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# They didn't know what they got till the crowd was gone

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# They didn't know what they got till the crowd was gone

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## Abstract

This paper revisits the relationship between Covid-19-related absence of stadium attendance and match outcomes, analyzing five seasons of the top tier of professional football in the Netherlands. Empty stadiums caused home advantages to disappear completely due to home teams scoring fewer goals. Additionally, in empty stadiums, away teams received fewer yellow cards. This persisted even when stadiums were filled to a maximum of one-third of their capacity. Under these circumstances, there were no effects on team performance. Thus, it is improbable that referee decisions were the intermediary factor influencing team performance. Players of home teams appear to have been directly and adversely affected by the absence of stadium crowds.

Keywords: Home advantage, professional football, Covid-19

JEL Classification: D91, L83, Z20

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The title of this paper is based on “*You don't know what you've got till it's gone*” in a 1970 song of Joni Mitchell entitled *Big Yellow Taxi*.

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# 1 Introduction

Sports matches are interesting to study, among other reasons, because stadium attendance may exert social pressure that affects individual decision-makers (referees) and team performance. This social pressure may provide home teams with an advantage, but it is not clear whether this effect is direct or indirect, stemming from biased referee decisions.

Due to Covid-19 crisis measures, professional football matches in many countries had to be played behind closed doors for a period of time, i.e., without stadium attendants. Since these stadium closures resembled natural experiments on stadium attendance, their consequences have been analyzed frequently. For example, Endrich and Gesche (2020) found that in German professional football, referees treated home teams less favorably in terms of assigning yellow cards in empty stadiums compared to matches with stadium crowds. Similarly, Fischer and Haucap (2021), also studying German professional football, found only weak evidence for a change in referee behavior, while they did not observe a negative effect on home advantage in terms of win probabilities. Cross and Uhrig (2023) investigated how empty stadiums affected so-called expected goals, i.e., a measure of the quantity and quality of shots on goal, in four top European leagues. They found that home advantage was lower in empty stadiums both in terms of expected goals and actual goals. In a study of professional football in four countries, Sors et al. (2021) found a reduced home advantage but no evidence of referee bias when matches were played behind closed doors. Bryson et al. (2021) examined matches from twenty-three professional leagues in seventeen countries and found that although for some countries there were effects on goal scoring on average across all matches in their sample, playing behind closed doors had no effect on the final match scoreline.<sup>1</sup> However, there was a reduction in yellow cards for away teams relative to home teams. Additionally, Benz and Lopez (2023) reached similar conclusions when generalizing over seventeen leagues in thirteen countries. Although empty stadiums were a consequence of Covid-19 measures, the effects on performance are not directly related to other measures, such as breaks in training. Earlier studies confirm the effects of playing behind closed doors also outside the Covid-19 period. Pettersson-Lidbom and Priks (2010) for example did a small-sample study on Italian football, Singleton et al. (2023) did one on Egyptian football and Reade et al. (2022) for a study using information from many football leagues, including the UEFA Champions League and the UEFA Europa League.

The current study compares variations in stadium attendance before, during, and

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<sup>1</sup>As with many other studies, Bryson et al. (2021) only examined variations in stadium attendance within the 2019/20 season. During that season, in the Netherlands, the competition was simply terminated because of the Covid-19 pandemic. Therefore, the Netherlands could not be included in previous cross-country studies.

after the pandemic, which differs from previous studies, with the exception of Singleton et al. (2023), as they did not include variations from crowds returning after the pandemic. The study confirms findings from prior research indicating that empty stadiums had a negative effect on the performance of home teams, while referees assigned fewer yellow cards to away teams. Additionally, the current study diverges from previous research by asserting that the effects on match outcomes materialized only when the stadium was completely empty, while referee behavior changed even when stadiums were not empty but had substantially smaller crowds.

## 2 Empty stadiums in professional football

This study draws upon data from the top tier of professional football in the Netherlands, a nation ranked sixth in the UEFA Country Ranking 2024. The top tier comprises 18 teams engaging in a double round-robin format, facing each opponent once at home and once away during a season. The Covid-19 pandemic impacted the top tier across three seasons, albeit unevenly.

Table 1 gives an overview of the available information in terms of matches with and without stadium attendance.

Table 1: **Overview of Matches and Stadium Attendance**

Season	Behind	With	All	Average
	Closed			
	Doors	Attendance	matches	Attendance
2018/19	0	306	306	18.0
2019/20	0	232	232	18.2
2020/21	271	35	306	4.9
2021/22	77	229	306	15.1
2022/23	1	305	306	18.4
Total	349	1107	1456	17.2

Note: Average attendance in matches with attendance (1000).

In 2022/23 one match was played behind closed doors due to misbehavior of home team fans in previous matches.

While matches in other leagues during the 2019/20 season were played behind closed doors due to Covid-19 measures, the Netherlands took a different approach. The 2019/20 season was abruptly terminated after 232 matches. Subsequently, the 2020/21 season predominantly transpired behind closed doors, with 271 matches played without stadium attendance and only 35 matches accommodating crowds, restricted to no more than one-third of stadium capacity. In contrast, the 2021/22 season witnessed a shift, with 77 matches played behind closed doors and 229 matches featuring regular attendance. Notably, a distinctive feature of the Covid-19 measures in the Netherlands was observed

during the 2020/21 season, where stadiums were either empty or hosted relatively small crowds. Conversely, during the 2021/22 season, stadiums were either devoid of spectators or filled in a regular manner. Average match attendance in the first season and the last season is about the same, indicating that stadium attendance fully recovered from the Covid-19-related restricted stadium access measures in seasons 2019/20 to 2021/22 (see Appendix A for further details on the data used).

Table 2 provides descriptive statistics of performance indicators and yellow and red cards, categorized by whether the match was played behind closed doors. In matches with stadium attendance, home teams enjoyed a clear advantage, winning 48.3% of their matches, while away teams won 30.5% of their matches, resulting in a home win advantage of 17.8%. However, in matches played behind closed doors, the home win advantage decreased to 2.6%, which was not statistically different from zero. The same trend was observed regarding goal scoring. In regular matches, there was a significant home advantage of 0.50 goals, which decreased to an insignificant 0.11 for matches played behind closed doors.

Table 2: **Descriptive Statistics**

	With attendance	Behind Closed Doors	$\Delta$	
Home Win (%)	48.3	38.4	-9.9	***
Away Win (%)	30.5	35.8	5.3	*
$\Delta$ Win (%)	17.8	2.6	-15.2	***
Home Goals	1.82	1.53	-0.29	***
Away Goals	1.32	1.42	0.10	
$\Delta$ Goals	0.50	0.11	-0.39	***
Home Yellow Cards	1.39	1.28	-0.11	
Away Yellow Cards	1.68	1.27	-0.41	***
$\Delta$ Yellow Cards	-0.29	0.01	0.30	***
Home Red Cards	0.08	0.09	0.01	
Away Red Cards	0.09	0.10	0.01	
$\Delta$ Red Cards	-0.01	-0.01	0.00	
Expected Home Win (%)	45.5	43.5	-2.0	
Expected Away Win (%)	32.0	34.0	2.0	*
$\Delta$ Expected Win (%)	13.5	9.5	4.0	***

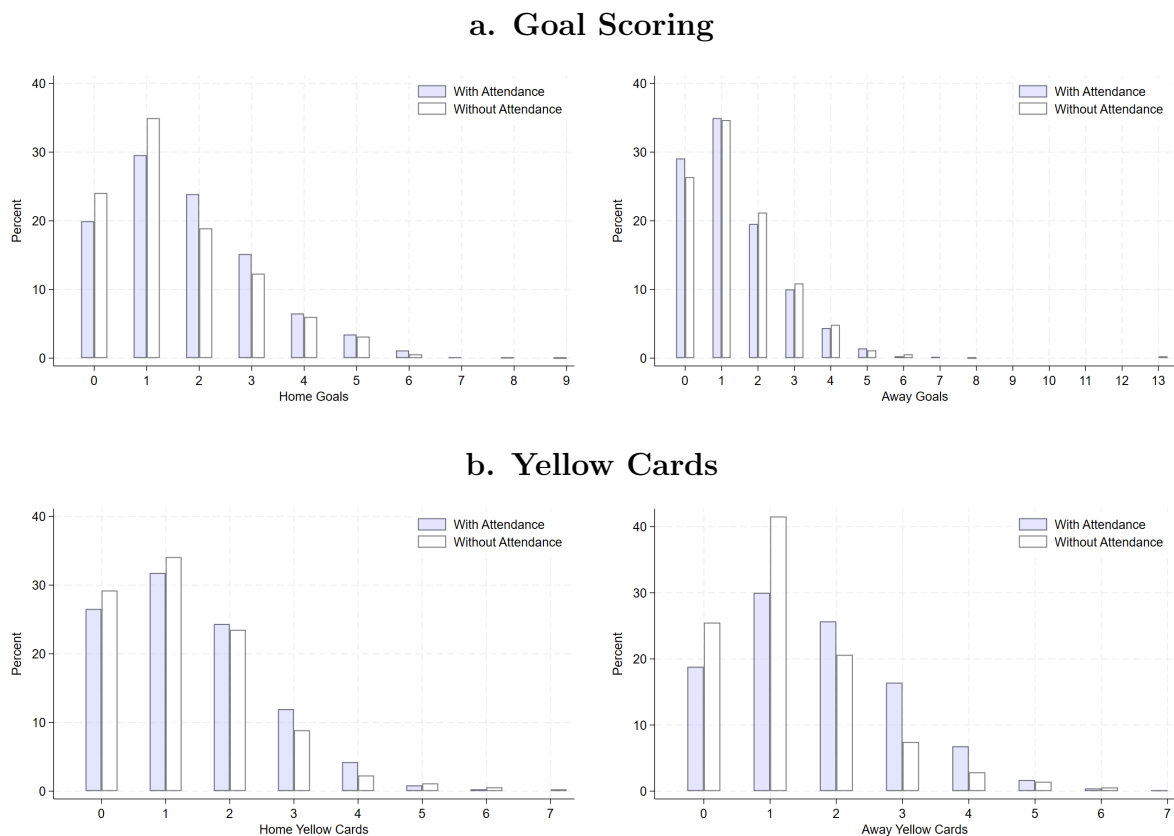
Note: 1456 matches of 25 teams in 5 seasons; 349 were played behind closed doors. Expected wins are based on bookmaker odds (see Appendix A). \*\*\* (\*\*, \*): different from zero at a 1% (5%, 10%) level of significance.

The presence of a stadium crowd did not significantly impact the number of yellow cards issued to the home team, but there was a notable decrease in the number of yellow cards issued to the away team. Specifically, there was a difference of 0.41 yellow cards, representing a 25% drop when a match was played without stadium attendants.

The number of red cards does not appear to have been affected by the presence of a stadium crowd. A red card, implying the sending off of a player, is a rare event and will not be further analyzed in this paper.

Figure 1 provides a graphical representation of the differences in goal scoring and yellow cards, distinguishing between home teams and away teams, and also distinguishing by whether or not there was a stadium crowd.

**Figure 1: Goal Scoring and Yellow Cards in Home and Away Matches; Matches With and without Stadium Attendance**



Note: 25 teams in five seasons

As shown, in matches played behind closed doors, home teams were more likely to score no goals or one goal, and less likely to score two or more goals. However, for goals scored by the away teams, there was no significant difference between matches with and without stadium attendance. Home teams in matches played behind closed doors were also more likely to receive no or just one yellow card, although the difference from matches with a stadium crowd was not substantial. However, the situation was different for the yellow cards the away teams received. In matches behind closed doors, they received fewer yellow cards. They were much more likely to receive no or just one yellow card, and less likely to receive more than two yellow cards in a match.

Finally, Table 2 illustrates the differences between expected home wins and expected away wins, based on bookmaker odds (see Appendix A for details). Although there is some discussion on bookmakers' odds being mispriced during the initial period of the

Covid-19 pandemic (Meier et al. (2021)), this is not likely to be problematic in the Netherlands, where competition was terminated in 2019/20 and resumed in 2020/21. These differences between matches with and without attendance were not directly related to the Covid-19 measures themselves. Instead, they provide an indication of the disparities in strength between the two teams competing in regular matches versus matches played behind closed doors. The Covid-19 measures were exogenous but not necessarily randomly distributed across matches. Indeed, as the bottom row of Table 2 indicates, in matches played behind closed doors, the differences in strength between the two teams were somewhat smaller than in regular matches.

### 3 Empirical analysis

#### 3.1 Set-up of the analysis

The relationship between stadium attendance and team performance is not one-sided. It may be that stadium attendance is higher if a team is expected to perform well (Van Ours (2021)). Additionally, the presence of a stadium crowd could potentially influence the performance of a team. If a stadium is empty due to Covid-19 regulations, then there is no need to consider expected performance affecting attendance, as attendance was set to zero for exogenous reasons. However, as shown in Table 2, this did not necessarily imply that the Covid-19 measures were randomly distributed across matches. Therefore, the effect of the absence of a stadium crowd is investigated conditional on the difference in strength between the two teams.

For win probabilities, goal scoring, and yellow cards of home team  $i$  and away team  $j$  in season  $t$ , the equation to be estimated is specified as follows:

$$Y_{ijt} = \alpha + \beta \Delta S_{ijt} + \gamma BCD_{ijt} + \varepsilon_{ijt} \quad (1)$$

where  $\Delta S_{ijt}$  indicates the difference in strength between  $i$  and  $j$  in season  $t$  and  $BCD$  is a dummy variable indicating whether or not the match was played behind closed doors.<sup>2</sup> Furthermore,  $\alpha$ ,  $\beta$  and  $\gamma$  are the parameters to be estimated and  $\varepsilon$  is the error term.

The difference in strength is related to the specific dependent variable. For home wins, home goals, and home yellow cards, the win probability of the home teams is used. For the away variables, it is the win probability of the away team; for the difference variables, it is the difference in win probabilities between the two teams.

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<sup>2</sup>Appendix B presents an analysis on the relationship between performance and attendance. There does not seem to be a relationship between attendance and performance in regular matches.



### 3.2 Main parameter estimates

The main parameter estimates for the various dependent variables are presented in panels a to c of Table 3. The first two columns show estimates obtained over the full sample, while the last three columns show estimates obtained by using only information from seasons 2020/21 and 2021/22.

Table 3: **Parameter Estimates**

		All Seasons (N=1456)				Seasons 2020/21 and 2021/22 (N=612)					
		Difference in Strength		Behind Closed Doors		Difference in Strength		Behind Closed Doors			
		(1)		(2)		(3)		2020/21		2021/22	
								(4)		(5)	
a. Win	Home	1.02	(0.04)***	-0.08	(0.03)***	1.07	(0.07)***	-0.05	(0.04)	-0.12	(0.06)**
	Away	1.00	(0.05)***	0.03	(0.03)	1.03	(0.08)***	-0.02	(0.04)	0.07	(0.06)
	Diff.	1.01	(0.04)***	-0.11	(0.05)**	1.05	(0.06)***	-0.04	(0.07)	-0.20	(0.10)*
b. Goals	Home	3.00	(0.12)***	-0.23	(0.08)***	2.98	(0.26)***	-0.01	(0.11)	-0.35	(0.15)**
	Away	2.75	(0.18)***	0.05	(0.07)	2.63	(0.30)***	0.12	(0.10)	0.03	(0.14)
	Diff.	2.81	(0.12)***	-0.28	(0.11)***	2.73	(0.19)***	-0.13	(0.15)	-0.39	(0.21)*
c. Yellow cards	Home	-0.78	(0.14)***	-0.13	(0.07)*	-0.47	(0.23)***	-0.14	(0.11)	-0.16	(0.16)
	Away	-0.56	(0.17)***	-0.40	(0.07)***	-0.65	(0.25)***	-0.43	(0.11)***	-0.37	(0.14)**
	Diff.	-0.63	(0.10)***	0.28	(0.09)***	-0.49	(0.15)***	0.30	(0.14)**	0.21	(0.22)
		Big four teams (N=588)				Other teams (N=868)					
		Difference in Strength		Behind Closed Doors		Difference in Strength		Behind Closed Doors			
		(1)		(2)		(3)		(4)			
d. Win	Home	1.06	(0.05)***	-0.04	(0.04)	0.91	(0.12)***	-0.11	(0.04)***		
e. Goals	Home	3.12	(0.19)***	-0.14	(0.12)	2.48	(0.35)***	-0.28	(0.10)***		
f. Yellow cards	Away	-0.39	(0.19)***	-0.44	(0.11)***	-1.00	(0.38)***	-0.36	(0.10)***		

Note: Difference in strength measured using bookmaker data; for home (away) estimates this is the win probability of the home (away) team; for the difference estimates it is the difference in win probabilities between the home and the away teams; panels d to f are based on the full sample; robust standard errors; \*\*\* (\*\*, \*): different from zero at a 1% (5%, 10%) level of significance.

The estimates in the first column indicate that all dependent variables are significantly related to the difference in strength as measured by bookmaker odds. The magnitude of the effect on win probabilities is insignificantly different from one, indicating that bookmaker expectations are, on average, accurate. When a match was played behind closed doors, the home team was about 8% less likely to win the match, and the away team (insignificantly) 3% more likely to win the match.

Panel b shows that this outcome is caused by the home team scoring fewer goals when no crowd was present in the stadium. Panel c shows that if the difference in strength between the two teams was bigger, fewer yellow cards were issued, both to the home team and the away team. If a match was played behind closed doors, both teams received fewer yellow cards, but the effect for away teams was much greater.

The pooled estimates are partly based on seasons in which all matches had stadium attendance. Of the Covid-19 affected seasons, 2020/21 and 2021/22 are most suitable for

within-season analysis. The within estimates for these seasons are shown in columns (3) to (5) of panels a to c of Table 3. The parameter estimates of the behind closed doors (BCD) effects in the 2021/22 season are very comparable to those for the full sample, showing significant effects on home wins, home goal scoring, and away yellow cards.

The BCD effects in the 2020/21 season are almost never significantly different from zero, which could have two reasons. The first reason is the limited number of observations, as there are only 35 matches (out of 306) with stadium attendance. The second reason is that stadiums could only have attendants up to a maximum of one-third of stadium capacity. All the more surprising is that the BCD effect for away yellow cards is still significantly different from zero. This suggests that the decision-making of referees was influenced more easily – with lower stadium crowds – than the performance of the home teams was.<sup>3</sup>

Over the period of analysis the big four teams in the top tier of professional football in the Netherlands were Feyenoord, PSV, AZ, and Ajax. Panels d to f of Table 3 show parameter estimates when a distinction is made between the big four teams, with an average home win probability of more than 60% (and an average away win probability of more than 50%), and the other teams. The effects of the difference in strength were very similar for both groups, but the effect of playing behind closed doors was notably different. For the big four teams, there was no significant negative effect of the absence of stadium crowds. However, the negative effect of playing behind closed doors on the yellow cards assigned to the away teams was present for both groups.

### 3.3 Sensitivity analysis

To investigate the robustness of the main findings, several sensitivity analyses were performed. First, to absorb relative team strengths in addition to bookmaker odds, fixed effects for home teams and away teams were included. Table 4 displays the relevant parameter estimates when fixed effects are included for both home teams and away teams. Although the parameter estimates sometimes differ in magnitude from those presented in Table 3, they do not reveal a different story. Playing behind closed doors had significant negative effects on the performance of the home team in terms of win probability and goal scoring, and significant negative effects on yellow cards, predominantly those for the away team.

Estimating the effects separately for the 2020/21 season and the 2021/22 season did not yield new insights. Table 5 shows separate parameter estimates for seasons 2020/21

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<sup>3</sup>Bryson et al. (2021) found for a sample of six countries that Covid-19 related restricted stadium crowds had no effects on match outcomes or yellow cards.

Table 4: **Parameter Estimates with Home and Away Team Fixed Effects**

		Difference		Behind	
		in Strength		Closed Doors	
a. Win	Home	0.71	(0.18)***	-0.08	(0.03)**
	Away	0.73	(0.13)***	0.04	(0.03)
	Diff.	0.70	(0.14)***	-0.12	(0.06)*
b. Goals	Home	1.87	(0.50)***	-0.23	(0.07)***
	Away	1.43	(0.49)***	0.09	(0.11)
	Diff.	1.22	(0.40)***	-0.32	(0.11)***
c. Yellow cards	Home	-0.86	(0.59)	-0.17	(0.07)**
	Away	-1.32	(0.61)**	-0.42	(0.11)***
	Diff.	-0.64	(0.28)**	0.27	(0.14)*

Note: Difference in strength measured using bookmaker data; for home (away) estimates this is the win probability of the home (away) team; for the difference estimates it is the difference in win probabilities between the home and the away teams; Robust standard errors; \*\*\* (\*\*, \*): different from zero at a 1% (5%, 10%) level of significance.

and 2021/22. These are very similar to those presented in Table 3.

Table 5: **Parameter Estimates Seasons 2020/21 and 2021/22**

		Season 2020/21				Season 2021/22			
		Difference		Behind		Difference		Behind	
		in Strength		Closed Doors		in Strength		Closed Doors	
a. Win	Home	1.12	(0.10)***	-0.08	(0.07)	1.02	(0.10)***	-0.12	(0.06)**
	Away	1.07	(0.11)***	0.02	(0.07)	0.99	(0.11)***	0.07	(0.06)
	Diff.	1.10	(0.09)***	-0.10	(0.12)	1.01	(0.09)***	-0.19	(0.10)*
b. Goals	Home	2.62	(0.35)***	0.05	(0.20)	3.33	(0.38)***	-0.36	(0.16)**
	Away	3.16	(0.50)***	0.25	(0.20)	2.09	(0.34)***	0.02	(0.14)
	Diff.	2.81	(0.29)***	-0.20	(0.27)	2.63	(0.25)***	-0.37	(0.21)*
c. Yellow cards	Home	-0.45	(0.33)	-0.30	(0.20)	-0.49	(0.33)	-0.14	(0.17)
	Away	-0.47	(0.35)	-0.55	(0.24)**	-0.83	(0.34)**	-0.36	(0.14)**
	Diff.	-0.43	(0.22)*	0.26	(0.28)	-0.16	(0.06)**	0.22	(0.19)

Note: Difference in strength measured using bookmaker data; for home (away) estimates this is the win probability of the home (away) team; for the difference estimates it is the difference in win probabilities between the home and the away teams; Robust standard errors; \*\*\* (\*\*, \*): different from zero at a 1% (5%, 10%) level of significance.

Furthermore, the effect of empty stadiums was interacted with stadium capacity. It could be that the effect is greater, the larger the average drop in stadium attendance (see Ferraresi and Gucciardi (2021)). However, this interaction term was not significantly different from zero. Finally, instead of using linear models, the analyses were redone using discrete choice models. This did not alter the main findings. Table 6 shows the relevant parameter estimates using discrete choice models. In terms of significance these are very much in line with those presented in Table 3.

Table 6: **Parameter Estimates Discrete Choice Models**

		Difference		Behind	
		in Strength		Closed Doors	
a. Win	Home	4.87	(0.31) <sup>***</sup>	-0.40	(0.14) <sup>***</sup>
	Away	4.97	(0.32) <sup>***</sup>	0.18	(0.14)
	Diff.	2.55	(0.14) <sup>***</sup>	-0.28	(0.12) <sup>**</sup>
b. Goals	Home	1.70	(0.09) <sup>***</sup>	-0.14	(0.05) <sup>***</sup>
	Away	1.86	(0.11) <sup>***</sup>	0.04	(0.05)
	Diff.	0.21	(0.01) <sup>***</sup>	-0.02	(0.01) <sup>**</sup>
c. Yellow cards	Home	-0.58	(0.10) <sup>***</sup>	-0.09	(0.06) <sup>*</sup>
	Away	-0.36	(0.11) <sup>***</sup>	-0.27	(0.05) <sup>***</sup>
	Diff.	-0.11	(0.02) <sup>***</sup>	0.05	(0.02) <sup>***</sup>

Note: Difference in strength measured using bookmaker data; for home (away) estimates this is the win probability of the home (away) team; for the difference estimates it is the difference in win probability between the home and the away teams. For home win and away win logit model are used, for the win difference ordered logit models are used; for goals and yellow cards Poisson models are used. For difference in goals and yellow cards the dependent variable is adjusted to deal with negative values: difference in goals +13, difference in yellow cards +6; <sup>\*\*\*</sup> (<sup>\*\*</sup>, <sup>\*</sup>): different from zero at a 1% (5%, 10%) level of significance.

## 4 Conclusions

Stadium crowds wield a profound influence on match outcomes in professional football in the Netherlands. Whether their presence is regular, significantly reduced, or absent altogether, makes a substantial difference. While variations in stadium crowds, if present, were generally not crucial, the absence or near-absence of stadium crowds emerged as significant factors. Matches played behind closed doors or with significantly reduced stadium attendance saw home teams scoring fewer goals, consequently reducing their likelihood of winning. It appears that stadium crowds significantly boost the performance of their favorite team. Additionally, in empty stadiums, away teams received fewer yellow cards.

The negative effect on away yellow cards appears to persist even when stadiums were filled to a maximum of one-third of their capacity and remained evident when only matches of the top four teams were considered. Under these circumstances, there were no discernible effects on team performance. Thus, it is improbable that referee decisions were the intermediary factor influencing the effect of attendance on team performance. Players of home teams appear to have been directly and adversely affected by the absence of stadium crowds.

From a research standpoint, establishing a relationship between team performance and the presence or absence of stadium crowds has been challenging until recently. Covid-19 measures have provided an opportunity for research and for football teams to experience the true impact of crowd support. With the absence of the crowd, football teams finally realized the significance of having their support.

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## Appendix A: Data

The sources of the data used in the analysis are the following:

- Match results, yellow cards, red cards, bookmaker odds: [football-data.co.uk](http://football-data.co.uk).
- Stadium attendance: Wikipedia Eredivisie – several years.

The bookmaker odds of B365 are transformed into probabilities of home win, draw and away win as follows:

- Probability of home win =  $\frac{1/H}{(1/H)+(1/D)+(1/A)}$
- Probability of a draw =  $\frac{1/D}{(1/H)+(1/D)+(1/A)}$
- Probability of away win =  $\frac{1/A}{(1/H)+(1/D)+(1/A)}$

where  $H$  are the odds for a home win,  $D$  are the odds for a draw and  $A$  are the odds for an away win. By calculating the three probabilities like this, the bookmaker margin is accounted for and the three probabilities add up to 1.

## Appendix B: Additional Parameter Estimates

Table B.1 presents the relationship between home win probabilities and various stadium attendance indicators. Panel a displays parameter estimates for matches with stadium crowds. Neither attendance nor the natural logarithm of attendance exhibit significant effects on home win probabilities. Panel b provides the parameter estimates when all matches are included. Once again, the number of attendants shows no significant effect. However, the dummy variable for the absence of stadium crowds demonstrates a negative and significant effect. Conditional on the difference in strength between the two teams, home teams are 8 percent less likely to win the match if it is played behind closed doors.

Table B.1: **Parameter Estimates Home Win Probability**

	Difference in Strength	Attendance (x 100)	Log Attendance	Behind Closed Doors
a. With attendance				
	1.06 (0.07)***	-0.16 (0.12)		
	1.05 (0.06)***		-0.03 (0.02)	
b. All matches				
	1.01 (0.05)***	0.05 (0.10)		
	1.07 (0.06)***	0.17 (0.12)		-0.11 (0.03)***
	1.02 (0.05)***			-0.08 (0.03)***

Note: With attendance 1106 observations; all matches 1456 observations. Difference in strength measured as the expected win probability of the home team using bookmaker data; Robust standard errors; \*\*\* (\*\*, \*): different from zero at a 1% (5%, 10%) level of significance.