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Master Thesis Economics of Markets and Organisations

How the crowds affect agents' behavior to create home advantage in European Football

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Abstract

This paper analyses the effects of crowds on performance in sports, using covid 19 restrictions as an exogenous shock to crowd presence in European football competitions. It investigates the crowd's role in terms of match outcomes and whether a separate effect exists for players as well as for referees. Lastly, it investigates a potential role of experience with crowd pressure for both agents. OLS-regressions are used to find generally positive effects of the home crowd on home advantage through match outcomes, whereas the role of crowd size remains ambiguous. Through yellow card home advantage and third-party individual performance ratings, I find indications that players and referees are both significantly affected by crowd presence, increasing overall home advantage. For players, I find that younger players seem to perform worse than older players in front of away crowds specifically, whereas, for referees, I do not find any significant effect of experience with crowd pressure.

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Introduction

In sports, the notion of home court advantage suggests that a team or a player, playing at their home court or stadium somehow has an advantage over the 'away' playing team or player. This phenomenon is most easily observable in team sports, where teams usually play about half of their matches in a home court or stadium and the other half on the opposing teams' courts. The fact that some sort of an advantage exists in many (team) sports is well documented over time, by Nevill and Holder (1999), for example.

The empirical literature in sports (economics) has identified three main mechanisms involved with home (court) advantage. These mechanisms are; travel distance/fatigue, familiarity of surroundings, and crowd pressure/support (Pollard, 1986). The notion that travel distance and surroundings likely play a part in home advantage has been established quite well in the empirical sports literature. Analyzing German football, Oberhofer, Philippovich, and Winner (2010), amongst others, find negative effects of travel distance on outcomes. Circumstances like pitch size or artificial grass have also been shown to affect home advantage (Van Ours, (2019)). Pollard (2002) suggests that the familiarity with the location matters as he found that sports teams that recently moved stadiums dropped in home advantage.

This paper focuses on the third mechanism, which consists of the crowd's pressure/support in home advantage. The presence of a (partisan) crowd provides pressure and/or moral support that can potentially affect home advantage. The idea of moral support as a factor affecting performance in the context of football/sports was showcased by Colella et al. (2021) in a natural experiment, where specifically the visiting support was excluded. Secondly, the crowd could also affect agents' behavior by creating social pressure. Social pressure by home crowds has been shown to sway referee decisions in favor of the home playing team, playing an integral part in the existence of home advantage (Garicano, Palacios-Huerta & Prendergast, 2005). This social pressure likely affects players as well, as they are the ones from whom a certain level of performance is expected by the people attending. The fact that people sometimes 'choke under pressure is well established in social psychology (Baumeister, 1985).

This paper aims to specifically find the crowd's effects on the outcomes of matches and competitions, as well as, separate effects for players' and referees' performance/behavior. For both types of agents, the factor of experience with crowd pressure is used to investigate within agent heterogeneity of the crowd effect. This paper therefore not only serves to confirm the

fact that the crowd plays a significant role in home advantage, but it also aims to better understand the mechanism(s) through which the crowd affects home advantage, as multiple types of agents are involved.

Generally, disentangling the crowd's effects from the other two mechanisms has been a problem in the past, as situations with a prolonged absence of crowds are very rare. This made it hard to isolate the crowd's effects specifically. Pre-covid 19 studies have used instruments like same city or even same stadium derbies to prevent the factors of travel distance and familiarity of surroundings from confounding with crowd effects (Ponzo & Scoppa, 2018). To disentangle mechanisms, these studies have often had to fall back on very specific matches where factors like crowd intensity are not likely similar to most other matches, which is an obvious problem in same city derbies.

Due to the covid-19 pandemic, however, over a season of football matches with virtually no crowd presence has taken place. It is therefore now possible to use matches from during the lockdown for covid-19 as a counterfactual for crowd presence as a natural experiment. The main question asked with regards to this natural experiment usually is; 'does the crowd's presence affect match outcomes?'. This paper specifically uses match outcome data from the top professional football competitions in England, Germany, and Spain, as well as, the second-tier competitions in England and Germany. In this paper, home advantage is defined as the surplus amount of points (not goals) awarded to home teams as compared to away teams, instead of the more commonly used goal-difference or home win-percentage statistics. This way, the measure of home advantage is most relevant to competitive outcomes. The first hypothesis, therefore, serves to determine whether the crowd significantly matters in terms of home advantage.

H1: Crowd presence positively affects home advantage

This hypothesis is tested by means of an OLS-regression model, where crowd presence is a binary independent variable (present or not), to measure the effect of the crowd on points scored by the home team. Here, the first complete season without a significant crowd presence (2020/2021) is used as the sample where crowd effects are not present.

If crowd presence matters, however, a follow-up question with regards to the effect of crowd size is extremely relevant, as crowd size would be the most obvious way to gain a competitive advantage through crowd effects. A larger crowd could potentially provide more

pressure/support and therefore increase home advantage. Do larger crowds provide a competitive advantage?

H2: Crowd size positively affects home advantage

To test this hypothesis, again, a very similar OLS-model is used, but in this case, it uses the crowd size, measured in absolute attendance, instead of crowd presence, where increased attendance is expected to increase home advantage, as per H2.

Previous research using matches played in empty stadiums post-covid 19, by Scoppa (2021) and Bryson et al. (2021), points towards the idea that the crowd is a significant factor in home advantage. Other studies in the same period, however, show mixed effects for crowd support on team performance. This is especially the case when separating effects of the crowd for different leagues and using lower-tier leagues as well the top competitions in a given country (Jimenez & Lavin, 2021; Benz & Lopez, 2021). Using the same lockdown period to investigate home advantage, Fischer and Haucap (2020) have hinted that occupancy rates of stadiums might affect home team performance more than absolute attendance. Perceived levels of pressure and support from the crowd seem to determine the effect of the crowd more than the size of the crowd itself. This finding seems to be in line with pre-covid-19 research on the effect of crowd size conducted by Dowie (1982) and Pollard (1986).

In this paper, however, the 2019/2020 season is excluded from the counterfactual. This is mainly because the effects of the covid-19 pandemic, which effectively started during the latter part of the season, were not likely very homogenous for many other factors than crowd presence. I pose that the erratic nature of the spread of the virus as well as the existence of geographical hot-spots, especially in the first wave of covid-19, affected clubs differently and thus affects the ceteris paribus condition on which much of the new research on crowd effects relies.

Next to determining the crowd's general effect on home advantage, this paper mainly aims to disentangle the effects on the two main agents that are involved in home advantage; the players and the referees. Does each agent significantly contribute to home advantage due to crowd effects? H1 is tested with separate measures for both agents, to test if both agents are even significantly involved and to what extent each agent is affected by the crowd. For each agent, the characteristic of experience/familiarity with large crowds is of interest, as it could be that there are learning effects of performing in front of these large (partisan) crowds.

H3: Experience with performance under crowd pressure decreases the crowd's effects on performance/bias for referees and individual players.

To investigate the crowd's effects with regards to referees, the concept of yellow card home advantage is used. If the referees' decisions are generally biased towards the home team, one would expect the amount of yellow cards received by home teams to be lower than by away teams. This difference in favor of the home team is called 'Yellow card home advantage'. Firstly, the effect of the crowd's presence on yellow card home advantage is measured, again using an OLS-model, where the independent variable 'crowd' is binary. Secondly, a binary measure for referee experience with crowd pressure is introduced, to find whether experience matters for the effect the crowd has on referees. If matches with experienced referees show less home advantage, this would also now establish that referee behavior is a significant factor in yellow card home advantage, as previously it could not be excluded that a large part of yellow card home advantage was due to player behavior. Referees with 10 or more matches in the European Champions League will be called 'experienced'. Experience in this specific competition is used because the pressure in the Champions League in general, and therefore from the crowd, is likely to be extremely high as the stakes in that specific club competition are generally the highest.

Lastly, I Investigate the effect of the crowd on individual player performance in the English Premier League, using average statistics-based performance ratings from a third party. Again, an OLS-model is used to determine the effect of the crowd, but now I distinguish between home and away performances in the situation with a crowd, as well as, without a crowd. Even though the direction of the effect with regards to home advantage is expected to be the same as for the referees, the distinction between the two effects remains of interest due to the type of pressure that both agents are subject to. Where referees face pressure to comply, the players are pressured to perform. Investigating individual players' performances generally provides the opportunity to study which characteristics of players might affect the players' propensity of being affected by the crowd. In this paper, I distinguish between 'older' players and 'younger' players and 'larger' and 'smaller' home stadiums. These distinctions serve to find an effect of experience with playing in front of large crowds, as well as, determining whether crowd size affects home advantage, but from a players' perspective specifically.

With respect to the crowd's effect on home advantage in general, I only find statistically significant effects of the crowd and crowd size in the English Premier League, but coefficients are consistently positive across all competitions. I do not find that absolute attendance seems

to affect home advantage significantly in either an economic or statistical sense, which is in line with the aforementioned investigation by Fischer and Haucap (2020).

With regards to referees, I do not find a significant difference between referees that have Champions League experience and those who do not have this experience. Overall, I find positive effects of the crowd on yellow card home advantage, with only the Spanish competition lacking any statistically significant effect, but even here, the direction and size of the coefficient is similar to all other competitions. These results solidify the notion of some degree of home bias existing.

Lastly, I find that players generally perform slightly worse in away games and better in home games when a crowd is present. Younger players are generally more strongly affected by the crowd presence than older players when playing away in particular. Older players' performances in away games on the other hand even increase with crowd presence. This is an indication that, at least from the players' perspective, experience matters. I do not find any convincing evidence that the size of one's home stadium/crowd matters significantly in home advantage. Since larger home stadiums do not seem to affect the difference between home and away performances, these results, again, do not indicate that crowd size affects home advantage directly.

The following chapter of this paper will explain the data and methodology used for all investigations regarding the crowd's effects on match outcomes and referee behavior, followed by data and methodology for the individual player performance part of the research. The third chapter will show and discuss all relevant results from the empirical tests, after which possible limitations of the research will be discussed. Finally, the paper will be wrapped up with some concluding remarks.

Data and methodology

I use publicly issued match data from competitions in England, Germany, and Spain to assess the crowd's effect on agent behavior as it pertains to Home advantage. For the countries England and Germany, I also use data from the second divisions to be able to make within-country comparisons for different levels of competition and crowd size. The three most recent pre-covid seasons are the sample 'with a crowd', to be able to compare to the 2020-2021 season of matches with 'no crowd'.

The 2019-2020 season is excluded because of the likely varying effects of covid-19 on different clubs. During the early stages of Covid-19 lockdowns, there were many adjustments made by clubs, which were likely different across clubs and even between competitions. Factors like staff size and geographical location of clubs could have created a situation where the effect of the pandemic is different between clubs, especially in the early stages of the pandemic. This variation might have affected results from previous studies on Home advantage, most of which mainly used data from early on in the pandemic i.e. the 2019-2020 season. The moment that matches stopped being played in front of crowds in that season might also not exactly have been when covid started affecting football clubs' organizations. In the 2020-2021 season, the pandemic had been internalized quite well by most football clubs in professional competitions through well-organized formations of bubbles and strict testing, to which all teams had had a chance to acclimatize at this point.

Match outcomes and yellow cards received by home teams and by away teams are retrieved from www.fbref.com for seasons before 2020/2021 and from www.football-data.co.uk for the most recent season. This sample includes 1.230 to 2.222 matches per competition, with 306 to 552 matches played without a significant crowd present. The variance in sample size between competitions depends entirely on the number of teams in each competition and whether some sort of post-season play-offs exists within a competition and the availability of post-season data. Since all competitions are played according to a round-robin format, all teams play as many home matches as away matches against all other teams in their competition. Including play-offs does not cause any problems since they always include a home and an away match between competing teams

It has to be noted that, even though all matches in the 2020/2021 season are called matches with ‘no crowd’, one to three competition rounds, were played in front of extremely reduced crowds in English and German competitions, with crowds never greater than 10.000 people and usually well below 10% of the stadium’s capacity. Even if the numbers for each of these matches were to be collected separately, they would not have been included in the ‘with crowd’ sample because of specific covid-19 protocols like the spacing of supporters, within stadiums, this means that 10.000 spectators in one of those games is not to be compared to a match with similar crowd size, but without the same protocol in my opinion. The decision to call these matches ‘no crowd’, is mostly justified, however, by the fact that crowds are in all cases extremely diminished compared to regular capacity/attendance. When referring to the absence of the crowd, this practically means the absence of a significant crowd from this point forward.

In this paper, home advantage is defined as the amount of points scored by the home playing team minus the amount of points scored by the away playing team per match in a specific competition. In all competitions, a team gains 3 points for a win, 1 point for a draw, and 0 points for a loss. By this definition of home advantage, each observation of one match will have home advantage value of 3 if the home team wins, 0 if the match ends in a draw, and -3 if the home team loses. Home advantage within a competition is therefore the result of home playing teams gaining more points per match than away playing teams over the course of one or multiple complete seasons.

For top competitions, I also make a distinction between matches that are refereed by a referee with Champions League experience and those that are not. This distinction serves to disentangle effects on referees from the effect on players, as well as, finding whether the referee specifically is affected more strongly by the crowd when less experienced/of lower ability. In this sample, referees with at least 10 matches of Champions League experience classify as referees with such experience. This leads to about 15% of matches refereed by ‘experienced’ referees in the Spanish and German leagues and About 24% in the English Premier League.

The reason 10 matches is chosen as the threshold for significant experience, is that this amount of matches equates to at least two seasons of refereeing in this competition, and therefore, these referees have had some chance to acclimatize to the pressure of the competition. These referees have proven themselves to be of high ability, as well as, of high enough ability in the context of this competition. This does, however, not automatically mean

that their home bias is different, as it is very well possible for two referees with the same level of home bias, to make a vastly different amount of (in)correct decisions. However, a less biased referee is a better referee all else equal. Naturally, a continuous measure for experience would have been preferable, but data collection restrictions made that infeasible for this piece of research. The data used to investigate effects on teams and referees is summarized in the following table:

Table 1: Competition-specific descriptive statistics with on the left side crowd absence and crowd presence on the right. Competitions are denoted by the first letter of the county and the number to distinguish between the competitions within countries. HA = Home Advantage, E =England, G = Germany, S= Spain.

COMP.	VARIABLE	MEAN	STD. DEV.	MIN	MAX	MEAN	STD. DEV	MIN	MAX
	crowd = 0					***crowd = 1***			
	N=380					**N=1140**			
E1	Home advantage	0.071	2.655	-3	3	0.516	2.595	-3	3
E1	Home score	1.353	1.320	0	9	1.566	1.319	0	7
E1	Away score	1.342	1.258	0	7	1.201	1.195	0	7
E1	Yellow card HA	0.024	1.543	-5	5	0.139	1.617	-6	5
E1	Home yellow	1.424	1.107	0	6	1.612	1.263	0	6
E1	Away yellow	1.447	1.160	0	5	1.752	1.285	0	7
E1	Attendance	-	-	-	-	37426	16937	9980	83222
	N=552					**N=1670**			
E2	Home advantage	0.223	2.588	-3	3	0.480	2.525	-3	3
E2	Home score	1.252	1.185	0	7	1.470	1.199	0	7
E2	Away score	1.056	1.016	0	5	1.132	1.054	0	6
E2	Yellow card HA	-0.007	1.572	-5	5	0.359	1.545	-5	6
E2	Home yellow	1.408	1.131	0	6	1.580	1.179	0	6
E2	Away yellow	1.400	1.170	0	6	1.939	1.319	0	7
	Attendance	-	-	-	-	20435	8703	2750	85826
	N=306					**N=918**			
G1	Home advantage	0.324	2.556	-3	3	0.542	2.541	-3	3
G1	Home score	1.676	1.397	0	8	1.683	1.375	0	8
G1	Away score	1.356	1.165	0	5	1.264	1.207	0	6
G1	Yellow card HA	0.127	1.570	-5	4	0.314	1.568	-6	6
G1	Home yellow	1.748	1.280	0	7	1.608	1.241	0	7
G1	Away yellow	1.876	1.300	0	7	1.922	1.236	0	7
G1	Attendance	-	-	-	-	43208	17306	13521	81365
	N=306					**N=918**			
G2	Home advantage	0.412	2.595	-3	3	0.428	2.495	-3	3
G2	Home score	1.637	1.218	0	5	1.514	1.231	0	8
G2	Away score	1.330	1.198	0	8	1.218	1.107	0	6
G2	Yellow card HA	0.108	1.945	-5	5	0.354	1.681	-6	5
G2	Home yellow	1.977	1.424	0	6	1.906	1.247	0	6
G2	Away yellow	2.085	1.409	0	6	2.260	1.265	0	7
G2	Attendance	-	-	-	-	19473	11297	2970	60000
	N=381[1]					**N= 1139**			
S1	Home advantage	0.362	2.512	-3	3	0.527	2.545	-3	3
S1	Home score	1.373	1.191	0	6	1.553	1.318	0	8
S1	Away score	1.136	1.057	0	6	1.188	1.180	0	6
S1	Yellow card HA	0.131	1.797	-5	6	0.281	1.978	-7	6
S1	Home yellow	2.165	1.415	0	8	2.394	1.514	0	8

[1] I find the irregularity of an uneven amount of games played with significant crowd presence. No crowd was allowed during the match between Barcelona FC and Las Palmas on October second, 2017 due to tensions between the authorities and supporters surrounding a referendum regarding the independence of Catalunya.

S1	Away yellow	2.297	1.434	0	7	2.675	1.468	0	8
S1	Attendance	-	-	-	-	27590	19406	3576	98485

The crowd's effect on match outcomes

The following OLS-regressions are used to determine whether a significant home advantage of the crowd exists within a competition and whether there is an effect of absolute attendance on home advantage.

$$Home\ advantage_{ijs} = \beta_0 + \beta_1 Crowd_s + h_i + a_j + e_{ijs} \quad (1)$$

$$Home\ advantage_{ijs} = \beta_0 + Attendance_{ijs} + h_i + a_j + e_{ijs} \quad (2)$$

At the first regression (1), I simply look for a general effect of crowd presence where the dummy for crowd presence equals 1 in the pre-covid seasons. In this regression, the dependent variable is home advantage in the game between home team i and away team j in season s. In the second regression (2), I look for a relationship between attendance (i.e. crowd size) and home advantage. Both regression include home team (h_i) and away team (a_j) fixed effects. These fixed effects are included to absorb effects on home advantage that are team specific and could therefore skew results. If team quality goes completely unaccounted for, for example, one would expect much higher crowd effects in competitions with less variance in team quality, as the crowd is likely going to affect the outcome of more matches. If the quality difference between teams is larger, this means that the effect of the crowd has to be more significant to show up in this particular measure.

It is important to note, however, that club fixed effects might not be as helpful as in previous research like Bryson et al. (2021) as there is now a gap of a year between the sample with a crowd and the sample without a crowd. This means that quality adjustments of the 2019/2020 season are absent in the sample that is used. Team fixed effects are generally much more crucial in previous research like Bryson et. al. (2021), due to the 'crowd' and 'no crowd samples' consisting of incomplete seasons, making the accuracy of team strength extremely important. In this paper, the regressions without these fixed effects are included as well in the appendix since they do provide the raw differences between outcomes with a crowd as

compared to without a crowd and act as a robustness check for the regressions with fixed effects.

Yellow card home advantage

Referee decisions are one of the main ways the crowd can affect home advantage. Yellow cards received are affected by the behavior of players and referees. The home crowd potentially affects either or both agents to skew the amount of yellow cards received in favor of the home team. The yellow card home advantage is therefore the difference between home and away team yellow cards in favor of the home team. The following OLS-regression will be used to find out whether there is an effect of the crowd on yellow card home advantage in general.

$$Yellow\ card\ home\ advantage_{ijs} = \beta_0 + \beta_1 Crowd_s + h_i + a_j + e_{ijs} \quad (3)$$

Here, again, (h_i) and (a_j) control for home team and away team fixed effects respectively. In the context of this particular model, they are supposed to absorb team-specific behavior, with regards to yellow cards received. Some teams generally might play more or less aggressively at home, due to crowd effects, for instance. This way, the measure of yellow card home advantage can somewhat be separated from player behavior. It does have to be stressed, again, that these fixed effects are not perfect with regards to absorbing team-specific behavior, in this case specifically due to the lack of the 2019/2020 season in the sample.

Next, I investigate whether yellow card home advantage in national leagues shrinks if referees have a higher degree of experience with large crowds/crowd pressure. By using experience in the Champions League, one selects for referees who have experienced high-pressure situations more often and are also repeatedly trusted to perform in such high-stakes situations. These factors lead to the expectation for matches led by these referees to show less home bias in general, as well as in situations with crowd pressure.

This mechanism is tested by the following regression, where the CL variable is a dummy for Champions League experience. Here, CL equals 1 if a referee has at least 10 matches of Champions League experience. This OLS-regression model captures crowd effects and distinguishes between two types of referees

$$Yellow\ card\ home\ advantage_{ijs} = \beta_0 + \beta_1 crowd_s + \beta_2 CL_{ijs} + \beta_3 crowd_s * CL_{ijs} + h_i + a_j + e_{ijs} (4)$$

This is also another way of potentially disentangling the effects of the crowd on referees and players. If yellow card home advantage is significantly different in matches where referees have Champions League experience, this confirms an effect of the crowd on referees which is separate from an effect of the crowd on players' behavior.

The crowd's effect on Individual performance

To determine the effect of the crowd on individual player performance, I use statistics-based individual performance ratings from 1 to 10 from whoscored.com. These performance ratings are based on events like successful passes and dribbles, which are kept by OPTA. The main advantage of using this type of performance metric compared to ratings from newspapers is that the ratings are primarily based on actual behavior and not perceived behavior. The ratings are created by whoscored.com, based on their undisclosed algorithm which takes into account 200 different raw statistics. They claim to take into account even relative importance of mistakes and success by the area on the pitch or consequences of mistakes. A failed dribble in one's own half of the pitch, which leads to a shot/scoring chance for the opposing team would hurt one's score more than a failed dribble on the opposing side's half and leads to a throw-in. Even with all this taken into account, however, it is still important to acknowledge that, due to the nature of a team sport, overall performance remains subjective and we can only objectively observe a limited amount of factors that play into performance. This subjectivity comes with the property that it is near impossible to completely rule out an effect of the crowd's presence on the accuracy of the ratings. It is, however, obvious that using strictly in-game statistics is likely more resistant to bias that could occur due to the crowd's presence than an expert's opinion.

For the analysis of individual performance, I use average ratings from players in only the Premier League 2018/2019 season and the 2020/2021 seasons. Only the English Premier League is used and the 'with crowd' sample is only one season in this case due to restrictions with data collection. All players receive ratings for home games, as well as away games. A rating represents one player's average performance in either home or away games. All ratings

are weighted over the amount of games this player has played at home or away in a given season. These weighted ratings represent a combined total of 20.877 appearances. This sample includes 1.945 average ratings, of which about 50% reflect average ratings for home games. The weights are applied to prevent distortion of any effects by players who played very few matches and whose rating is therefore likely more volatile. To distinguish between appearances with or without a crowd, I use appearances in the 2020/2021 season to represent appearances without a significant crowd presence.

To validate these subjective ratings of the players; it is notable that the algorithm that is used to get to these ratings finds very similar top-performing players to the ones that are rewarded Player of the year. In the 2020/2021 season, six of the eight nominees for the Barclays premier league player of the year also scored top six in the rankings on whoscored.com. In the 2018/2019 season, six out of the seven players nominated for player of the year made it into the top seven on whoscored.com's rankings. Figures 1 and 2 show kernel density scores of ratings of players in the season with a crowd, as well as the season without a crowd. In both cases home and away performances resemble a normal distribution and home performances are generally slightly better than away performances. From these distributions, it seems likely that the algorithm used to rate players, tends to rate players very densely around the mean; between 6 and 7 out of 10. This density is likely for a significant part due to the fact these ratings are average ratings and therefore generally much less volatile than ratings for each performance separately.

Figure 1: Distribution of ratings 2018/2019

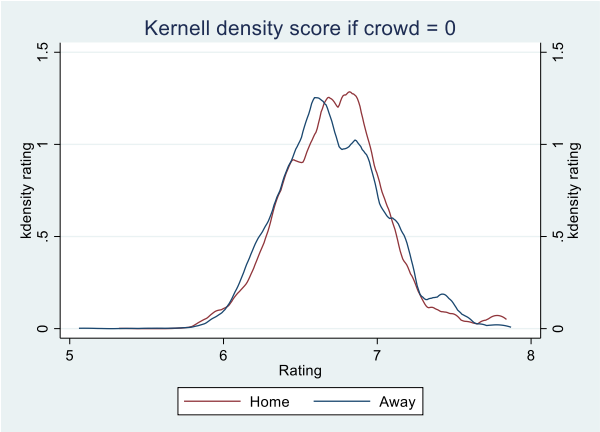
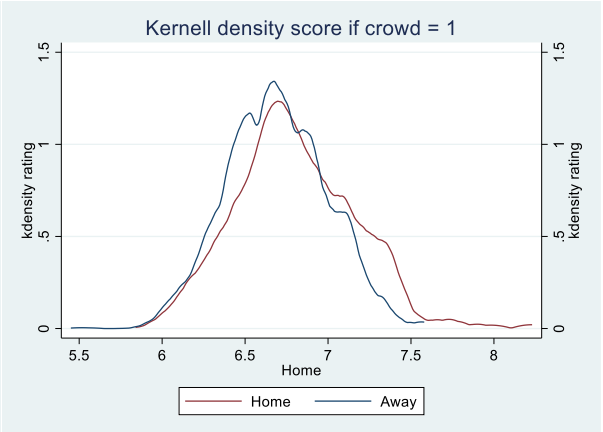


Figure 2: Distribution of ratings 2020/2021



Next, Players are categorized by age by calling them “young”’ below the age of 24 and “old” above 30 as these are both about a standard deviation from the appearance weighted mean age of players on the pitch in a given match. This distinction provides the opportunity to separate agents that could be affected differently based on expectations with respect to the difference in experience. From younger players, it is expected that acclimatization to performance in front of large crowds is an ongoing process, whereas for the older players it is expected that they will now be as comfortable with performing under pressure as they could ever get. Generally, at this point in their career, players will not be exposed to more pressure in terms of crowd pressure and the general stakes at play, since the peak of football players is generally thought to be in the period between the two categories as indicated by Torgler & Schmidt (2007).

Next to that, I also make the distinction between players and thus appearances made by players who play for teams with “large” home stadiums and “small” home stadiums, by calling stadiums with capacities at least 50.000 people “large”, and stadiums with capacities up to 25.000 people “small”. This distinction allows for investigation into the effect of stadium/crowd size in home advantage, but from an individual players’ performance perspective specifically. It is important to be careful with interpreting the difference between these two groups based on familiarity with large crowds. Even though familiarity with pressure is likely higher for players who play in large stadiums, the difference between home and away pressure and support is also highest for them. To reasonably infer any such effects, there is a need to control for many more factors, since a very non-random selection has taken place.

The standards for the two different types of stadiums are based mainly on the sample distribution and common sense, where both categories should represent a sufficient part of the sample and the difference between the standards must be large enough to create an unmistakably different experience for each type of player. The average stadium capacity in the premier league in the relevant season is about 36.500 visitors, with a standard deviation of about 15.000. Table 2 summarizes the data on individual players in both the ‘with crowd’ and ‘without crowd’ scenarios.

Table 2: Descriptive statistics individual players

CROWD = 0	RATING	AGE	APPS	CROWD = 1	RATING	AGE	APPS
Away, N= 516				**N=492**			
Mean	6.590	26.452	10.058	Mean	6.588	28.864	10.657
Std. Dev.	0.395	4.312	5.766	Std. Dev.	0.346	4.022	5.754
Min	5.06	17	1	Min	5.45	18	1
Max	7.87	39	19	Max	7.58	42	19
Home, N=499				**N=488**			
Mean	6.614	26.539	10.435	Mean	6.702	28.852	10.732
Std. Dev.	0.379	4.058	5.663	Std. Dev.	0.403	4.000	5.735
Min	5.32	17	1	Min	5.84	18	1
Max	7.84	38	19	Max	8.23	41	19
Total, N=1015				**N=980**			
Mean	6.602	26.495	10.243	Mean	6.645	28.858	10.694
Std. Dev.	0.387	4.187	5.716	Std. Dev.	0.379	4.009	5.742
Min	5.06	17	1	Min	5.45	18	1
Max	7.87	39	19	Max	8.23	42	19

N= amount of players, APPS= amount of appearances/games played

Again, an OLS-regression is used to investigate players' performance and if this is affected by playing at home or away, and whether the existence of such effects is dependent on the presence of a crowd. This is also a way of disentangling the crowd's effect on players' performance from the crowd's potential effect on referee behavior. To make the distinction between all possible scenarios with regards to the crowd's presence and playing at home or away, I use interactions between the two binary variables. The following regression expresses the effect that both variables have on performance in one appearance.

$$Individial\ performance_{is} = \beta_0 + \beta_1 Crowd_s + \beta_2 Home_{is} + \beta_3 Crowd_s * Home_i + e_{is} \quad (5)$$

In the above regression, individual performance of player i in season s is dependent on crowd's presence and playing at home or not at home i.e. Away.

The following regressions (6) and (7) test how younger players and older players respectively, are affected by the crowd in home and away games. Hypothetically one would expect learning effects of dealing with crowd pressure and support to have occurred with older players, whereas younger players are still learning to adapt to crowd pressure/support.

$$Performance\ Young_{is} = \beta_0 + \beta_1 Crowd_s + \beta_2 Home_{is} + \beta_3 Crowd_s * Home_i + e_{is} \quad (6)$$

$$Performance\ Old_{is} = \beta_0 + \beta_1 Crowd_s + \beta_2 Home_{is} + \beta_3 Crowd_s * Home_i + e_{is} \quad (7)$$

Lastly, the following regressions, (8) and (9) are used to determine whether the effects of the crowd change depending on the size of the stadium. I distinguish between players who play for clubs with larger home stadiums and smaller home stadiums. I explore whether there is a different effect on individual performance of playing in front of a large home crowd, compared to playing in front of a small home crowd. Does a larger home crowd affect the difference between home and away performance?

$$Performance\ Large_{is} = \beta_0 + \beta_1 Crowd_s + \beta_2 Home_{is} + \beta_3 Crowd_s * Home_i + e_{is} \quad (8)$$

$$Performance\ Small_{is} = \beta_0 + \beta_1 Crowd_s + \beta_2 Home_i + \beta_3 Crowd_s * Home_i + e_{is} \quad (9)$$

Results

The crowd's effect on match outcomes

The first set of results with regards to match outcomes in table 3 shows a lack of a statistically significant home advantage in all competitions except for the English Premier League. In this competition, I find a very strong and significant effect of crowd presence on home advantage. The fact that all coefficients are positive, however, does mean that home teams have performed better in all competitions when a crowd was present. These effect sizes would practically be relevant from an economical/competitive perspective because as much as 0.1 effect size in a 20 club competition would average about 1.9 points per team per season if they were hypothetically allowed to play with a home crowd and opponents were not.

In the regression without fixed effects in table 7 (appendix). I find very similar results, yet with much lower explanatory power. In these models, however, the constants, which essentially represent home advantage without crowd effects, are generally much closer to 0 and therefore seem a lot more proportionate to the crowd effect. It could very well be the case that the team fixed effects exaggerates home game effects in scenarios when teams that are promoted to a competition are very different from relegated teams, especially because there is a season-long gap in the sample.

Table 3: Linear regressions of the crowd's effect on home advantage in points per game

	(1)	(2)	(3)	(4)	(5)
Home advantage	E1	E2	D1	D2	S1
Crowd	0.669***	0.160	0.216	0.0728	0.148
	(0.175)	(0.245)	(0.181)	(0.246)	(0.171)
_cons	0.755*	0.814*	-0.0542	1.169	0.773
	(0.393)	(0.469)	(0.446)	(0.899)	(0.780)
N	1520	2222	1224	1224	1520
adj. R^2	0.225	0.078	0.140	0.049	0.183
Home FE	Yes	Yes	Yes	Yes	Yes
Away FE	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 4 presents the effects of attendance on home advantage, which reflect similar results for all competitions as when crowd presence is binary. I find that, even in the Premier League, the effect size of attendance is so small that 10.000 extra supporters do not affect home advantage by more than 0.0125 points per match, which is negligible in the context of a complete season. The coefficient for the second competition in Germany is ever so slightly negative, but this effect is extremely and statistically insignificant. When home and away team fixed effects are left out, the effect of attendance remains positive, but now is significant for all competitions except the German second division (appendix). This difference is most likely due to the fact that teams with larger stadiums are usually the richer and therefore better teams. Therefore, a stronger correlation between attendance was to be expected. Even though effect sizes of the models without fixed effects are larger, they are still all well below a tenth of a point per match, meaning that even these effects lack economical relevance, and it has to be noted the explanatory power of these models is so extremely low that inference of the models with team fixed effects is preferred slightly.

These results show that, to the extent that crowds can create an advantage, it does not seem likely that incremental changes in crowd size make a large difference. Larger stadiums/crowds do not significantly seem very helpful in the context of winning a competition. Whether there is a crowd size effect in general remains ambiguous from this analysis.

Table 4: Linear regressions of the crowd size's effect on home advantage in points per game

	(1)	(2)	(3)	(4)	(5)
Home advantage	E1	E2	G1	G2	S1
Attendance*10.000	0.0125***	0.0107	0.00576	-0.00197	0.00398
	(0.00381)	(0.0108)	(0.00360)	(0.0102)	(0.00401)
_cons	0.686*	0.572	-0.00267	1.311	0.760
	(0.416)	(0.562)	(0.429)	(0.895)	(0.772)
N	1520	2222	1224	1224	1520
adj. R^2	0.223	0.078	0.141	0.049	0.183
Home FE	Yes	Yes	Yes	Yes	Yes
Away FE	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Yellow card Home advantage

Whether there generally exists a crowd induced effect on yellow card home advantage is determined in models (1), (3), (4), (6) and (8). A statistically significant effect on yellow card home advantage is found in both of the English competitions and the second competition in Germany. Very notably, the coefficients of both second-tier competitions are about double the size of all other competitions. The sign of the crowd coefficient being positive for all competitions entails that within all investigated competitions, the difference between home and away team yellow cards increases in favor of the home team when there is a crowd present. A coefficient of 0.25, means that the difference between home team and away team yellow cards is a quarter of a yellow card per match greater than in matches without a crowd ceteris paribus. On average, a home team receives one more yellow card than the away team over the course of 4 matches. These positive coefficients do indicate a home bias in referee behavior in particular since at least some of the team-specific behavior is absorbed by the team fixed effects.

The main reason for the absence of a significant effect in Spanish competition seems to be that the constant term is very high. This could mean that higher amounts of yellow card home advantage exist in this competition even without any crowd, whereas the constants are even negative in all other competitions. Team fixed effects could play a part in this large constant, but they cannot be removed in models regarding yellow card home advantage since this would make inference from a referee perspective impossible.

Models (2), (5), and (7) specify matches led by referees with Champions League experience and find no significant difference between matches led by experienced referees and non-experienced referees. The CL coefficient describes the effect of Champions League experience on yellow card home advantage when no crowd is present. In the German first competition, the matches led by referees with champions league experience, though statistically insignificant, surprisingly exhibit more yellow card home advantage than other referees when no crowd is present. Whereas in the other competitions I find the expected yet insignificant effect of slightly lowered yellow card home advantage when referees do have

Champions League experience.

The interaction term in the same models explains the difference in yellow card home advantage between matches refereed by referees with and without Champions League experience in the scenario that a crowd is present. This interaction term is statistically insignificant in all competitions, but the direction of these coefficients is surprising nevertheless since the positive coefficients in English and German competitions imply that home advantage is larger when referees have Champions League experience, even though these referees are generally expected to be the best referees in each competition.

Table 5: Linear regression of the crowd's effect on yellow card home advantage in yellow cards per game

Yellow card HA	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	E1	E1	E2	S1	S1	D1	D1	D2
Crowd	0.215**	0.230*	0.558***	0.172	0.204	0.167	0.227*	0.636***
	(0.107)	(0.119)	(0.145)	(0.137)	(0.142)	(0.117)	(0.127)	(0.189)
CL		-0.00589			-0.0692		0.212	
		(0.191)			(0.343)		(0.243)	
Crowd*CL		0.171			-0.0581		0.0504	
		(0.143)			(0.189)		(0.167)	
_cons	-0.187	-0.179	-0.0212	1.133**	1.140**	-0.0194	-0.0858	-0.734
	(0.263)	(0.269)	(0.294)	(0.572)	(0.572)	(0.302)	(0.307)	(0.735)
N	1520	1520	2222	1520	1520	1224	1224	1224
adj. R^2	0.080	0.079	0.085	0.059	0.060	0.056	0.056	0.026
Home FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Away FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

The crowd's effect on individual players

Table 6 displays all results with regard to home advantage from an individual players' perspective. All coefficients are differences from the constant, which is the average rating when no crowd is present in away matches. The crowd coefficient, therefore, displays the difference between performance with and without a crowd in away games. Next, the home coefficient is the difference between home and away performance when the crowd is not present, which essentially encapsulates the part of home advantage for individual performance that is separate from crowd effects. The interaction term displays the difference between away performance with a crowd, as opposed to home performance with a crowd. The total effect of the crowd in home games is therefore the sum of the crowd coefficient and the interaction coefficient.

In table 6, a positive coefficient of 0.1, for example, entails a 0.1 average increase in rating for that coefficient. Effect sizes are generally very small in this section and part of the reason for this is likely due to the density of the distribution of ratings. This density is expressed in the standard deviation in the complete sample of ratings, which is only just 0.38 approximately. This puts a seemingly very small coefficient of 0.08 in context as it is still over a fifth of a standard deviation of the sample.

In the first model (1), I find that the effect of the crowd is generally significantly negative in away games. The effect of the crowd on players in away games is less than five percent of a standard deviation, meaning that it is not very large even in the context of the sample. Effect of home being positive, yet insignificant and even smaller than the crowd coefficient, means that home advantage from the mechanisms other than crowd effects seem generally negligible. The interaction term in this model is positive and significant, and expectedly, the largest effect size at about a tenth of a rating point per appearance and about a quarter of a standard deviation. It seems that playing at home in front of a crowd generally leads to the best performance.

Models (2) and (3) show a comparison between the crowd effects on younger and older players respectively. Older players perform surprisingly, statistically even significantly better in away games when a crowd is present, whereas younger players perform worse to a much

larger degree than the average player at about a quarter of a standard deviation. Since the home coefficient partly encapsulates familiarity with surroundings, it is not surprising that this effect is much larger and more significant for older players than for younger players. Lastly, the difference between home and away performance with a crowd is significantly positive for both agents, but here the effect is somewhat larger for older players. From these results, it does seem to be the case that younger players are more fazed by opposing crowds particularly, whereas older players even perform even better in front of hostile crowds than they do in front of no crowd. These results are in line with the hypothesis that familiarity with crowds matters in terms of home advantage from a players' performance perspective.

Models (4) and (5) are meant to compare effects for players, who play in large home stadiums as opposed to smaller home stadiums. Here, effects are opposite expectations, as one would expect teams with larger stadiums to find the largest effect of playing at home in front of the crowd if crowd size positively affects home advantage. From these models, it seems to be the case that players in larger stadiums benefit less from the crowd's presence when playing at home than even players in very small home stadiums do. It is even the case that the interaction coefficient is not significant and smaller for players of larger clubs, which implies a smaller difference between and away performances for players of larger clubs. For the players of larger clubs, the total effect of playing in front of the home crowd is even negative, as the sum of the crowd and interaction coefficients is negative. For individual player performance, larger home stadiums do not seem advantageous. Speculatively, the effects of crowd support and crowd pressure, might not always work in the same direction. When stadium size increases, pressure could possibly increase to a degree where 'choking' under pressure is more likely to happen.

The fact that even the players with small home stadiums come quite close to the average effect seems to confirm the narrative that mostly perceived levels of crowd pressure and support matter. From a support perspective, the largest clubs do not generally have the most passionate fan bases. A prime example of this would be Barcelona, for example, where the audience has been described as a theatre audience. An environment that is not necessarily conducive to the most moral support. On the other hand, 'smaller' clubs are generally described as clubs 'of the people', in which clubs' fanbases generally exists comparatively much more fanaticism in the average supporter. An example of this idea in the Netherlands could be, ADO Den Haag.

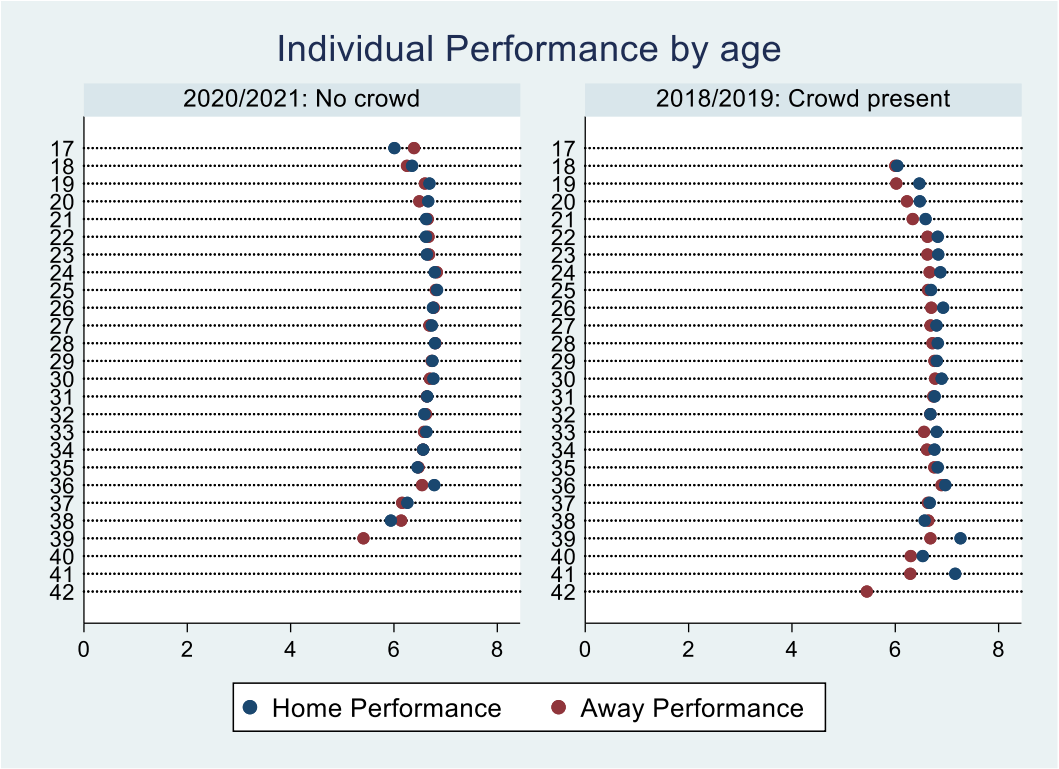
Table 6: Linear regression of the crowd's effect on individual players performance in Rating points

	(1)	(2)	(3)	(4)	(5)
Rating	Overall	Old	Young	Small	Large
Crowd	-0.0158**	0.0757***	-0.0944***	-0.0401***	-0.0772***
	(0.00654)	(0.0110)	(0.0168)	(0.0136)	(0.0151)
Home	0.0107	0.0343***	-0.0178	-0.0346**	-0.0860***
	(0.00655)	(0.0126)	(0.0123)	(0.0137)	(0.0181)
Home*crowd	0.0936***	0.168***	0.109***	0.0791***	0.0150
	(0.00654)	(0.0110)	(0.0166)	(0.0137)	(0.0151)
_cons	6.708***	6.623***	6.699***	6.875***	6.643***
	(0.00464)	(0.00887)	(0.00862)	(0.00971)	(0.0128)
N	20877	7098	4208	5217	3627
adj. R^2	0.016	0.039	0.024	0.018	0.023

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Figure 3 shows in a more intuitive way that a small difference between ratings for home and away games occurs when a crowd is present and that almost all of this difference disappears when the crowd is excluded. From this graph, it is a little more obvious that the difference between home performance and away performance is more pronounced for younger players when a crowd is present. From table 6 it shows that the majority of this difference between younger and older players manifests itself in away games, where younger players 'choke' under opposing pressure and older players seem to flourish under the same pressure. From this figure, it is also notable that again, when no crowd is present, there is barely any difference noticeable between home performance and away performance. A small caveat with this figure is that there are so few appearances of players that are 38 years and older, that these data points become much more volatile as is evident from the figure.



Limitations

The most striking and most obvious limitation is the fact that there is a complete season between the sample with a crowd and without a crowd for all tests conducted in this piece of research. Some of the relevance of this piece of research hinges on the not 100% verifiable idea that the effects of covid-19 for clubs at the beginning of the pandemic were more heterogeneous. Even if one accepts this as a fact, there is something to be said for the notion that some things could have changed over the entirety of the excluded season that could affect results. In this case, one needs to think of club takeovers and player transfers between clubs, if one does not view these events as endogenous in the sports/football realm. These changes, therefore, are mainly a problem when considering team fixed effects, as a year of change that would otherwise be accounted for is now out of sample.

A possible confounder with all research that uses post-covid 19 data to study home advantage is the changing of rules. The main relevant rule change is that substitutions went from 3 substitutions per match to 5 per match. In theory, this should give added benefit to teams with more money and therefore more depth to their player selection and this benefit might help

these squads do better in away matches than they otherwise would have against smaller clubs. This could in theory have harmed results, but in practice, such an effect does not seem to have taken place in a team performance context. No extraordinary gap between top-performing and lowest-performing teams has been particularly noticeable. It is possible that such a rule change could have affected player appearances e.g. players who normally would not have played do now get more playing time. If home advantage without would be very large it could be the case that these players play disproportionally at home in games that are already won, in which it is consequently easier to get a higher rating. It does not seem very likely that this rule change has disbalanced home and away substitutions very much because the observed level of home advantage is generally not overwhelmingly large from a player perspective.

A further limitation with this paper stems from the data collection aspect. Several dummies have had to be formed, which generally gives a less accurate view of the impact a variable has on the dependent variable. The main reason for this is that the benchmarks chosen for such a variable remain somewhat arbitrary and can impossibly give as transparent of an overview of the effects as a continuous variable can in most situations. Similarly, the lack of match-by-match data availability of individual player performance data has likely led to a significantly more dense distribution of the ratings which made the results less obvious as well as possibly less accurate.

When observing age as an independent variable, it is important to be careful with inference because there could be some selection effects. It might be the case that young players who do not perform well under the pressure are the ones that do not ‘make it’ and therefore the older players that are in the league are just the ones that did not ‘choke’ and therefore got to stay. However, Since Figure 3 has shown that the difference between home and away performance is not very large, even for young players, I do not believe this to be a large problem, but nonetheless, something to take note of.

Conclusion

This piece of research has attempted to find the effect that the crowd has on outcomes of football matches, as well as, investigate the mechanisms i.e. to what extent different types of agents are involved in this effect. It contributes to the empirical literature about home advantage in several ways. Firstly, it reaffirms some previous notions about the crowd's role in home advantage, with similar but slightly different methodology and ever so slightly newer data. In a match outcome sense, nothing new has been found in that there generally seems to be a positive effect of the crowd in most competitions. This is an effect that is probably strongly reliant on the specific competition and some variance in the measure used for home advantage within that season in that competition. The role of absolute attendance remains ever so ambiguous in this research, which, in combination with small effect sizes, leads me to believe that the role of absolute attendance is not extremely relevant and not necessarily a pathway for interesting further investigation.

The second part of this research starts with the reaffirmation of an already often researched topic, of yellow card home advantage. For yellow card home advantage, the conclusions are again, overwhelmingly similar to general home advantage. This means that slowly but surely, empirical research is progressing to better understand at least the broad effects the crowd has on home advantage. The second part of the investigation regarding referee behavior could have been an opening into the within agent-type effects of the crowds for referees. It seems to be the case that using the very specific benchmark has made it less likely to get very significant results that could separate the effect the crowd has on referees, as well as, identify heterogeneity within this specific agent. In future research, continuous variables of Champions League experience or total matches refereed, for instance, could be utilized to more accurately assess some effect of experience of familiarity with crowds.

The last part of this research has easily the most insightful and yet most fallible results. From this part of the research, it can firstly be inferred that also from an individual player performance angle, there is at least some merit in the claim that the crowd plays a role in home advantage. Since the data is not especially strong, for reasons discussed above, inference has to be done with care, but these results do at the very least suggest some variation within players in terms of crowd effects. Most strikingly, younger players' performances seem to suffer much more under the pressure of playing in front of a hostile crowd. This suggestion is in line with the hypothesis that familiarity with pressure matters for

performance. On the other hand, the findings with regard to different stadium sizes are much less expected, and yet to be explained, as players with smaller home stadiums experience more advantage from the home crowd than players with larger home stadiums and thus keeping the effect of crowd size in home advantage ambiguous. Altogether, this opens the door for plenty of avenues for new research into what type of players, or agents in general suffer under pressure or perform better with support. Can these results be replicated in other competitions? It does appear to be the case that the crowd in the English competitions is persistently among the most significant, from a size, as well as effect perspective (Benz & Lopez, 2021).

Lastly, I will speculate about the relevance of all the findings in this paper in a more general, non-sports context. If a partisan crowd is a significant factor in agents' performance and it appears to be the case that an inexperienced agent is more likely to 'choke under pressure' when the crowd is hostile, it might be advisable for principals to use agents with more experience in situations where crowds are more likely to be hostile, even though a younger agent might perform better on average. This could, for example, be the case for lawyers in a case where the opposing party brings a large crowd, which wants to see this lawyer fail and believes the opposition should win. When hiring new agents who are required to perform in front of audiences it could also very well be advisable to look for any experience an agent has had with hostile crowds, as this is the most likely scenario for any agent to 'choke' due to crowd pressure, especially when inexperienced.

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Appendix

Table 7: Linear regressions of the crowd's effect on home advantage in points per game without fixed effects

	(1)	(2)	(3)	(4)	(5)
Home advantage	E0	E1	D0	D1	S0
crowd	0.587***	0.257**	0.219	0.0163	0.165
	(0.156)	(0.126)	(0.168)	(0.170)	(0.149)
_cons	-0.0711	0.223**	0.324**	0.412***	0.362***
	(0.136)	(0.110)	(0.146)	(0.148)	(0.129)
N	1520	2222	1224	1224	1520
adj. R^2	0.009	0.001	0.001	-0.001	0.000

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 8: Linear regressions of attendance's effect on home advantage in points per game without fixed effects

	(1)	(2)	(3)	(4)	(5)
	E0	E1	D0	D1	S0
attendance	0.0239***	0.0205***	0.0121***	0.00387	0.0204***
	(0.00290)	(0.00469)	(0.00290)	(0.00566)	(0.00280)
_cons	-0.302***	0.101	0.0969	0.368***	0.0637
	(0.110)	(0.0909)	(0.122)	(0.110)	(0.0909)
N	1520	2222	1224	1224	1520
adj. R^2	0.039	0.008	0.012	-0.000	0.027

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$