. Error	t	Sig.	
Type of game	-0.633	0.286	-2.209	0.029	**
Goal difference (H)	-0.191	0.065	-2.929	0.004	***
Constant	3.818	0.202	18.882	0.000	

Table 7: Multiple Linear Regression for Extra Time

Ghost games significantly reduce the overtime given by the referee. Also statistically significant is the goal difference. More goals by the home team decrease the overtime. This could be due to a home bias by the referee who gives (only) the home team more time if it need it to win or not to lose.

6. Discussion

We discuss our hypotheses separately before we come to some general points. Our first hypothesis is (see Section 3):

1) The home bias disappears in ghost games.

We can confirm this hypothesis. A purely descriptive examination of the results shows a decline in home wins, home points scored and goals scored by home teams. In the t-tests the decreases of these variables are statistically significant and also in the tests of the individual samples the goals differences in favour of the home team is significantly positive only before the COVID-19 break. Nevertheless, the disappearance of the home bias does not turn into a significant advantage for the away team or a home disadvantage. The binary logistic regression confirms the disappearance of the home advantage even controlling for other variables like differences in team values that a very important by themselves. This confirmation of our first hypothesis follows the results of Reade, Schreyer and Singleton (2020) as well as Fischer and Haucap (2020), despite some differences in the examination of the home bias.

Our second hypothesis has not been analysed so far (to the best of our knowledge):

2) The referees' decisions no longer benefit the home team without spectators.

There are significant decreases in the yellow, red and total number of cards for away teams. The away teams committed fewer fouls in the ghost games, too, but this difference is not significant. The difference in cards the home and away team get is significantly changed. In regular games the home teams got significantly less cards and in the ghost games they got insignificantly more. This is also confirmed by the linear regression model, in which the ghost games have significant effect that evaporates any home bias in this regard.

As a further indicator of the change in refereeing behaviour, we use the length of extra time at the end of the game. There is also a significant difference between regular games and ghost games. The average overtime is reduced from 3.73 minutes to 3.23 minutes. The linear regression shows a significant influence of the type of match day on the length of extra time but no significant influence of fouls that could cause delays. However, the goal difference from the point of view of the home team has a significantly negative influence on the extra time. This is an indicator of a home bias because games are finished sooner when the home team is leading whereas they go on longer if the home team need one more goal to win or reach a draw. This can explain why there is a significantly negative sign of the length of extra time in the regression model of the home win. In sum, there is strong evidence for a home bias in the refereeing behaviour in regular matches that is at least reduced if not eliminated in ghost games in accordance with our hypothesis.

This is our third hypothesis:

3) The performance of the home teams without spectators becomes weaker and at the same time that of the away team becomes stronger with the following parameters: distance run in km, passes accuracy, ball possession, won tackles and shots necessary to score.

This hypothesis cannot be confirmed. There are only significant differences in the performance characteristics distance run by the home team, passes accuracy of the away team and shots on target by the home teams. Although these differences fit into the direction of the hypothesis as the home teams becomes weaker and the away team stronger, it should be noted that the mileage of away teams also decreases, although insignificantly, while the passes accuracy also increases for the home team at an insignificant level. The number of shots on tar-

get by the home team decreases significantly but the number of shots required per goal decreases, although insignificantly, such that these variables could cancel each other out. It should also be noted that none of the performance variables was significant in the binary logistic regression for the home bias, and therefore the performance characteristics recorded here do not appear to have any relevant influence on the achievement of a home win.

In summary, the disappearance of the home advantage in ghost games can be seen from the pure results as in previous investigations without the emergence of an away advantage. While the performance measures of the teams surveyed here have no relevant influence on this, the referees' behaviour changes significantly and contributes to the disappearance of the home bias.

As already mentioned in Section 1, there were external conditions besides the (missing) spectators that influenced the results and are not included in our evaluation, such as the return of key players, different incentives at the end of the season by the table positions, differences in the game schedule before and after the break, different training conditions and preparations of the teams, activities on the transfer market in winter and some rule changes as the possibility to change five players instead of only three during a ghost game. Perhaps even the virus itself had an influence on the games. For example, Mario Götze, a player at Borussia Dortmund and a former world champion, missed the last games because he did not want to go into planned quarantine due to his family situation. In a perfect experiment, these effects would all be non-existent and games would take place under exactly the same conditions with and without spectators. However, this is not feasible and there has never been such comparability of games with and without spectators as in the season 2019/20.

7. Conclusion and Outlook

In conclusion, we were able to show the disappearance of the home bias in ghost games and show one reason for this, the changed behaviour of referees who lost their bias for the home team without spectators. The German Bundesliga has made the prelude for a restart and therefore we have investigated it. Just as the German Bundesliga has made a kick-off for football, research on this can be the prelude to a wide range of different research in the sports field on the effects of the COVID-19 pandemic.

Further research is needed with regard to the breadth of the data set. Further first leagues in Europe should be analysed and also lower leagues could be included, as Fischer and Haucap

(2020) have already done for the second and third leagues in Germany. The Economist (2020) also looked at several leagues in Europe and descriptively found a decline but no disappearance of the home advantage while the home bias of referees vanished completely. In addition, possible differences and similarities between men's and women's football could be surveyed. For reasons of comparability of the sporting framework conditions, it should be avoided to use data that are not in the current season and allow the data set to be mirrored. Other variables, other competitions besides league games as well as other sports could also be analysed.

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