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Home advantage in soccer : Greece, COVID and Video Assistant Referee

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Περίληψη

Στόχος της παρούσας διατριβής είναι να εξετάσουμε εάν έχει μεταβληθεί το πλεονέκτημα της γηπεδούχου ομάδας στο ελληνικό πρωτάθλημα ποδοσφαίρου έπειτα από την εισαγωγή του βοηθού - βίντεο διαιτητή (Video Assistant Referee - VAR). Ο βοηθός - βίντεο διαιτητή εισήχθη στο ελληνικό πρωτάθλημα κατά το ποδοσφαιρικό έτος 2019-2020 με σκοπό η χρήση του να βοηθήσει τους διαιτητές στη λήψη αποφάσεων με μεγαλύτερη ακρίβεια και ορθότητα. Η εφαρμογή του νέου αυτού συστήματος στο ποδόσφαιρο συνέπεσε με την πανδημία του κορωνοιού το 2020, η οποία είχε ως συνέπεια τα γήπεδα της Ευρώπης να «κλείσουν» προκειμένου να μειωθεί η διασπορά του ιού. Η Ελλάδα δεν αποτέλεσε εξαίρεση και το πρωτάθλημα ολοκληρώθηκε χωρίς την παρουσία φιλάθλων. Εξετάζουμε, λοιπόν, επιπλέον κατά πόσο η απουσία των φιλάθλων κατά τη διάρκεια της πανδημίας επηρέασε το πλεονέκτημα της γηπεδούχου ομάδας. Τα δεδομένα μας αφορούν τους αγώνες στην πρώτη εθνική κατηγορία της Super League κατά τα έτη 2017-2018, 2018-2019 που δεν είχε εφαρμοστεί το VAR καθώς και τα έτη 2019-2020, 2020-2021 οπότε ξεκίνησε η χρήση του VAR και η πανδημία του κορωνοϊού. Ειδικότερα, τα δεδομένα μας περιλαμβάνουν τον αριθμό των γκολ, των κόκκινων και κίτρινων καρτών, των πέναλτι, των offside και των foul και για τις δυο ομάδες για κάθε αγώνα που πραγματοποιήθηκε κατά τα προαναφερθέντα έτη. Για την υλοποίηση της διατριβής χρησιμοποιήσαμε την R και εφαρμόσαμε μεθόδους των γενικευμένων γραμμικών μοντέλων. Συνοπτικά, το πλεονέκτημα της έδρας δε φαίνεται να επηρεάστηκε από την εφαρμογή του VAR. Μετά την εισαγωγή του, κατά μέσο όρο τα offsides μειώθηκαν, ενώ τα πέναλντι και τα φάουλ αυξήθηκαν. Κατά τη διάρκεια της απουσίας των θεατών από τα γήπεδα το πλεονέκτημα της έδρας δεν εξαλείφθηκε αλλά μειώθηκε δραστικά. Συγκεκριμένα, την περίοδο της πανδημίας οι γηπεδούχες ομάδες σκόραραν λιγότερα γκολ σε σύγκριση με τις φιλοξενούμενες και κέρδιζαν λιγότερα πέναλντι. Οι κόκκινες και κίτρινες κάρτες, κατά μέσο όρο μειώθηκαν κατά την πανδημία που οι αγώνες ήταν κεκλεισμένων των θυρών ενώ τα fouls και τα πέναλντι αυξήθηκαν.

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Abstract

The main purpose of this thesis is to examine whether home advantage in Greek soccer has changed after the introduction of video assistant referee (VAR). The video assistant referee was implemented in the Greek league during the 2019-2020 football season, in order to help referees make decisions with greater accuracy and correctness. The implementation of this new technology in Greek football first appeared, and then the coronavirus pandemic started in March of 2020. As a result, almost all of the European stadiums were closed to prevent spreading the virus. Greece was no exception, and that year's championship was completed without the presence of fans. Therefore, we examine additionally whether the absence of fans during the pandemic affected home advantage. Our data was obtained from the Super League. Matches included were played in 2017-2018, 2018-2019 seasons, before VAR or Covid-19 pandemic, and in 2019-2020, 2020-2021 seasons when VAR was introduced, and coronavirus pandemic started. Specifically, our data includes the number of goals, red and yellow cards, penalties, offsides and fouls for both teams for each match played in the aforementioned years. We used R and applied generalized linear modeling methods to implement the thesis. In summary, home advantage in the Greek football was not affected by the implementation of VAR. Following Var introduction offsides decreased, penalties and fouls increased. During the fans' absence due to Covid-19 pandemic, home advantage was not eliminated but it was drastically reduced. During fans' absence home teams scored fewer goals than the away teams and fewer penalties were awarded against the away team. Red and yellow cards decreased during the pandemic, but penalties and fouls increased.

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Στον παππού μου Κωστή, που βλέπαμε μαζί αγώνες ποδοσφαίρου.

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This thesis focuses on home advantage in the Greek football and on how it was affected by the introduction of Video assistant referee. Additionally, we investigate how the absence of crowd support during the COVID-19 pandemic affected home advantage.

Chapter 1 is an introduction on home advantage and VAR. It includes home advantage's definition and the factors that cause it. Moreover, an introduction on video assistant referee's use is included.

The second chapter is a literature review on home advantage. We focus on research on the impact of VAR and the COVID-19 pandemic on football and more specifically on home advantage. We also review the findings of the research conducted so far on the Greek league.

Chapter 3 contains the principles of generalized linear models' theory. We focus on Poisson case since the data we are interested in are counts of events during a football match.

Chapter 4 includes the descriptive statistics of the data we have available, from the Greek Super league. We have collected data on the following match variables: fouls, goals, yellow and red cards, penalties and offside per match, two years before and after VAR's implementation and COVID-19 pandemic.

In chapter 5 we employed methods of the generalized linear models theory, to examine and interpret the effect of VAR and COVID-19 pandemic on the Greek football, referees' behavior, and home advantage.

In chapter 6, we summarize the conclusions drawn for the Greek football, home advantage and the changes brought about by the crowd support absence and Video Assistant Referee introduction.

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Chapter 1

Introduction

1.1 Home advantage in football

Home advantage in sports refers to the tendency for teams to perform better when playing on their home ground compared to when they play away. It is a worldwide phenomenon but varies considerably from country to country. It has declined in the major leagues in Europe over the last 15 years. It tends to be greater in football than in other team sports. (Pollard 2008). Investigation into home advantage has started since the 70s but the main factors that account for it have not yet been fully understood and explained .

Many factors have been suggested over the years to drive home advantage. Research shows that is difficult to investigate these factors separately as they interact with each other. A crucial factor of home advantage is the fans of the home team, also called the 12th player. Crowd effect is not easy to study and includes the size of the crowd, density, the intensity of the supporters and the proximity of the crowd to the playing field, Pollard(2008). Another factor is the travel fatigue for the away team. Research on this factor has produced mixed results, and this should apply only to long-distance travels. Familiarity with the local conditions of its own stadiums a home team has should also advance their performance. It is also hypothesized that a team's home advantage decreases when moving to new stadium facility. The most studied probably factor of home advantage is referee bias. Referees seem to be affected by the home team's fans or by the quality of the teams and tend to be biased and treat the home team more favorably. Territoriality is another proposed factor. It is assumed that the home teams perform better because of their willingness to defend their territory. It has been observed that smaller teams tend to have an increased home field advantage due to territoriality. Special tactics is another factor, as it has been observed that both home and away teams tend to adopt a different style of play. For instance, away teams

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tend to play more defensively, giving the home team an advantage (Pollard, 2008). Changes in the rules on which football, or any other sport, is based, cause changes in home advantage, it has been called rule factors. A recent example of this kind could be the video assistant referee system that was introduced to review referee's decision. Psychological factors refer to the acknowledgement of the existence of home advantage itself. Additionally, Pollard (2008) in his review on home advantage is suggesting including team ability when calculating home advantage as it has been proved that it affects home advantage. Pollard was the first to quantify home advantage but since then several methods have been proposed trying to account for all the aforementioned factors and their interactions. *"Clearly, there is still much to be learnt about the complex mechanisms that cause home advantage, both in soccer and other sports. The topic remains a fruitful area of research for sports historians, sociologists, psychologists, and statisticians alike",* (Pollard, 2008)

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1.2 Video Assistant Referee

Refereeing in sports is about fairness. The referee's job is to balance what the player with the ball thinks is fair with what the player trying to take the ball thinks is fair. Referees are judges on those two opposite opinions (de Oliveira et al, 2023). The referees are therefore called to take under consideration these two views before judging, to apply the rules of the sport and usually they have to finalize their decision within a few minutes or seconds, while at the same time they may be under pressure from both the crowd noises and the competing teams. Moreover, referee decisions are of great importance as they often influence the match's outcome and therefore their decisions have both social and economic impact on players and teams.(Spitz et al,2021) There are types of decisions where right and wrong are not clearly distinguished and it is up to the referee's discretion to decide. Such decisions of referees, that are open to interpretation can be affected by noise, pressure from fans, the importance of the match, the home advantage, and the quality of the team Kolbinger, 2017.

Several technological tools have been introduced in sports to assist referees make more accurate judgments. Ball-tracking cameras are used in tennis, association football and cricket in order referees to have a clear view of the ball's position each second. In basketball and American football can be advised by instant replays to review their decisions(Spitz et al,2021). Zhang, Yeqin, et al.(2022) summarize these technologies into three categories: *(Kolbinger and Link, 2016) those that help in terms of perception (e.g., goal-line technology to identify whether the ball goes over the goal line, Nlandu, 2012); (2) those that substitute referees for some refereeing decisions (e.g., Hawk-Eye system to determine the ball's bounce point and trajectory, Bal and Dureja, 2012); and (3) those that assist referees in enforcing sports regulations (e.g., vanishing spray to mark the required distance of defending players in football, Kolbinger and Link, 2016)*. The latest technological tool introduced in the laws of the game in 2018, is the video assistant referee which belongs to first category mentioned above, Zhang, Yegin et al(2022).

Video assistant referee was introduced aiming to increase (objective) fairness and assisting in decision-making with respect to the following four situations: goals, penalty kicks, (straight) red card incidents and administrative incidents (mistaken identity), Holder et al, 2021. Thus, VAR

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intervenes only in the case of the aforementioned match-changing incidents and specifically checks for any infringement leading up to a goal, if a penalty should be awarded or id a penalty was correctly awarded, if a red card was correctly given, in addition if a decision to caution or send off a player was given to the correct player.

There are two types of VAR reviews that could take place during a match but in both cases the final decision or whether a decision should be changed belongs to the main referee. When an incident occurs that requires a subjective decision, such as a red card, the referee may request a review by making a TV signal and he will watch it on the side of the pitch, this is called an on-field review. There is also the VAR – only review regarding factual decisions, where the VAR team reviews the footage and communicates their findings to the main referee through a headset. In practice during a football game, VAR assistants constantly screen video material and, if needed, inform the main referee about a doubtful situation, Holder et al,2021.

Various papers have been published since the introduction of Video assistant referee in world competitions as well as in national leagues and we will review the existing literature in chapter 2.1.

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Chapter 2

Literature Review

2.1 Home advantage and video assistant referee

The video assistant referee was first introduced in football game at the 2018 FIFA World Cup and since then a plethora of articles have been published on how VAR affects home advantage, an advantage expressed through the various match variables of a football game, namely goals, penalties, red cards, yellow cards and offside. SPITZ, Jochim, et al. (2021) investigated the impact of Video Assistant Referee (VAR) on decision-making in football. The authors highlight the increased accuracy of decision-making that VAR provides, after analyzing data from matches of 13 national football associations for the 2016-2017, 2017-2018 seasons. They also note that the flow of the game is affected as the game time increases due to VAR checks, mainly due to on -field reviews and, in addition, more penalties and red cards are given but fewer goals are scored. Overall, the article suggests that VAR has the potential to increase the accuracy of referees' decisions in football although, the human factor cannot be eliminated, and they suggest that alongside with VAR's evolution, referee training should be increased to minimize the usage of VAR and reduce the disadvantages it appears to have. Holder, U., Ehrmann, T., and König, A. (2022) analyzed data from Italian Serie A and German Bundesliga two years before and after the implementation of VAR. Regarding the referees' decisions, their behavior is changed, as they tend to award fewer red cards and penalties, but due to VAR's interventions the total number of red cards and penalties eventually remains constant over time. Additionally, from their analysis it is revealed that in the Italian league, referees favored the home team by giving extra time in the second half of the match if they were behind in the score, which was eliminated after the introduction of VAR.

Zhang, Yeqin, et al. investigated the effect of VAR on FIFA Women's World Cup. They compared data from 2015, before VAR, and 2019, after VAR, tournaments. According to their results, the time of the first and second half and thus the total duration of the matches increased after the implementation of the var, but this increase is not large. No statistically significant changes were observed between the two tournaments in terms of the match variables goals, offsides, penalties, fouls, corners, red and yellow cards. However, the authors suggest that further research should be conducted in women's football in order to explore the impact of var in depth, as there is currently very little literature on the subject.

The increase in average game time, per match and the decrease in the number of goals scored per game are also noted by Gürler, C., and Polat, V. (2021) as statistically significant results, in their study, where they analyze data from the Turkish Super League. In addition, they note a decrease in yellow cards given, which is not a statistically significant result, but could suggest that due to VAR players adopt a more cautious way of playing. Gürler, C., and Polat also compare the VAR statistics between two seasons of VAR implementation in Turkish Super league and conclude that there is a decrease in the frequency of decisions that did not change in the second season and, in the total number of reviewed positions. This is explained as referees consult the VAR less during the second season. Lago-Peñas et al (2021) analyzed data from the Spanish La Liga for the 2016/17, 2017/18 seasons, one year prior and post VAR's implementation in order to examine the changes brought about by the implementation of the new system in the Spanish league. Their findings include an increase in the total minutes of play (as well as the first and second halves), of around 70 seconds mainly due to the on-field var reviews. In addition, the number of offsides in the second half and the match decreased after VAR's implementation, which authors explained as players may play more consciously. The above-mentioned differences are more related to the on – field reviews. Similar results were obtained from the research of Han et al. who also studied VAR's effect in the Chinese Super League and except the significant increase in the playing time, they also found a significant decrease in the number of offsides and fouls.

The conclusions drawn from the literature around var's implementation are not absolute and vary on the country and league. A common finding in studies which compare

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the period before and after VAR is the increased game duration and the concern on how pauses in the game due to var checks will affect the flow and pace of play. However, research by Buyukcelebi, Hakan, et al. (2022) comparing matches from the 2018 FIFA World Cup and the 2020 European Football Championship shows that the evolution of VAR will potentially eliminate these drawbacks, since the duration of the second half and the overall game's duration decreased during the 2020 European Championship. The number of offsides penalties increased. Further research is needed to better understand the impact of var as the way it is implemented evolves, its terms of use become better understood and the referees become more familiar with its use.

2.2 Home advantage and crowd support

The coronavirus pandemic in March 2020 led countries to take various protective measures to reduce its spread. One of them was to hold closed-door matches. This was an opportunity to study how the absence of home team's crowd support, one of the main causes that drives home advantage, affected football and home advantage. The number of publications on this topic is increasing. McCarrick, Dane, et al (2021) analyzed data from 15 leagues across Europe, which during the Covid-19 pandemic banned spectator gatherings, to explore the impact of lack of audience on the performance of both players and referees. Regarding the first part, the authors found that the home advantage was not eliminated but rather reduced significantly, almost by half, during the pandemic when matches were played behind closed doors. The home team continued to score more and earn more points compared to the away team, but goals and points decreased compared to when there were spectators in the stadiums. As for the referees and whether the crowd affects their decisions, home teams also received fewer yellow and red cards as well as fouls during COVID-19 period, but the differences between home and away teams were mitigated. However, the authors note that their results differed significantly when the dominance of a team was added to the model, and therefore the reasons that influence the decisions of the referees are not clear as it is not proven that their decisions are influenced by the crowd. Similarly, Wunderlich, Fabian, et al. (2021) examined data from professional and amateur football matches from Spain, England, Italy, Germany, Portugal, and Turkey for the seasons 2010/2011 to 2019/2020 focusing on how the lack of football fans affected the disciplinary sanctions, the match dominance, and the market expectations. Their findings can be summarized as follows: referees tend to make less decisions in favor of the away teams when there are spectators in the stadiums, the dominant team, the one that shoots more and more accurately is still the home team despite the absence of the fans and the home advantage is reduced, insignificantly, but not eliminated, and its existence is independent of the division, since it also exists in amateur leagues.

Szabó, Dávid Zoltán, and Péter Kerényi (2023) analyzed data from four women's football leagues and concluded that the home advantage is not affected by the absence of

spectators. On the contrary, fewer yellow cards were awarded to the away team when the match was played without spectators. Bryson, Alex, et al (2021) also analyzed data from the season 2019/2020 using 6841 football matches from seventeen countries and twenty-three leagues and they resulted that the absence of home crowd did not affect the outcome of the match, but there was significant reduction in the number of yellow cards earned by the away team wins by a third.

Inan, Tuğbay (2020) used data from the first divisions of Germany, Spain, France, United Kingdom, Italy, for the seasons 2015 to 2019, and a logistic regression model to examine the influence of both crowd size and crowd density on home advantage. His analysis concludes that home advantage exists in all major European football leagues and that crowd effect, i.e. crowd density and size are important factors for the home advantage although results differ among the leagues.

Fischer, K., & Haucap, J. (2021) analyzed the ghost matches of the three major leagues in Germany and found that the home advantage was reduced only in the Bundesliga, while no differences were observed in the smaller leagues in terms of the home advantage due to the lack of audience, concluding that the decrease in the expected number of spectators at the stadium affects the home advantage more. Similarly, Matos, Rui, et al. (2021) focused on Portuguese league during the pandemic when spectators were also banned from the stadiums in the last rounds of the season, and they found no significant differences in home advantage between the first 24 and the last 10 rounds – played without a crowd - during 2019-2020 season in the Portuguese league. They also calculated home advantage using two different methods, the methods of Pollard (1986) and Matos et al (2020), which gave similar results, and they proved that the home advantage is declining in the Portuguese league in recent decades, confirming the literature. Correia-Oliveira, C. R., & Andrade-Souza, V. A. (2022) analyzed data from the 2019/2020 season from the two major leagues of Germany, England, Spain, and Italy. From their results, it appears that the home advantage was not eliminated during the 2019/2020 season but rather reduced compared to the previous three seasons in the top division, in both Germany and Italy. Additionally, when comparing the first half of the 2019/2020 season - before the start of the pandemic - with the second half - after the

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resumption of the championships - in four out of seven leagues included in the study, the home advantage decreased. For the Bundesliga and the second English division, the home advantage turned into a disadvantage. The authors point out that home advantage is highly correlated with the team's quality.

In general, the lack of fans in the stadiums seems to have affected home advantage and the behavior of the referees. There is a pattern in the effects of the lack of crowd support but generally its magnitude varies from league to league according to the literature. A common thread in the findings, so far, is that home advantage although reduced, was not eliminated which demonstrates the complexity of the issue as the home advantage determinants are many and interact with each other.

2.3 Literature review on Greek football

The literature on Greek football and home advantage is limited. Armatas, Vasilios, et al., 2013 compared home advantage between Greek amateur and professional football leagues. They have found that referees in the Greek Super League (top professional division) tend to favor the home teams by awarding to the home team more penalties and "punishing" the away teams with more yellow and red cards. Additionally, home advantage is greater in the professional division compared to the amateur divisions. Pollard and Seckin (2007) as well as Armatas Vasilis, and Richard Pollard (2014) have included in their studies the Greek top professional division and they found that home advantage exists in Greece. Moreover, both papers agree on the fact that the regional teams in Greece have a greater home advantage than the teams in the capital Athens, meaning that the role of territorial protection is probably an important factor of home advantage in the Greek football. Team of Xanthi was found to have the higher home advantage compared to the average home advantage. Additionally, Armatas and Pollard (2014) support that differences between home and away teams are related to the match variables, but home and away teams' do not differ in terms of outcomes. They also found that the most significant factor for home advantage was the kicked shots within the penalty area. Travel distance was not found to be an important factor, a logical conclusion as distances in Greece are not that long. Marek, Patrice, and František Vávra (2020) used data of 19 leagues to investigate the home advantage phenomenon using an alternative perspective. The highest home advantage was found to be in Greek Super League.

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Chapter 3

Generalized Linear Models

3.1 Principles of Generalized Linear Models

There are problems where the residuals do not follow a normal distribution, problems where the dependent variable is binary or discrete. In addition, some of the assumptions of linear regression are likely to be invalid, for instance, the assumption of homoscedasticity. In all the above cases we cannot use a general linear model. In these cases, therefore, we use the generalized linear models.

In general linear models we make the following two assumptions: we assume that the random variable (outcome variable) Yi has a normal distribution with mean μ_i and variance σ^2 and we also assume that the expected value of the mean is a linear function of p predictors. In generalized linear models we generalize the above two assumptions. Therefore, we assume that Yi comes from a distribution of the exponential family which includes as special cases the normal, binomial, Poisson, exponential, gamma, and inverse Gaussian distributions. In addition, instead of modeling the mean we introduce a one-to-one continuous differentiable transformation g(μi) and focus on $\eta_i = g(\mu_i)$. The function g(μi) is called the link function. We now assume that the transformed mean follows a linear model $\eta_i = x_i'\beta$. η_i is called the linear predictor. Since the link function is one - to - one we can obtain $\mu_i = g^{-1}(X_i'\beta)$.

Below are analyzed the basic theory and formulas of generalized linear models based on Dobson, Annette J., and Adrian G. Barnett. An introduction to generalized linear models. CRC press, 2018.

The Exponential Family

The distribution of a single random variable Y which depends on a single parameter θ, belongs to the exponential family if it can be written as f(y;θ) = s(y)t(θ)$e^{a(y)b(\theta)}$, where a, b, s are known functions.

Or equivalently: f(y;θ) = exp [a(y)b(θ) + c(θ) + d(y)], where s(y) =exp [d(y)] and t(θ)= exp[c(θ)].

If a(y) = y, the distribution is said to be in canonical form and b(θ) is also called as the natural parameter of the distribution. If there are other parameters, in addition to the parameter of interest θ, they are regarded as nuisance parameters forming parts of the functions a, b, c and d, and they are treated as though they are known.

It can be shown that if Yi has a distribution in the exponential family, then it has mean and variance:

$E[a(y)] = -\frac{c'(\theta)}{b'(\theta)}$

$Var[a(y)] = \frac{b'(\theta)c'(\theta) - c''(\theta)b'(\theta)}{[b'(\theta)]^3}$

The proofs of the above formulas are included in detail in Dobson, Annette J 2018.

Maximum Likelihood estimation

Estimation of **β** is obtained by maximizing the log-likelihood. The log-likelihood for a distribution in the exponential family is:

l(θ;y) = a(y)b(θ) + c(θ) + d(y)

The derivative of l(θ;y) with respect to θ is called Score Statistic :

$U(\theta;y) = \frac{dl(\theta;y)}{d\theta} = a(y)b'(\theta) + c'(\theta)$

The expected value of U is $E(U) = b'(\theta)\, E(a(Y) + c'(\theta)$.

The variance of U is called information $J = var(U) = \frac{b''(\theta)c'(\theta)}{b'(\theta)} - c''(\theta)$.

$U'(\theta) = \frac{dU}{d\theta} = a(Y)\, b''(\theta)+c''(\theta)$ and its expected value $E[U'] = - var(U) = - J$.

For each Yi, the log-likelihood function is $l_i = y_i\, b(\theta_i) + c(\theta_i) + d(y_i)$ and $g(\mu_i) = x_i^T \beta\eta_i$.

To obtain the maximum likelihood estimator for the parameter β_j we need to differentiate according to the rule of the chain the score statistic:

$\frac{\partial l}{\partial \beta_j} = U_j = \sum_{i=1}^{N} \frac{\partial l_i}{\partial \beta_j} = \sum_{i=1}^{N} [\frac{\partial l_i}{\partial \theta_i} \frac{\partial \theta_i}{\partial \mu_i} \frac{\partial \mu_i}{\partial \beta_j}]$.

It can be shown that we conclude to the following system of equations which we need to solve.

$\sum_{i=1}^{N} [\frac{y_i - \mu_i}{Var(Y_i)} X_{ij} \frac{\partial \mu_i}{\partial \eta_i}] = 0$

The above system of equations is solved using Newton – Raphson methodologies and the proof can be found in Dobson, 2018.

Hypothesis testing

Hypothesis testing can be performed using either Wald tests, Score tests or likelihood ratio plots.

The null hypothesis for a parameter vector β of length p, Ho: $\beta = \beta_o$ can be tested against the alternative hypothesis H_1: $\beta \neq \beta_o$ using the sampling distribution of the Wald statistic $(\hat{\beta} - \beta o)^T J(\hat{\beta} - \beta o) \sim \chi^2(p)$.

Also, the score statistic is used: $U^T J^{-1} U \sim \chi^2(p)$.

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Deviance or Likelihood Ratio test

We use the deviance which is also called log likelihood (ratio) statistic to assess the goodness of fit of a model. We can compare the model of interest with the saturated model which is a model that provides a separate parameter for each observation and thus saturated model's likelihood has the largest value. We can also compare any two nested models which have the same probability distribution and link function.

We compare two models by comparing their log likelihoods:

$$D = 2 [l(b_{max} ; y) – l(b ; y)]$$

where b_{max} denotes the saturated/full model and b denotes the simpler model. The sampling distribution of the deviance is, approximately, $D \sim \chi^2_{(m - p, \upsilon)}$, where υ is the non-centrality parameter.

In order to compare two different nested models, we also compare their deviances.

$$\Delta D = D_0 – D_1 = 2[l(b_1;y) – l(b_0;y)]$$

where Mo is the simpler model and M_1 is the more general model. If both models describe the data well $D_o \sim x^2_{(N-q)}$, $D_1 \sim x^2_{(N-p)}$ and $\Delta D \sim x^2_{(p-q)}$, p>q provided that certain independence conditions hold.

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3.2 Poisson Regression

The Poisson distribution is often used to model counts particularly counts of a phenomenon over a particular unit of time. If the random variable Y represents the number of occurrences, its probability distribution can be written as

$f(y) = \frac{\mu^y e^{-\mu}}{y!}$, y= 0, 1, 2, ... where μ is the average number of occurrences.

It can be shown that E(Y) = μ and var(Y) = μ.

The Poisson regression model is a generalized linear model used in the case of count data or for contingency tables and it is also called a log-linear model. The link function for the Poisson regression is the log link function. We use the log- link function to ensure that both parts of the equation are greater than 0.

$$\log E(Yi) = X_i^T \beta$$

Exponentiating the previous equation we obtain a multiplicative model for the

mean itself $E(Y_i) = \mu i = \exp\{ X_i^T \beta\}$.

Parameter estimates are often interpreted on the exponential scale e^{β} in terms of ratios of rates.

Hypotheses about the parameters βj can be tested using the Wald, score, or likelihood ratio statistics.

The fitted values are given by $\widehat{Y_1} = \widehat{\mu_1} = n_i e^{x_i^T b}$, i= 1, ...,N.

The Pearson residuals are $r_i = \frac{o_i - e_i}{\sqrt{e_i}}$ where o_i denotes the observed value of Yi and e_i denotes the expected values.

For the Poisson distribution the chi-square goodness of fit statistic and the Pearson residuals are linked

$X^2 = \sum r_i^2 = \sum \frac{(o_i - e_i)^2}{e_i}$

The deviance for a Poisson model can be written in the form

$D = 2 \sum [o_i \log (\frac{o_i}{e_i}) - (o_i - e_i)]$.

Deviance can be simplified to $D = 2 \sum [o_i \log \left(\frac{o_i}{e_i}\right)]$ when $\sum o_i = \sum e_i$.

The goodness of fit statistics X^2 and D are closely related.

$D = 2 \sum [(o_i - e_i) + \frac{1}{2} \frac{(o_i - e_i)^2}{e_i} - (o_i - e_i) = \sum \frac{(o_i - e_i)^2}{e_i} = X^2$.

Statistics D and X^2 can be used directly as measures of goodness of fit, as they can be calculated from the data and the fitted model (because they do not involve any nuisance parameters). They can be compared with the central chi-squared distribution with N – p degrees of freedom, where p is the number of parameters that are estimated. Differences between Poisson deviances for nested models (i.e., the log of the likelihood ratio test criterion) have asymptotic chi-squared distributions under the usual regularity conditions.

The likelihood ratio chi-squared statistic $C = 2[l(b) - l(b_{min})]$ can be used to test the null hypotheses that $\beta_2 = ... = \beta_p = 0$, comparing with the central chi-squared distribution with $p - 1$ degrees of freedom.

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Chapter 4

4.1 Data collection and description

The goal of this thesis is to examine whether the introduction of the video assistant referee in the Greek football, during the 2019/20 season affected the home advantage. Additionally, we examine how the absence of fans during the pandemic affected the home advantage and referee behavior. In order to accomplish our goal, we gathered data from the first division of the Super league of the 2017/18, 2018/19, 2019/20, 2020/21 championship seasons from https://www.football-data.co.uk/greecem.php and https://www.slgr.gr/el/. The data includes the number of goals, yellow and red cards, penalties, fouls, and the number of offsides for each team per match, as well as the result of each match. Team names for each match are also included in the dataset. To the best of our knowledge, there are no statistics available that relate exclusively to the use of VAR for the Greek Super League. To study VAR's effect we added a dummy variable that takes the value 0 for the seasons 2017/18, 2018/19 and value equal to1 for the seasons 2019/20 and 2020/21 when VAR was introduced in the Super league. We have also added a dummy variable called home advantage that takes the value 1 if the team to which the statistics refer is the home team of the game and 0 if it corresponds to the away team. Finally, we have added a dummy variable called covid which indicates the absence of the crowd due to coronavirus pandemic or the presence of the fans, takes values 1/0 respectively. Each football season in the Super league includes 240 matches. We have excluded a total of 6 matches due to missing values. The data set consists of 477 matches played before and after the implementation of VAR. Additionally, a total of 658 matches were played with fans and 296 matches played behind closed doors due to the restrictions of covid-19 pandemic.

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Variable name	**Description**
game	Character variable indicating the two opposing teams for each match
FTG	Numerical variable - the full-time goals scored
red	Numerical variable -the number of red cards awarded
yellow	Numerical variable - the number of yellow cards awarded
Fouls	Numerical variable - the number of fouls awarded
penalties	Numerical variable - the number of penalties won
Covid	Factor variable – 0 for the pre-covid period and 1 for the post covid period
ha	Factor variable – 1 if the corresponding team is the home team and 0 if it is the away team, representing the home advantage
Year	Factor variable – levels 2017/18,2018/19,2019/20,2020/21 the season in which the match was held
offsides	Numerical variable - the number of offsides
ftr	Character vector – the match result takes the values “H” for a home win, “A” for an away win and “D” for a Draw
Team A	Factor variable - the name of the team to which scores – 19 levels
Team B	Factor variable - the name of the team which is receiving the goal – 19 levels
VAR	Factor variable – 0 for the pre-VAR period and 1 for the after-VAR period

Table 1 Names and description of the variables included in the data

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4.2 Descriptive statistics

We will focus on match variables such as goals, penalties, red and yellow cards, fouls and offside as these are outcome-changing incidents of a football match. Additionally, VAR intervenes in some of these cases. Following are the histograms of these variables.

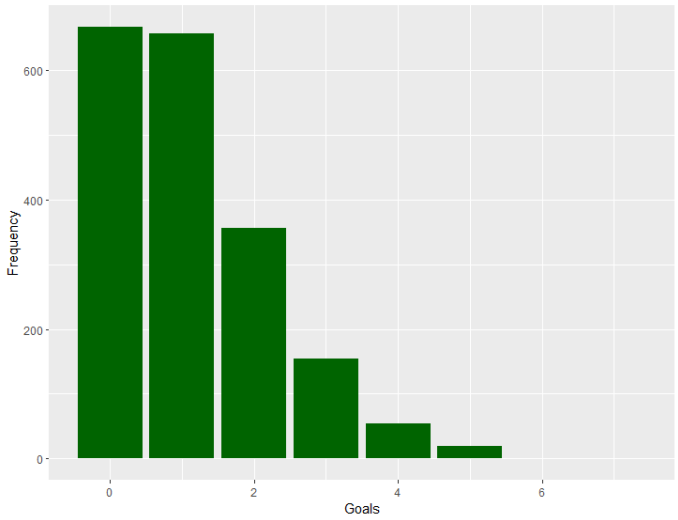

Figure 1 Bar plot of goals

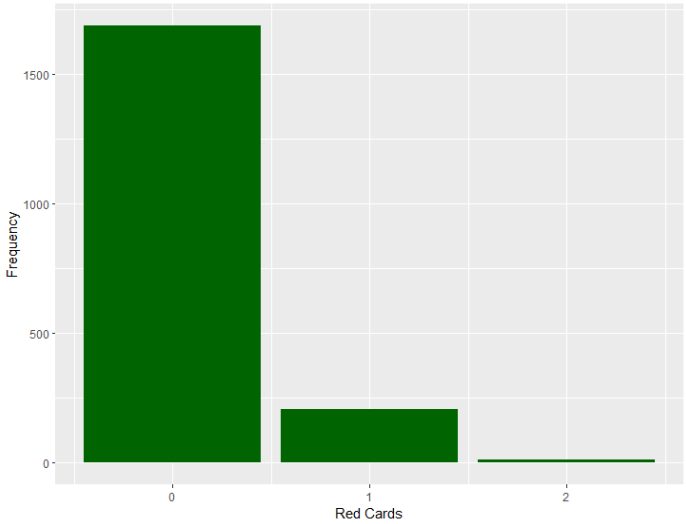

Figure 2 Bar plot of red cards

https://doi.org/10.26219/heal.aueb.6043

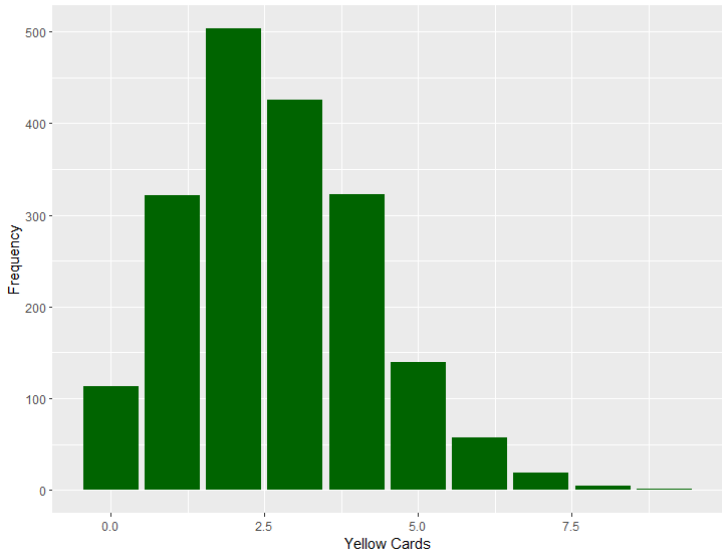

Figure 3 Bar plot of yellow cards

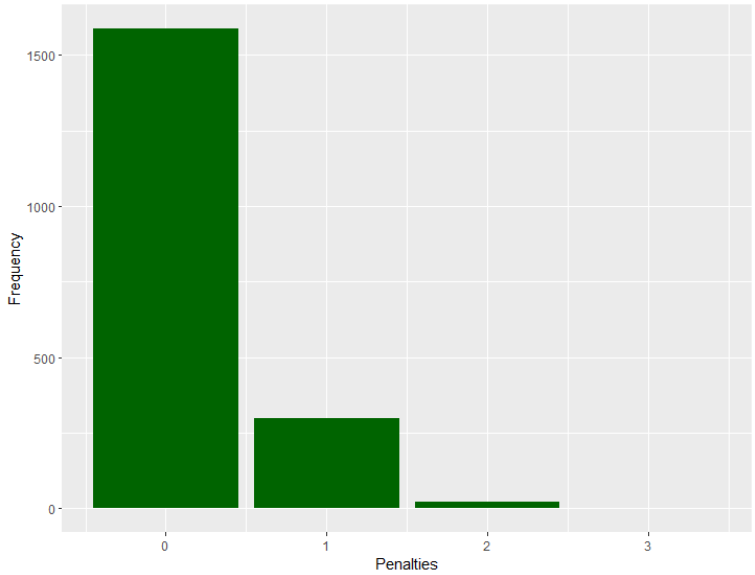

Figure 4 Bar plot of penalties

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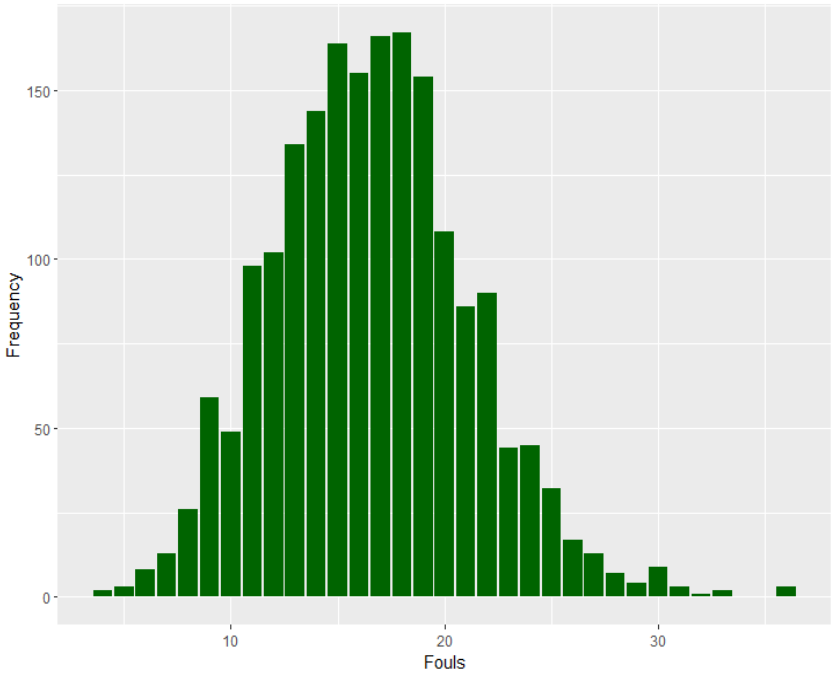

Figure 5 Bar plot of fouls

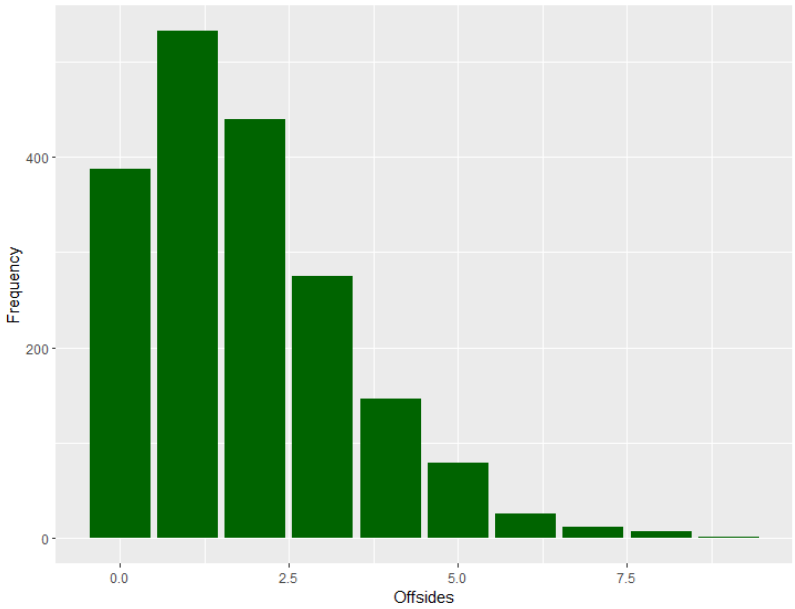

Figure 6 Bar plot of offsides

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In Table 2, the descriptive statistics of the match variables are presented for the seasons 2017/18, 2018/19, 2019/20,2020/21.

Match Variable	Mean	Standard deviation	Median	Min	Max	1st Qu	3rd Qu	Mean
Goals	1.13	1.14	1	0	7	0	2	1.13
Fouls	16.59	4.61	16	4	36	13	19	16.59
Penalties	0.18	0.42	0	0	3	0	0	0.18
Yellow Cards	2.68	1.53	3	0	9	2	4	2.68
Red Cards	0.12	0.35	0	0	2	0	0	0.12
Offsides	1.85	1.57	2	0	9	1	3	1.85

Table 2 Descriptive statistics for the match variables

In total during these four football seasons 1.13 goals on average per game were scored, 0.12 red cards and 2.68 yellow cards were given. Fouls committed per game were on average 16.59, offsides were on average 1.85 and penalties awarded 0.18 on average per match.

In the following diagrams (Figures 7,9) the mean number of goals scored, red and yellow cards, fouls and offsides given and penalties between home and away teams per season are presented. The green columns in the diagrams represent the home teams, and the grey columns correspond to the away teams. Home teams score more goals on average than the away teams. There is a decrease on the difference between home and away teams in relation to goals scored, on average, during season 2020/21. The number of penalties awarded is continuously increasing throughout this four-year period we are analyzing, and the home teams are consistently awarded more penalties, on average than the away teams. Regarding offsides there is no clear pattern. During seasons 2017/18, 2019/20 more offsides, on average were awarded against the home teams compared to away teams. For seasons 2018/19, 2020/21 more offsides were awarded, against the away teams. There is a decline in the number of offsides awarded, on average the seasons 2019/20, 2020/21.

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This was when Video assistant referee was introduced, and the pandemic started. Offsides, goals and penalties are incidents where Var intervenes, thus we are interested in investigating its impact on these match variables.

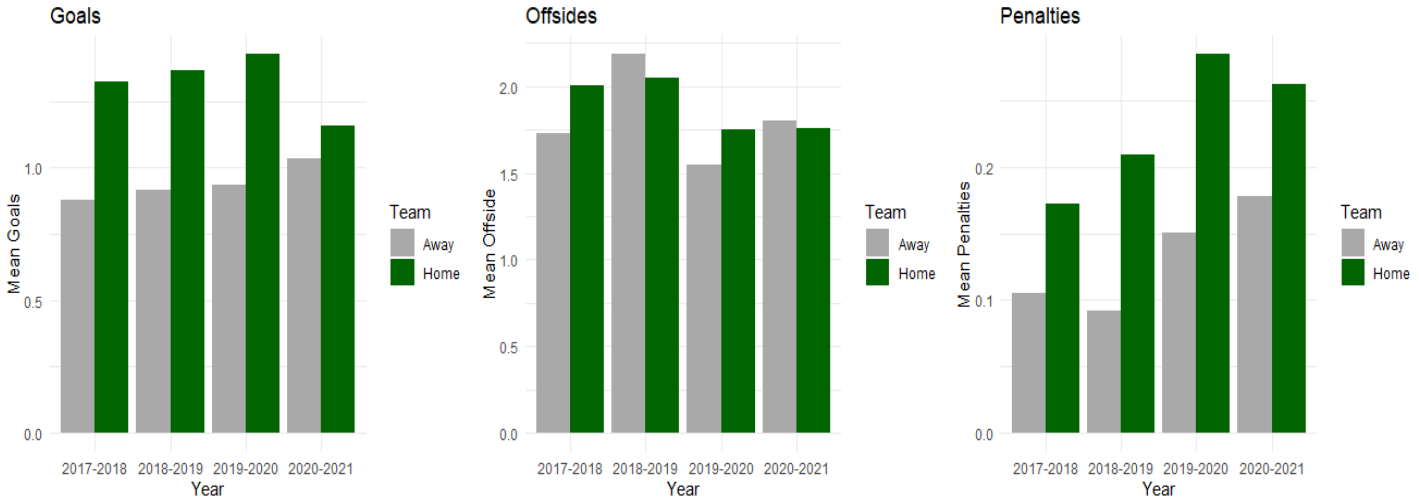

Figure 7 Mean number of goals, Offsides and Penalties per season

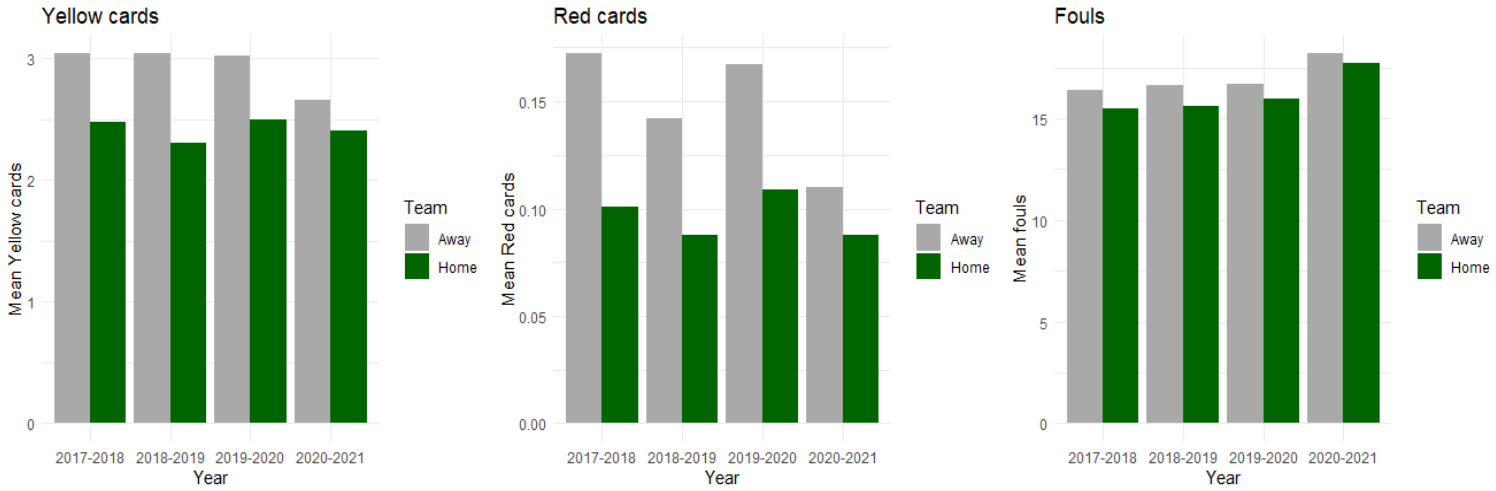

Figure 8 Mean number of Yellow, red cards and Fouls per season

Yellow cards are awarded, on average more frequently against the away teams each year. There is a decline on the average number of yellow cards awarded during season 2020/21, when there were no spectators at the stadiums. Similarly, on average red cards are awarded

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more frequently against the away teams. This difference between home and away teams decreased in season 2020/21, during fans absence. Additionally, the same year a decline on the average number of red cards awarded is captured. VAR also intervenes on the red cards incidents. Concerning fouls, on average more fouls are awarded against the away teams each season. The average number of fouls increases throughout the years for both home and away teams. In the next chapter we will check whether these differences noted, are indeed significant and whether VAR or the crowd support absence influenced the aforementioned match variables.

In table 3 we can see the number of home, away wins and draws per season. We can see that in 2019/20, when VAR was implemented and pandemic started, both away and home wins decreased, draws increased. In 2020/21 when the championship was completed without the fans' presence home teams' wins decreased further and the matches won by the away team increased in comparison to 2019/20 season. Home wins are more than away team wins for each season.

Season	Away Team Wins	Draws	Home Team Wins
2017/18	114	144	218
2018/19	136	110	232
2019/20	126	138	214
2020/21	155	140	181

Table 3 Number of home, away team wins and draws per season.

We will check whether the continuous variables are correlated using Pearson's correlation coefficient.

$r_{xy} = \frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i-\bar{y})^2}}$, where $\bar{x}, \bar{y}$ are the sample means.

From Figure 9 we can see that the continuous variables are not correlated.

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We also check whether any association exists between the discrete variables home advantage (ha), VAR (indicating Var's implementation), and Covid (indicating fans' absence or presence) using the chi- squared independence test.

The null hypothesis for this test is Ho : no association between the two variables and the alternative is that there is association between the two variables. Our results are presented below in Table 4. We conclude that covid and var are correlated. Thus, we will analyze their effect on home advantage separately.

Test	***X-squared***	***P-value***
Covid ~ Var	855.41	< 0.0001
ha ~ Covid	0.0075769	0.9306
ha ~ Var	0.0020964	0.9635

Table 4 Chi-squared test for the factor variables

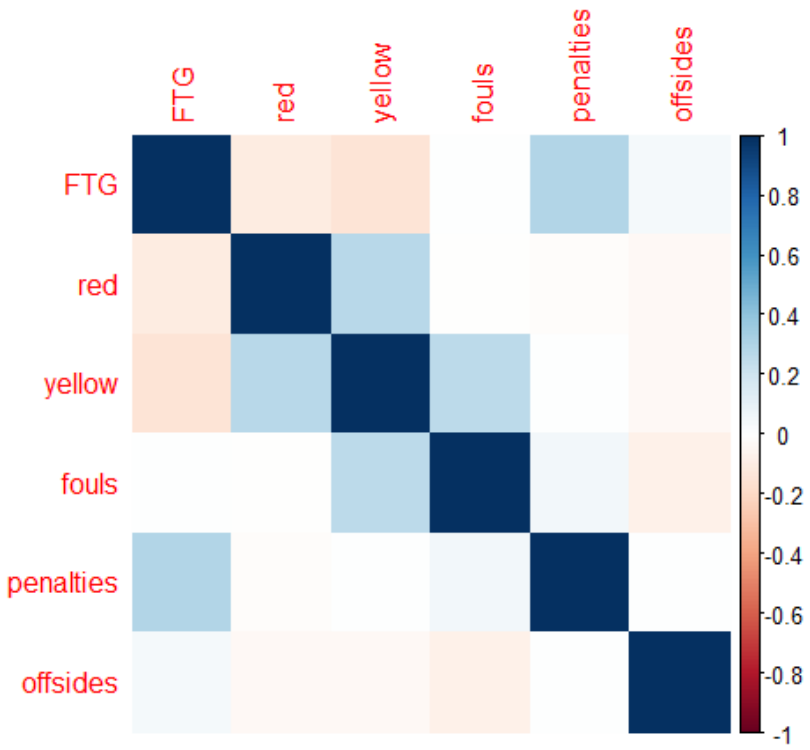

Figure 9 - Correlation Plot

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Chapter 5

ANALYSIS AND RESULTS

5.1 Home Advantage

Richard Pollard (1986) quantified home advantage as the number of points won at home expressed as a percentage of all points won for the competitions where draws are allowed. To calculate the home advantage using Pollard's formula, an equal number of home and away matches is required. A percentage of 50% indicates no home advantage, over 50% percent indicates home advantage and below 50% is interpreted as home disadvantage.

$$HA = \frac{\text{points won at home}}{\text{all points won}} * 100\%$$

Since, this is the case for the Greek Super League we calculated home advantage for the football seasons 2017/18, 2018/19, 2019/20, 2020/21. The results indicate that home advantage in the Greek Super league decreases over the years (Figure 10) taking the lowest value in season 2020/21, which is approximately 53%.

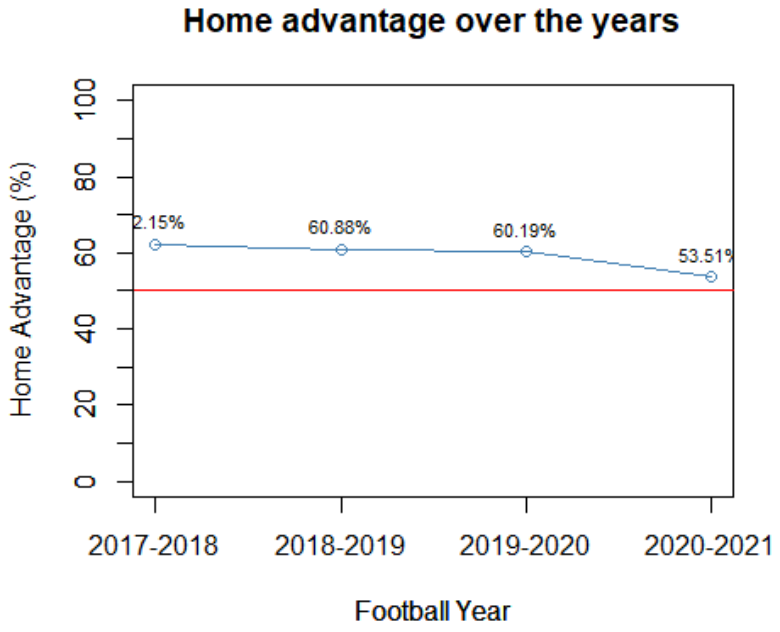

Figure 10 Home advantage in the Greek Football

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In order to examine further home advantage effect in the Greek Super league throughout these four years we applied generalized linear models' theory. Each match variable was used as an outcome variable and the independent variables were factor variables. Home advantage, indicating whether the match variable (goal, penalty kicks, fouls, etc) refer to a home or away team, Team A and Team B, the names of the competitive teams for each match. We applied Poisson regression models for each season 2017/18, 2018/19, 2019/20 and 2020/21.

Home Advantage and Goals

We present below the obtained results for home advantage effect on goals. The table that contains the full results can be found within the Appendix section.

$$\log(\mu_{goals}) = \beta_o + \beta_{ha} * ha + \beta_{teamA} * team_A + \beta_{teamB} * team_B$$

Season	Coefficient	Estimate	p-value	Standard Error	95% Confidence Interval [2.5%, 97.5%]
2017-2018	Home Advantage1	0.415	<0.0001	0.089	[0.241, 0.591]
2018-2019	Home Advantage1	0.403	<0.0001	0.088	[0.232, 0.576]
2019-2020	Home Advantage1	0.415	<0.0001	0.086	[0.247, 0.585]
2020-2021	Home Advantage1	0.116	0.1861	0.088	[-0.055, 0.289]

Table 5 Goals and Home Advantage effect- Results

For the years 2017/18, 2018/19 and 2019/20, level 1 of the factor variable home advantage, i.e., being the home team, was statistically significant for the outcome variable goals and the estimated coefficient is positive suggesting that the home team scored more often compared to the away team given that the rest variables are held constant. The narrow confidence intervals confirm the results. For season 2020/21 we see that home advantage is not statistically significant. We performed goodness of fit tests for all the above four models by comparing each one to the saturated model. The results suggest a strong fit for all four models.

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Home Advantage and Yellow Cards

Regarding the yellow cards (Table6), for each season the estimated coefficients for home advantage were negative, suggesting that the players of the home team are not awarded with yellow cards as frequently as the players of the away teams. Home advantage was not found to be a statistically significant predictor, on a 5% significance level, for the 2020/21 season.

$$\log(\mu_{yellow\ cards}) = \beta_o + \beta_{ha} * ha + \beta_{teamA} * team_A + \beta_{teamB} * team_B$$

Season	Coefficient	Estimate	p-value	Standard Error	95% Confidence Interval [2.5%, 97.5%]
2017-2018	Home Advantage1	-0.202	0.0002	0.055	[-0.311, -0.096]
2018-2019	Home Advantage1	-0.277	<0.0001	0.057	[-0.388, -0.166]
2019-2020	Home Advantage1	-0.193	0.0005	0.055	[-0.301, -0.084]
2020-2021	Home Advantage1	-0.100	0.0825	0.058	[-0.213, 0.013]

Table 6 Yellow Cards and Home Advantage effect – Results

Home Advantage and Red Cards

With respect to red cards, the predictor home advantage was not statistically significant at 5% significance level only for the seasons 2018/19 and 2020/21. For the seasons 2017/18 and 2019/20 it was statistically significant at significance levels 5% and 10% respectively, and the estimated effect was negative, leading to the same conclusion we made for the yellow cards. The expected number of red cards awarded to the players of the away team is greater, compared to expected number of red cards awarded to the players of the home team. The estimated standard errors and 95% confidence intervals for home advantage confirm the above results (Table 7).

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$$\log(\mu_{red\ cards}) = \beta_o + \beta_{ha} * ha + \beta_{teamA} * team_A + \beta_{teamB} * team_B$$

Season	Coefficient	Estimate	p-value	Standard Error	95% Confidence Interval [2.5%, 97.5%]
2017-2018	Home Advantage1	-0.530	0.039	0.257	[-1.048, -0.034]
2018-2019	Home Advantage1	-0.449	0.109	0.280	[-1.012, 0.092]
2019-2020	Home Advantage1	-0.424	0.093	0.252	[-0.929, 0.064]
2020-2021	Home Advantage1	-0.249	0.402	0.297	[-0.840, 0.331]

Table 7 Red cards and home advantage effect - Results

Home Advantage and Penalties

As for penalties we observe that the predictor home advantage was statistically significant at significance level 5% for seasons 2018/19, 2019/20,2020/21 and at significance level 10% for 2017/18. The estimated coefficients for each year were positive, indicating that the home team is more frequently awarded penalties compared to the away team.

$$\log(\mu_{penalties}) = \beta_o + \beta_{ha} * ha + \beta_{teamA} * team_A + \beta_{teamB} * team_B$$

Season	Coefficient	Estimate	p-value	Standard Error	95% Confidence Interval [2.5%, 97.5%]
2017-2018	Home Advantage1	0.494	0.052	0.254	[0.004, 1.004]
2018-2019	Home Advantage1	0.808	0.001	0.257	[0.317, 1.331]
2019-2020	Home Advantage1	0.632	0.002	0.206	[0.235, 1.046]
2020-2021	Home Advantage1	0.399	0.046	0.200	[0.011, 0.796]

Table 8 Penalties and home advantage effect - Results

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Home Advantage and Fouls

Regarding fouls (Table 9), being the home team was not statistically significant for the 2020/21 season at a significance level 5%. For the first three seasons the effect of home advantage on fouls was statistically significant at a significance level 5% and the estimated coefficients were negative for each season.

$$\log(\mu_{fouls}) = \beta_o + \beta_{ha} * ha + \beta_{teamA} * team_A + \beta_{teamB} * team_B$$

Season	Coefficient	Estimate	p-value	Standard Error	95% Confidence Interval [2.5%, 97.5%]
2017-2018	Home Advantage1	-0.059	0.009	0.023	[-0.104, -0.014]
2018-2019	Home Advantage1	-0.063	0.006	0.022	[-0.108, -0.018]
2019-2020	Home Advantage1	-0.047	0.038	0.023	[-0.092, -0.003]
2020-2021	Home Advantage1	-0.026	0.221	0.022	[-0.069, 0.016]

Table 9 Fouls and home advantage effect – Results

Home Advantage and Offsides

Concerning offsides (Table 10), after taking into consideration the obtained p-values, standard errors and 95% estimated confidence intervals for each year, we conclude that home advantage effect on offsides was not statistically significant for seasons 2018/19, 2019/20 and 2020/21. For season 2017/18 home advantage effect was found to be statistically significant on offsides at a significance level 5% and the corresponding estimated coefficient was positive. By calculating the exponential value of the estimated coefficient, we obtain that the expected number of awarded offsides to the home team is 15.9% greater than the expected number of awarded offsides to the away team, assuming all the other variables are held constant.

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$$\log(\mu_{offsides}) = \beta_o + \beta_{ha} * ha + \beta_{teamA} * team_A + \beta_{teamB} * team_B$$

Season	Coefficient	Estimate	p-value	Standard Error	95% Confidence Interval [2.5%, 97.5%]
2017-2018	Home Advantage1	0.148	0.028	0.067	[0.017, 0.281]
2018-2019	Home Advantage1	-0.061	0.333	0.063	[-0.184, 0.063]
2019-2020	Home Advantage1	0.119	0.095	0.071	[-0.021, 0.260]
2020-2021	Home Advantage1	-0.018	0.808	0.069	[-0.151, 0.118]

Table 10 Offsides and home advantage effect – Results

Summarizing, in this chapter we analyzed home advantage effect on the Greek Super league for seasons 2017/18, 2018/19, 2019/20 and 2020/21. First of all, we calculated home advantage according to Pollard's formula. Home advantage decreased over these four years, but during season 2020/21 was almost eliminated. Subsequently, we employed generalized linear models to study the home advantage effect in the Greek football in greater depth. Overall, home advantage has a greater effect on the goals scored as well as the penalties, the fouls and the yellow cards awarded. In particular, home teams score more frequently than the away teams. Home teams are awarded more penalties, but fewer fouls and yellow cards. Additionally, home teams are awarded fewer red cards compared to away teams. We cannot establish a pattern related to the home advantage effect on offsides. Moreover, we confirmed Pollard's formula results, that home advantage effect diminished during season 2020/21, as it was either not statistically significant for most of the match variables or only marginally statistically significant.

In the next two chapters we will focus on whether video assistant referee introduction and covid-19 pandemic affected home and away teams' performances, i.e., home advantage effect.

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5.2 Home Advantage and VAR

Video assistant referee was introduced in the Greek Super league during the season 2019/2020. VAR intervenes in specific match changing incidents like penalties, goals, red cards and offsides and in the case of mistaken identity. Its use is intended to help referees make more accurate decisions or correct mistaken ones. We will examine if it has fulfilled its purpose. We included 477 matches before and after the implementation of VAR.

In Figures 9, 10 we see the differences between home and away teams regarding the mean goals scored, red cards and offsides awarded, as well as fouls, yellow cards, and penalties, before and after the implementation of video assistant referee in the Greek Super League. As identified in chapter 5.1, home teams score more than the away teams, but we can see that this difference in mean goals scored between home and away teams decreased since the introduction of the VAR. The differences between the means regarding fouls, red and yellow cards awarded also decreased between the home and away teams.

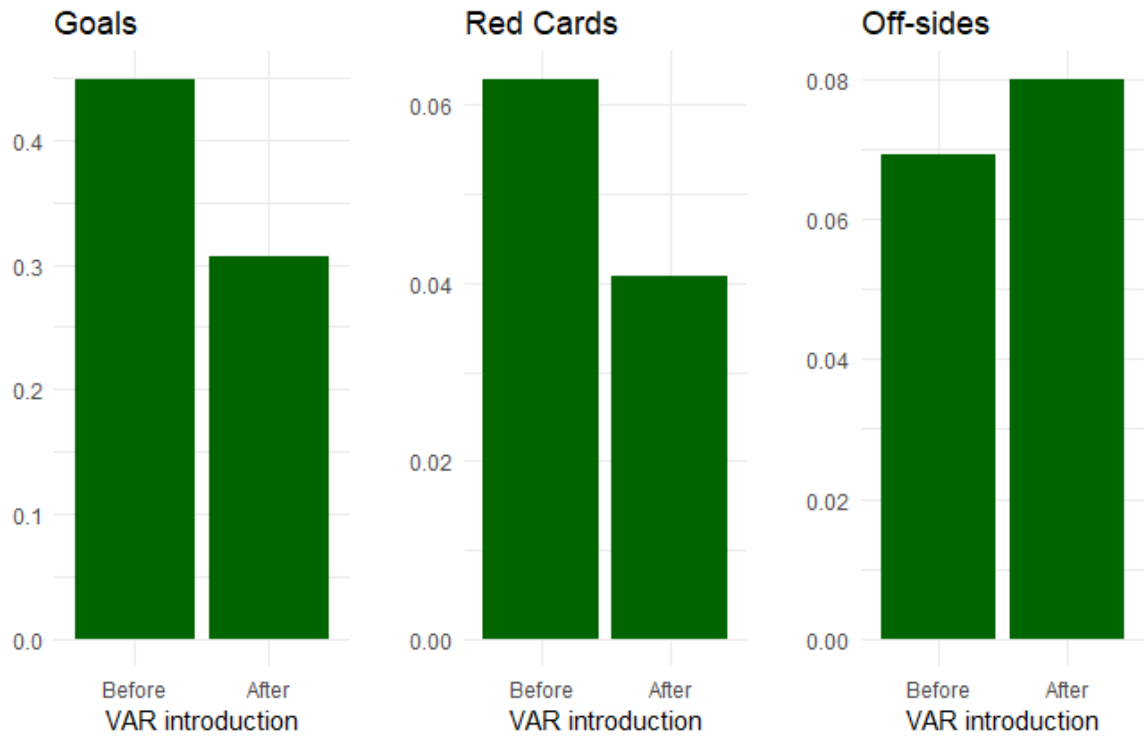

Figure 11 Difference between home and away teams on mean Goals, Red cards, Offsides

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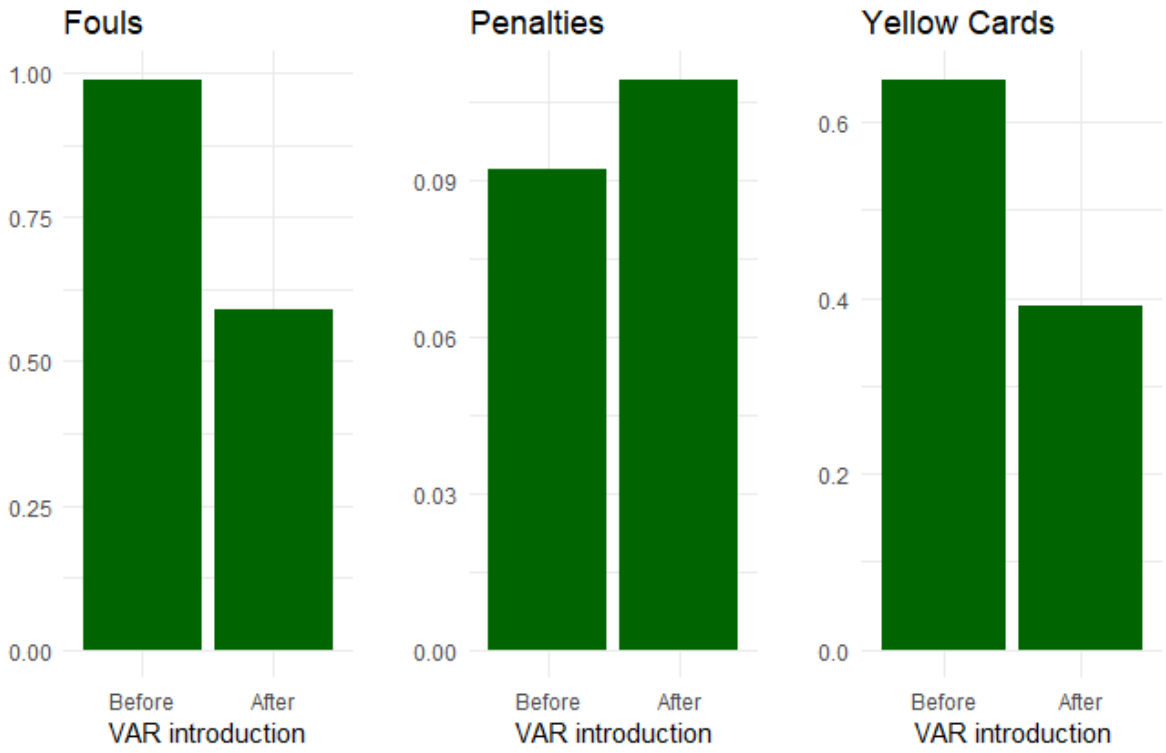

Figure 12 Difference between home and away teams on mean Fouls, Penalties, Yellow cards

Additionally, the difference in mean offsides and penalties between home and away teams increased following Var implementation.

In the previous chapter we detected that home effect in the Greek Super league is expressed as home teams score more frequently than the away teams, are awarded more penalties but fewer fouls, red and yellow cards. VAR implementation is expected to diminish these observed differences between home and away teams, especially regarding goals, red cards, and penalties. In Figures 9,10 a decline in those differences is captured, but further investigation is needed to determine whether these differences are statistically significant. To investigate that, we employed generalized linear models for each match variable of interest. Due to the nature of the data, i.e., count variables, we used Poisson distribution. The outcome variables were goals, offside, red cards, penalties, incidents where VAR intervenes and could lead to review as well as, yellow cards and fouls. The explanatory variables included in each model are a dummy variable indicating var introduction or not, a dummy variable

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representing home advantage effect, i.e., if the respective team is home or away team, the interaction between VAR and home advantage and two factor variables which are called team A and team B, representing the competitive teams per match. Both variables Team A and Team B have 19 levels, which are the Greek football teams participating in the Super league during the aforementioned football seasons. These teams are AEK, Apollon, Aris, Asteras Tripolis, Atromitos, Giannina, Kerkyra, Lamia, Larisa, Levadeiakos, OFI Crete, Olympiakos, Panathinaikos, Panetolikos, Panionios, PAOK, Platanias, Volos NFC, Xanthi. For our calculations we used R-studio.

In Table 11, a summary of the results for each generalized linear model is presented. The results are included in detail in the Appendix section.

Variable	Var Estimate	p-value	Home advantage Estimate	p-value	Var * Home advantage Estimate	p-value	Residual Deviance
Goals	0.008	0.913	0.400	<0.0001	-0.125	0.152	2005.4
Red Cards	-0.265	0.175	-0.506	0.007	0.1614	0.548	958.71
Yellow Cards	-0.073	0.084	-0.239	<0.0001	0.090	0.107	1752.9
Penalties	0.431	0.032	0.665	0.0002	-0.146	0.525	1143.4
Offsides	-0.189	0.0004	0.033	0.469	0.014	0.841	2555.5
Fouls	0.041	0.020	-0.062	0.0001	0.026	0.249	2244.4

Table 11 Results of the Generalized linear model for each match variable and VAR

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For each generalized linear model (GLM) we present below the respective error bar plots which include the point estimates for each independent variable per GLM and the respective 95% confidence intervals to have a better view of the variability of the GLMs.

The results of the generalized linear models suggest that following Var implementation the expected number of goals was not affected, and home teams continued to score more frequently compared to the away teams. Home advantage variable was found to be statistically significant at a 5% significance level for the outcome variable goals. The respective confidence interval of home advantage variable (ha1 - Figure 11) does not include 0 and it is narrow indicating home advantage effect is statistically significant . The respective residual deviance for this GLM is 2005.4 on 1868 degrees of freedom.

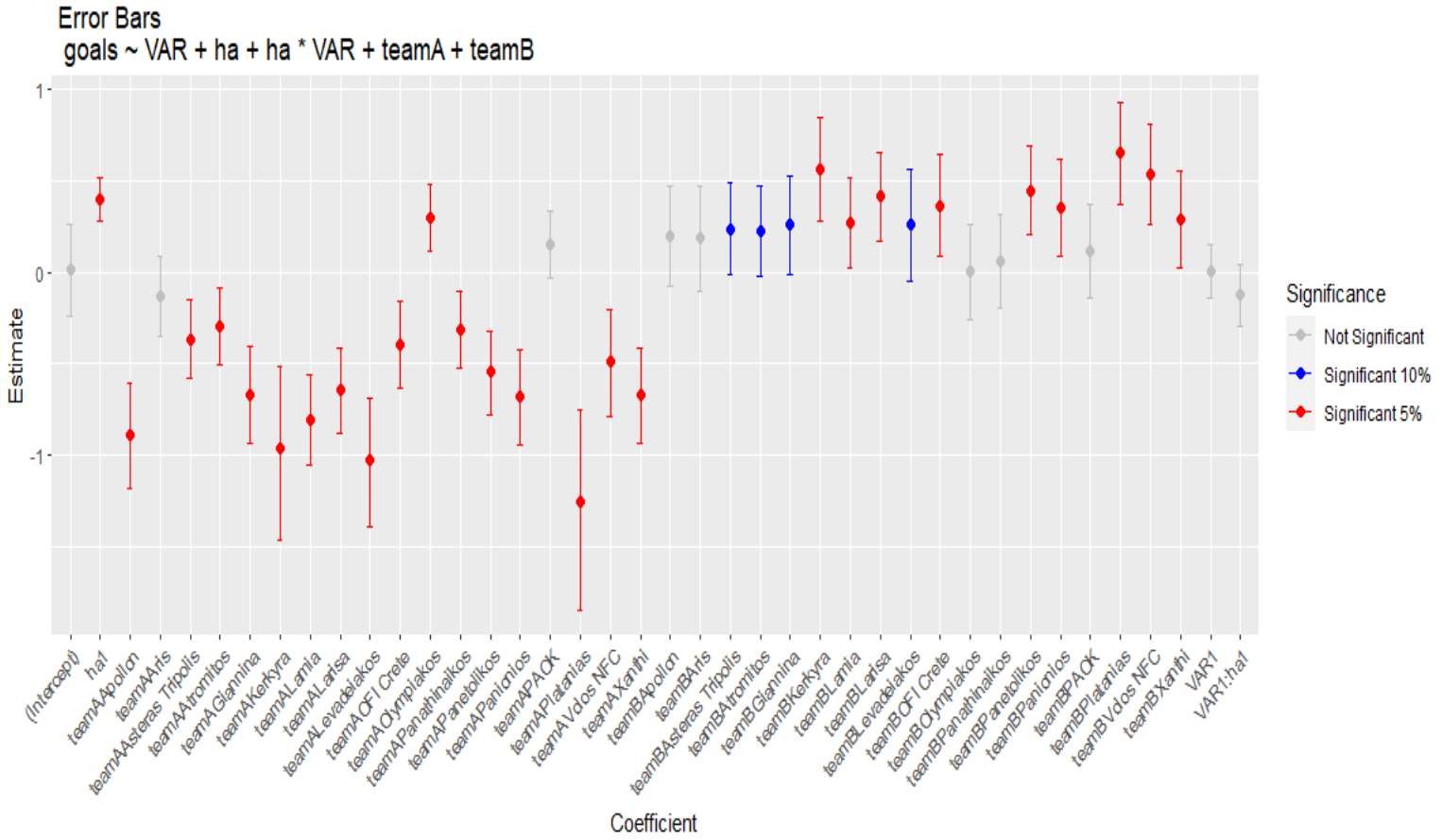

Figure 13 Error bar Plot 1

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VAR and VAR*ha variables are not statistically significant for the outcome variable red cards. The expected number of red cards awarded to the home teams is 39.7% less than that awarded to away teams, assuming the rest variables are held constant. The respective residual deviance for this GLM is 958.71 on 1868 degrees of freedom.

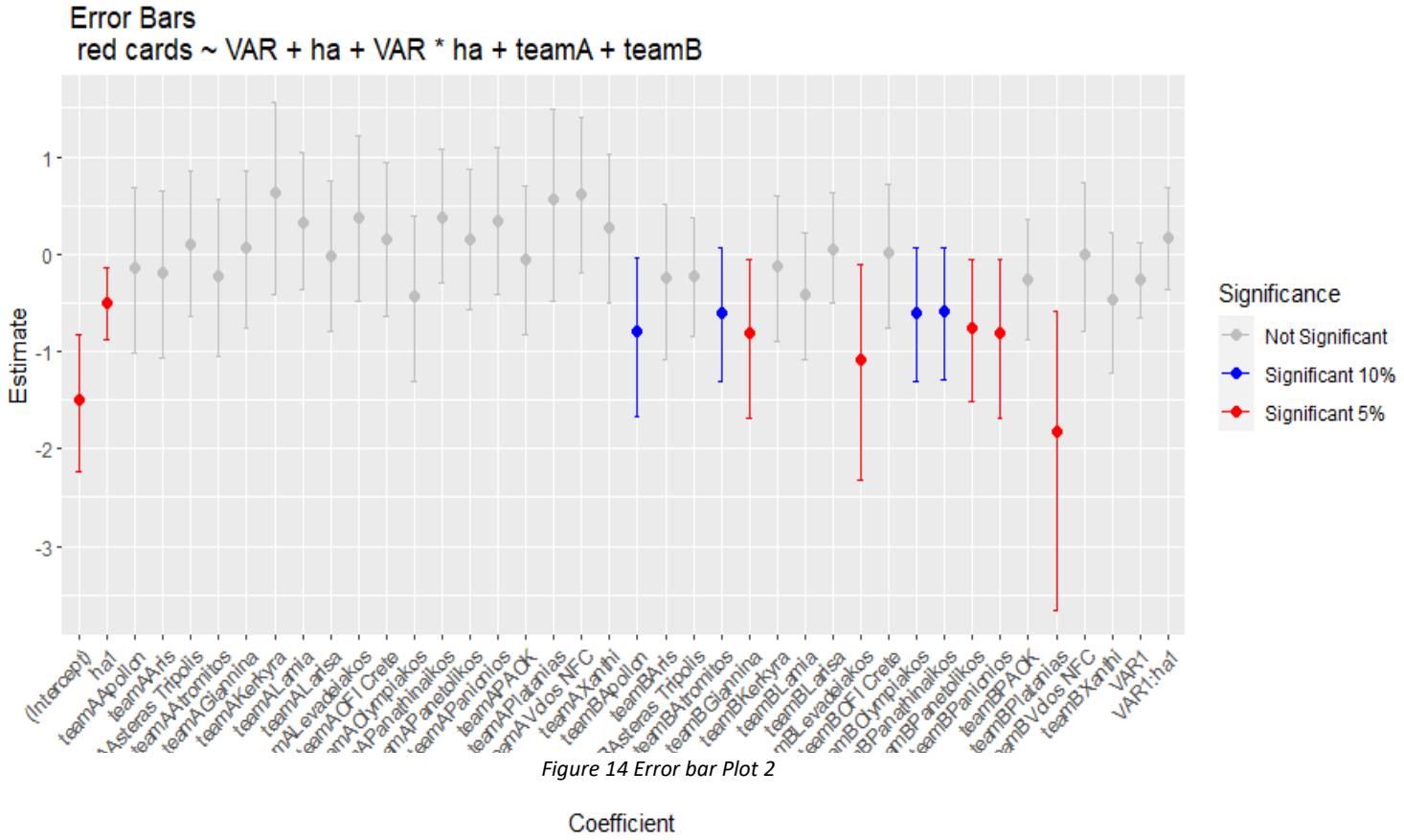

Figure 14 Error bar Plot 2

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Regarding the outcome variable yellow cards, home advantage was statistically significant at a 5% significance level and the corresponding coefficient estimate was negative. The expected number of yellow cards awarded to the home teams is 21.25% less than that awarded to away teams, assuming the rest variables are held constant. Variable VAR was statistically significant at a 10% significance level. The corresponding coefficient estimate was negative indicating a decrease on the total number of the yellow cards awarded after VAR introduction in the Greek Super league, assuming the rest of the variables are constant. We also notice though that the respective confidence interval for VAR variable includes 0, Figure 13. The respective residual deviance for this model is 1752.9 on 1868 degrees of freedom. The comparison with the saturated model indicates a good fit.

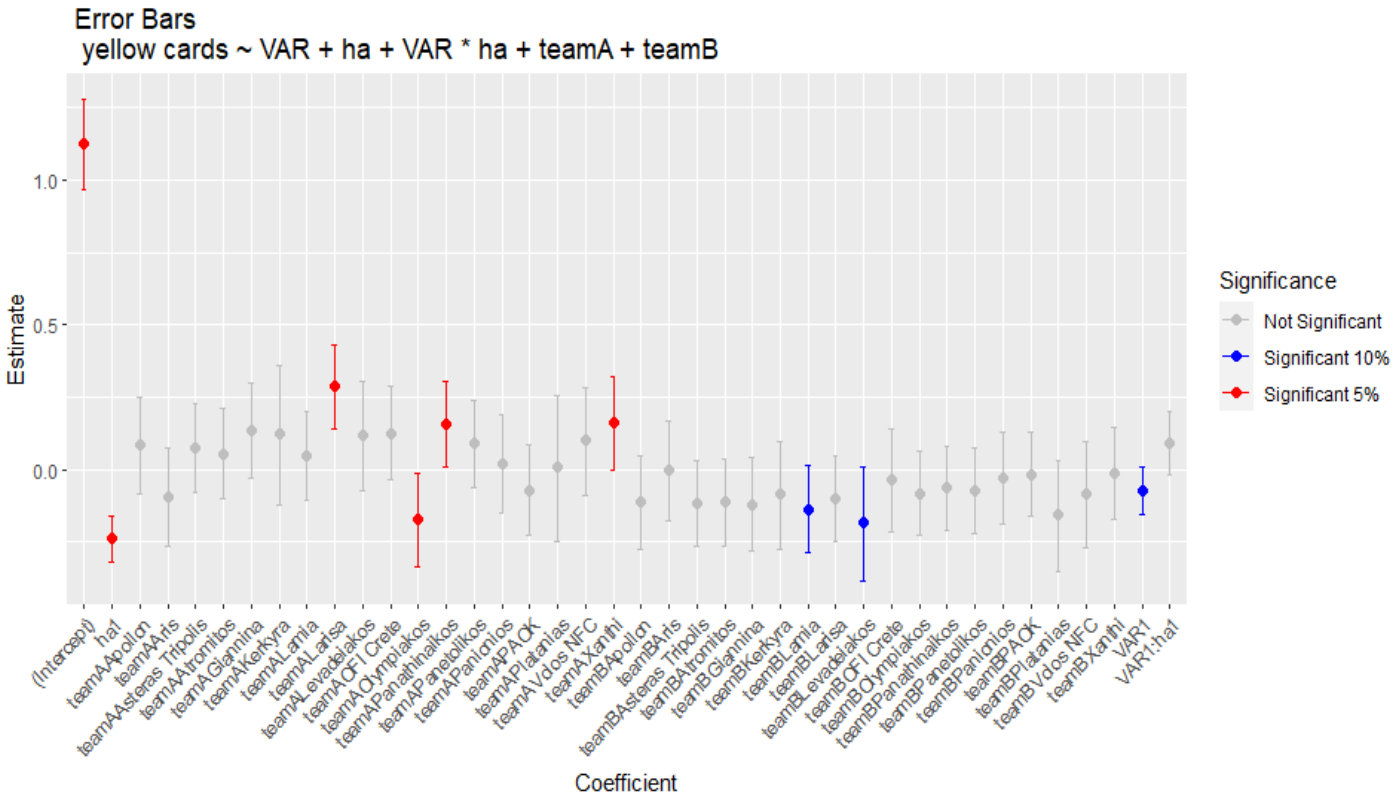

Figure 15 Error bar Plot 3

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Concerning penalties, VAR and home advantage variables were statistically significant at a 5% significance level. The variable ha * var was not found to be statistically significant. Home effect on penalties did not change following VAR implementation, but the expected number of penalties awarded was increased by 53.9% after VAR, assuming the rest variables are held constant. The respective residual deviance for this model is 1143.4 on 1868 degrees of freedom.

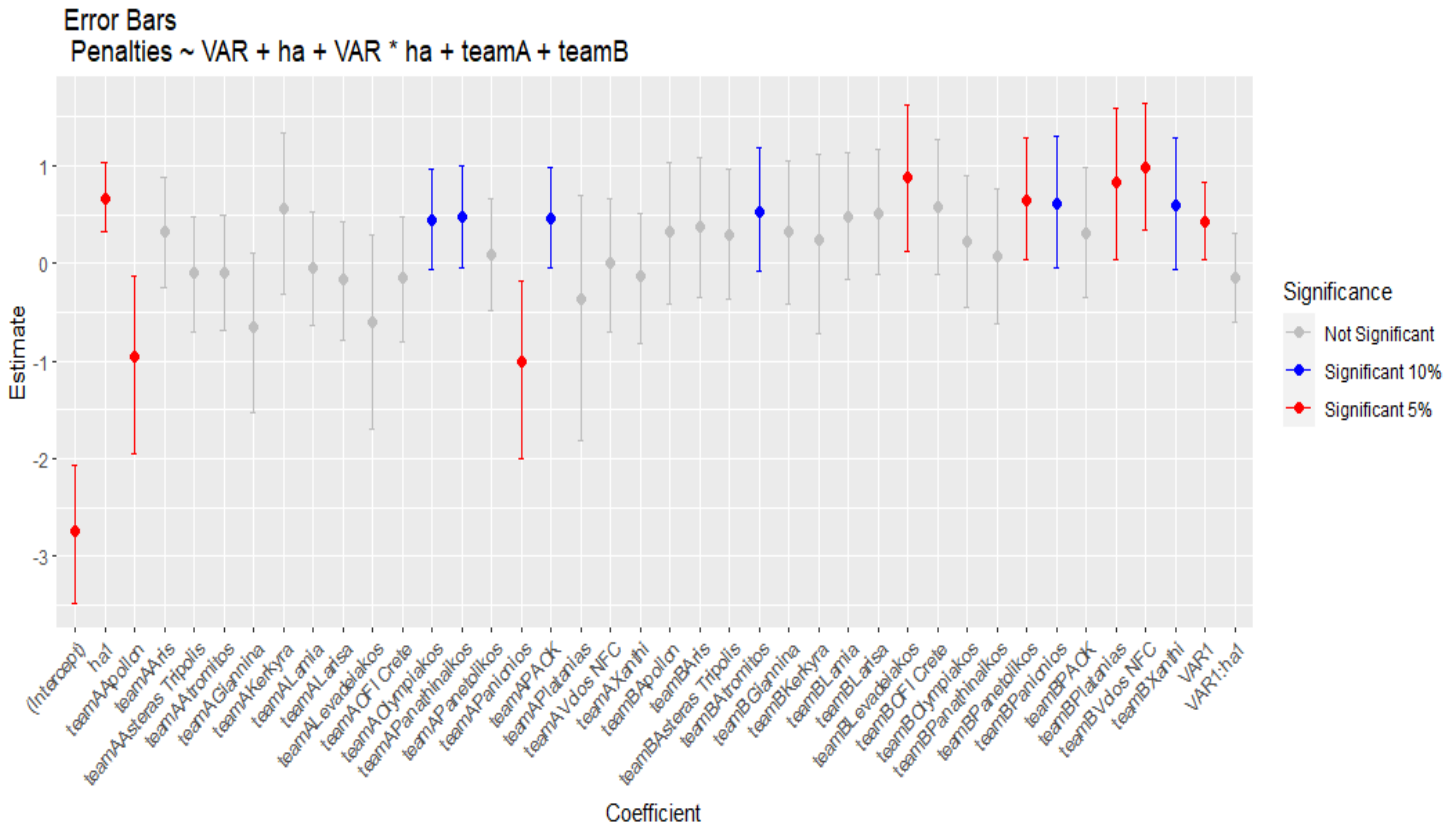

Figure 16 Error bar Plot 4

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For the outcome variable offsides, home advantage and the interaction term between home advantage and VAR were not found to be statistically significant. The variable VAR is statistically significant at a 5% significance level. The expected number of offsides decreased by 18% after the introduction of VAR system in the Greek league, assuming the other variables are constant . The respective residual deviance for this model is 2555.5 on 1868 degrees of freedom.

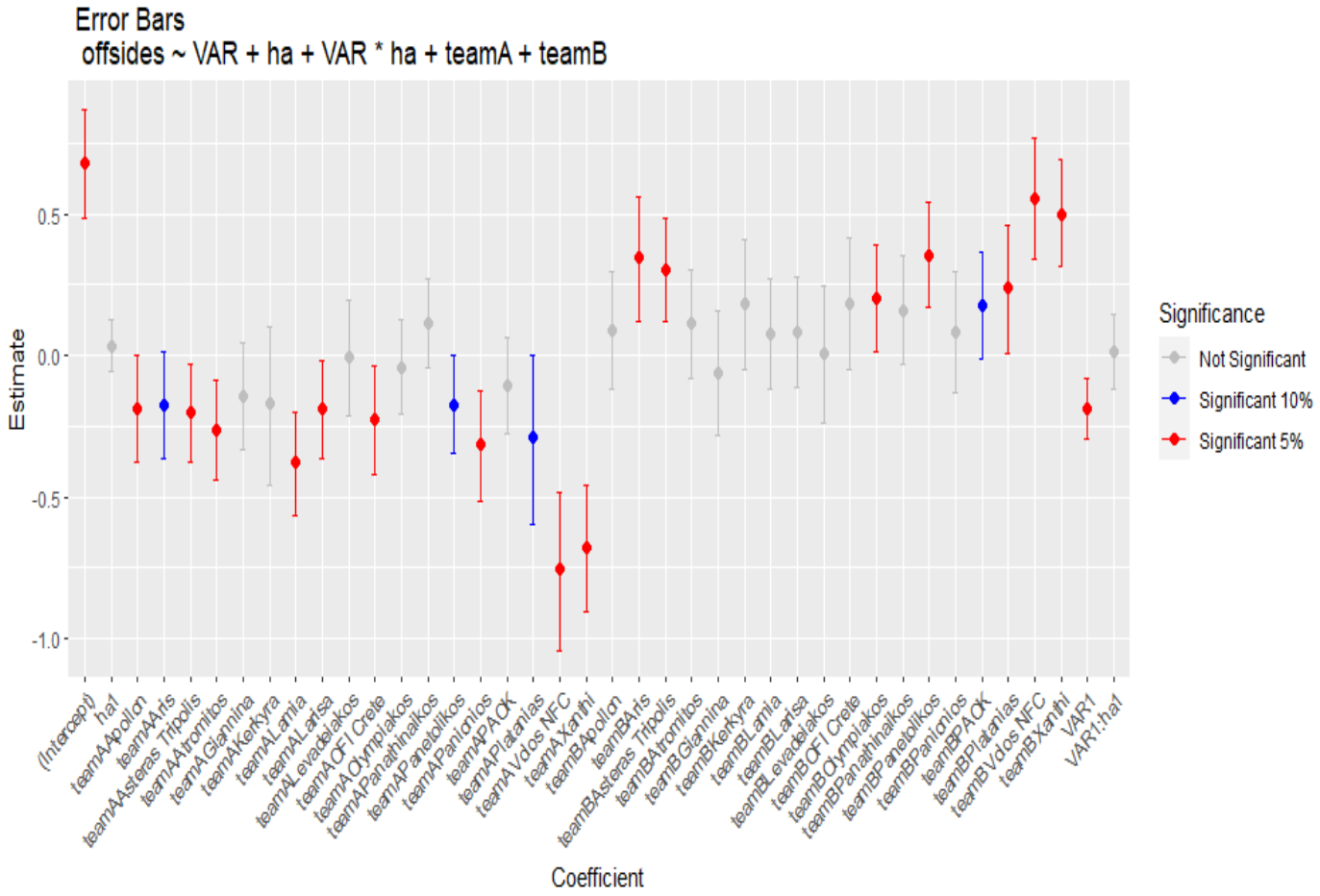

Figure 17 Error bar Plot 5

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In relation to fouls, home advantage and VAR are statistically significant at a 5% significance level. The respective confidence intervals are relatively narrow suggesting precise estimates. The interaction term of home advantage and VAR was not statistically significant. The expected number of fouls increased by 4.16% after the VAR implementation in the Greek football, assuming the other variables are constant. The residual deviance for this GLM is 2244.4 on 1868 degrees of freedom.

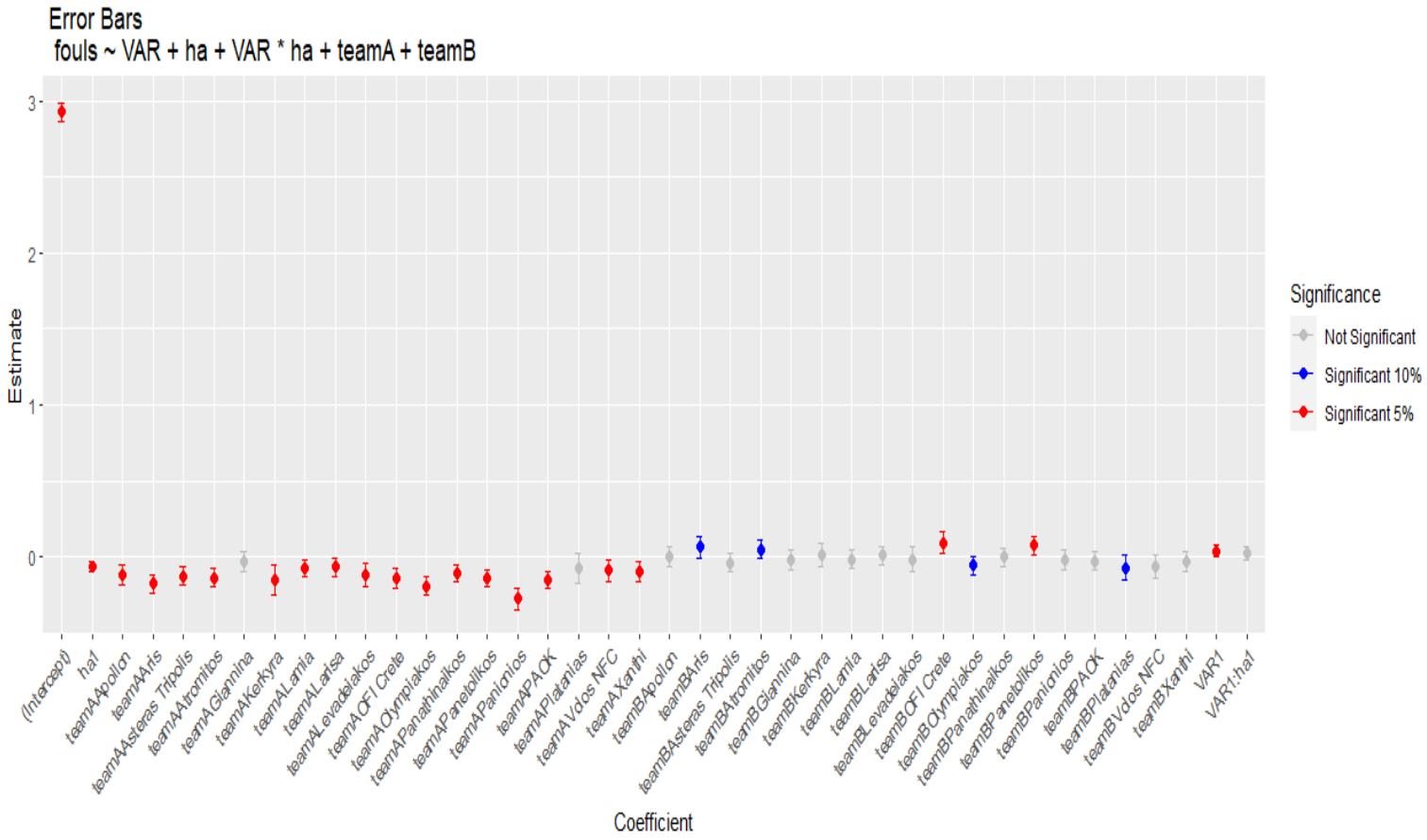

Figure 18 Error bar Plot 6

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Penalties, goals, red cards and offsides are incidents where a VAR review could potentially happen, to correct an erroneous decision made. We applied Poison regression models, one per match - outcome variable goals, red, yellow cards, penalties, offsides and fouls. The independent variables were the factor variables home advantage, VAR, the interaction of home advantage and var, as well the competitive teams, Team A and team B. Summarizing our results, following Var implementation in the Greek Super league offsides decreased, and the expected number of penalties and fouls increased. VAR introduction did not affect the expected number of goals, yellow and red cards, since VAR variable was not statistically significant at a 5% significance level. Home effect did not change after VAR was introduced since the interaction between home advantage and VAR (ha*VAR) was not statistically significant for any outcome variable.

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5.3 Home advantage and Covid-19

Crowd support is assumed to be one of the main factors that causes home advantage in football. Its effect has not yet been fully investigated and understood. Findings disagree on the importance of this factor. Coronavirus pandemic was a unique opportunity to study crowd support effect on both home advantage and referees, as fans were absent from the Greek stadiums. We have included 658 with and 296 matches without spectators. The matches are related to the 2017/18, 2018/19 seasons, which occurred before the pandemic, as well as 2019/20 and 2020/21 seasons which took place after the pandemic started.

In chapter 5.1 we observed that home advantage effect decreased during season 2020/21. For most match variables like goals, red cards, fouls and offsides, home effect factor was not significant during that season, when the matches were held behind closed doors. For the previous seasons, home advantage in the Greek Super League was over 60% and home teams scored more than the away teams. Additionally, referees' decisions were in favor of the home teams. Home teams were awarded more penalties and fewer fouls, red and yellow cards compared to the away teams. Furthermore, we will investigate whether the absence of fans impacted both teams' performances and referees' behavior.

Figures 17, 18 below present the difference between the mean value of the match statistics of home and away teams before and after the pandemic. The difference between home and away teams in the mean goals scored, mean red cards and mean offsides dropped dramatically. A decrease in the difference of mean yellow cards, mean penalties awarded, and fouls given is also noted. At a first glance, the differences between home and away teams attributed to the home effect were mitigated during covid-19 pandemic when the crowds were absent. In the following section we will examine whether these results are statistically proven.

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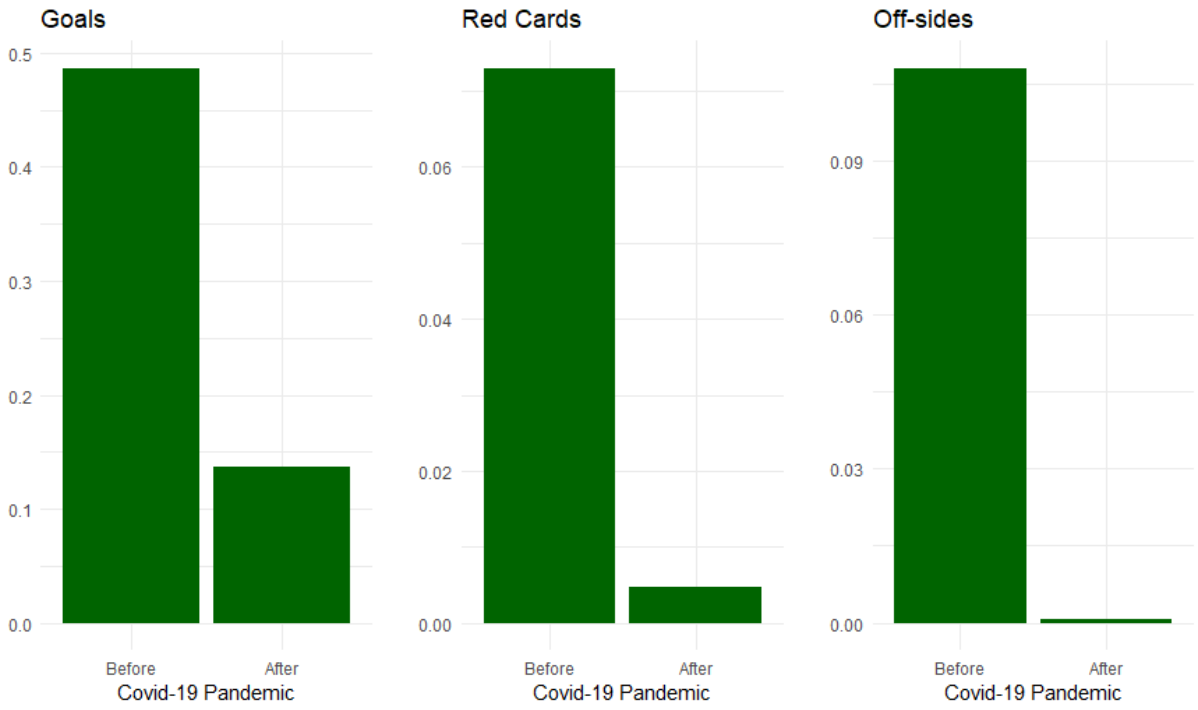

Figure 19 Difference between home and away teams on mean Goals, Red cards, Offsides

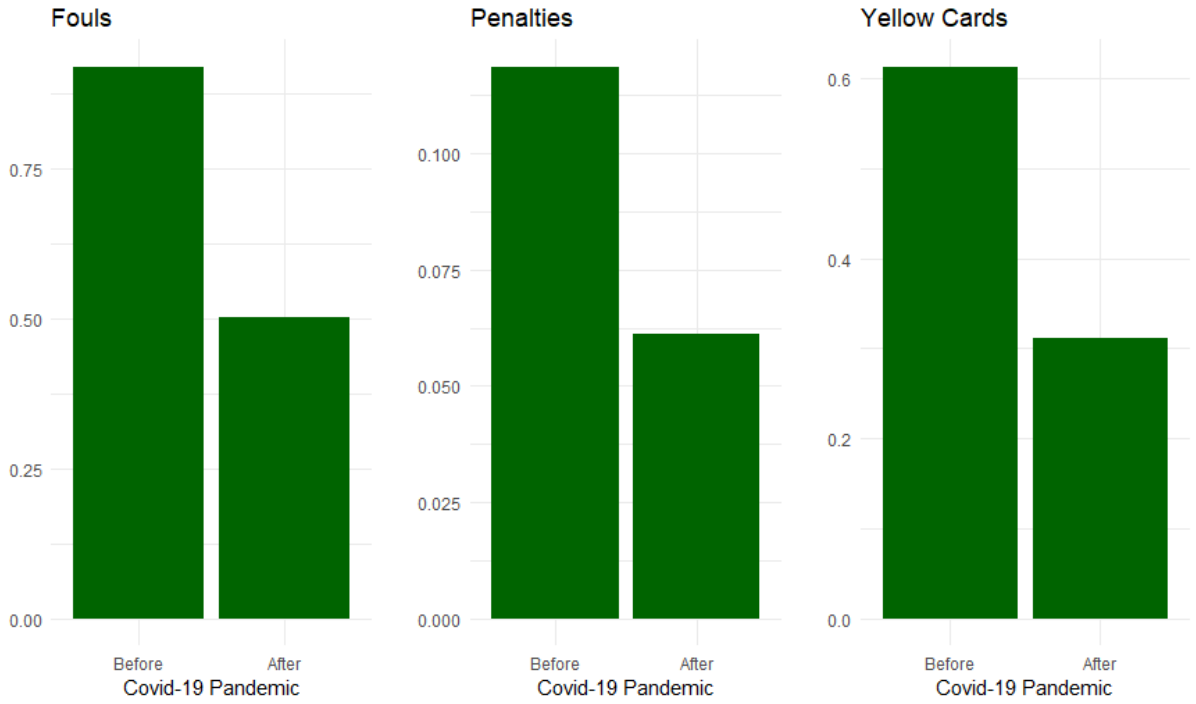

Figure 20 Difference between home and away teams on mean Fouls, Penalties, Yellow cards

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We applied generalized linear models for each match variable of interest, i.e., goals, penalties, fouls, offsides, red and yellow cards. We used the Poisson distribution, since the outcome variables are counts of events. For each generalized linear model, the same set of explanatory variables was used. These are a factor variable called covid indicating the absence of spectators or not, the home advantage, which takes the value 1 if the respective team is the home team, and 0 if not. The interaction term of covid and home advantage was included to represent the change in home advantage after the pandemic started. Two more factors were added, Team A and Team B, representing the names of the competitive teams per game. Both have 19 levels, and the reference level is AEK. Table 12 includes the results of the generalized linear models for each match variable.

Variable	Covid Estimate	p-value	Home advantage Estimate	p-value	Covid * Home advantage Estimate	p-value	Residual Deviance
Goals	0.0619	0.404	0.426	<0.0001	-0.294	0.002	1995.1
Red Cards	- 0.530	0.013	-0.570	0.0003	0.527	0.081	953.88
Yellow Cards	-0.095	0.030	-0.225	<0.0001	0.104	0.089	1751.5
Penalties	0.493	0.009	0.753	<0.0001	-0.458	0.046	1143.4
Offsides	-0.091	0.102	0.056	0.157	-0.059	0.429	2565.9
Fouls	0.067	0.0001	-0.057	<0.0001	0.028	0.245	2223.0

Table 12 Results of the Generalized linear model for each match variable and Covid-19

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Regarding the outcome variable goals, covid coefficient was not found to be statistically significant at a 5% significance level, meaning that we do not have enough evidence to prove that the expected number of goals differs when the crowd is absent. On the other hand, home advantage, the interaction of covid and home advantage variables were statistically significant at 5% significance level. The estimated coefficient for home advantage is positive meaning that the expected number of goals is higher for a home team compared to the away team when of the rest variables are constant. The estimated coefficient for the interaction term is negative, which means that the expected number of goals for a home team during the pandemic, is approximately 25.49% less than for an away team during the pandemic, assuming the remaining variables are constant. The residual deviance for this model is 1995.1 on 1868 degrees of freedom and comparing to the null model it fits the data well. The relatively narrow confidence intervals for these two variables indicate certainty for the obtained coefficients.

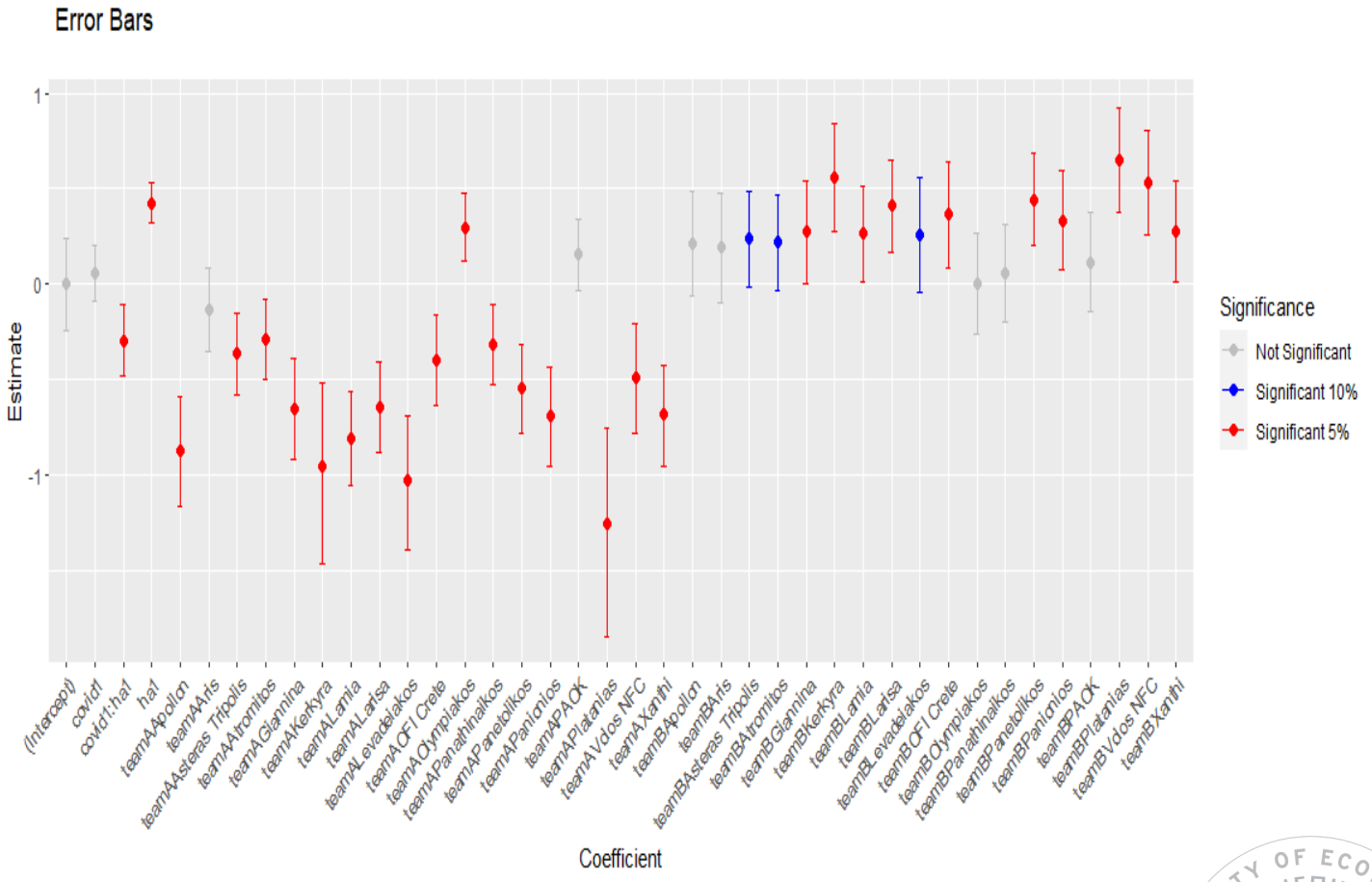

Figure 21 Error bar plot |Goals and Covid -19

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As far as outcome variable red cards is concerned, home advantage and covid variables were statistically significant at a 5% significance level. The expected number of red cards given during the crowd absence was approximately 41.17% less compared to when crowds were present, assuming the other variables remain constant. The obtained confidence intervals are relatively narrow. The interaction term of home advantage and covid was statistically significant at a 10% significance level, and the corresponding confidence interval includes 0, suggesting uncertainty. In general, the estimated coefficient for the interaction term was negative but we do not have enough evidence to decide on the actual effect of this variable. The residual deviance for this model is 953.88 on 1868 degrees of freedom and comparing to the null model it fits the data well.

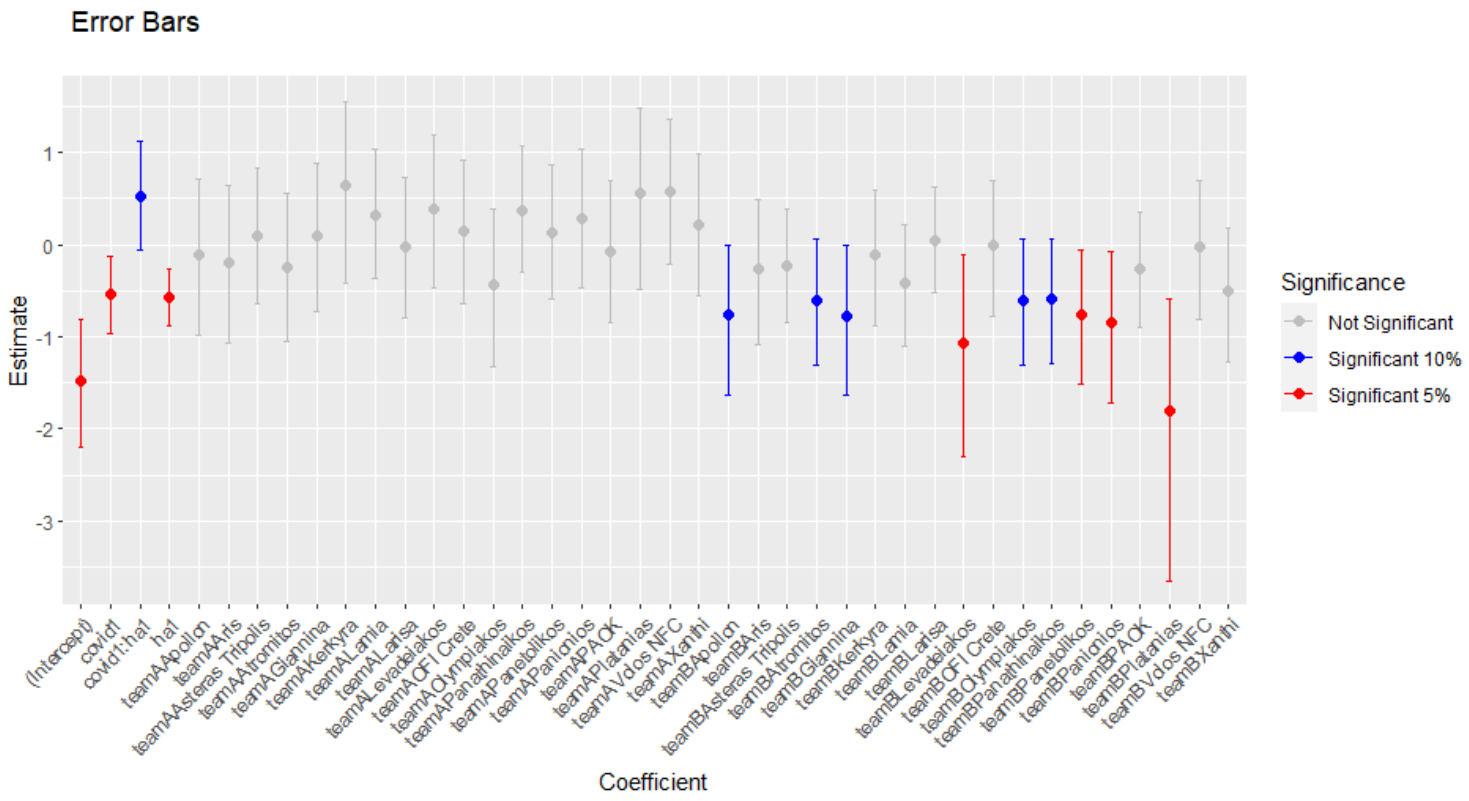

Figure 22 Error bar plot | Red cards and Covid-19

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With respect to yellow cards, home advantage and covid were statistically significant at a significance level of 5%. The expected number of yellow cards given during the pandemic was approximately 10% less compared to when fans were present, assuming the rest of the variables are constant. The respective 95% confidence intervals for home advantage and covid variables are relatively narrow. The effect of the interaction term between home advantage and covid cannot be clearly determined since the estimated coefficient was statistically significant at a 10% significance level, and the corresponding confidence interval includes 0. The residual deviance for this model is 1751.5 on 1868 degrees of freedom and the comparison to the null model suggests a good fit.

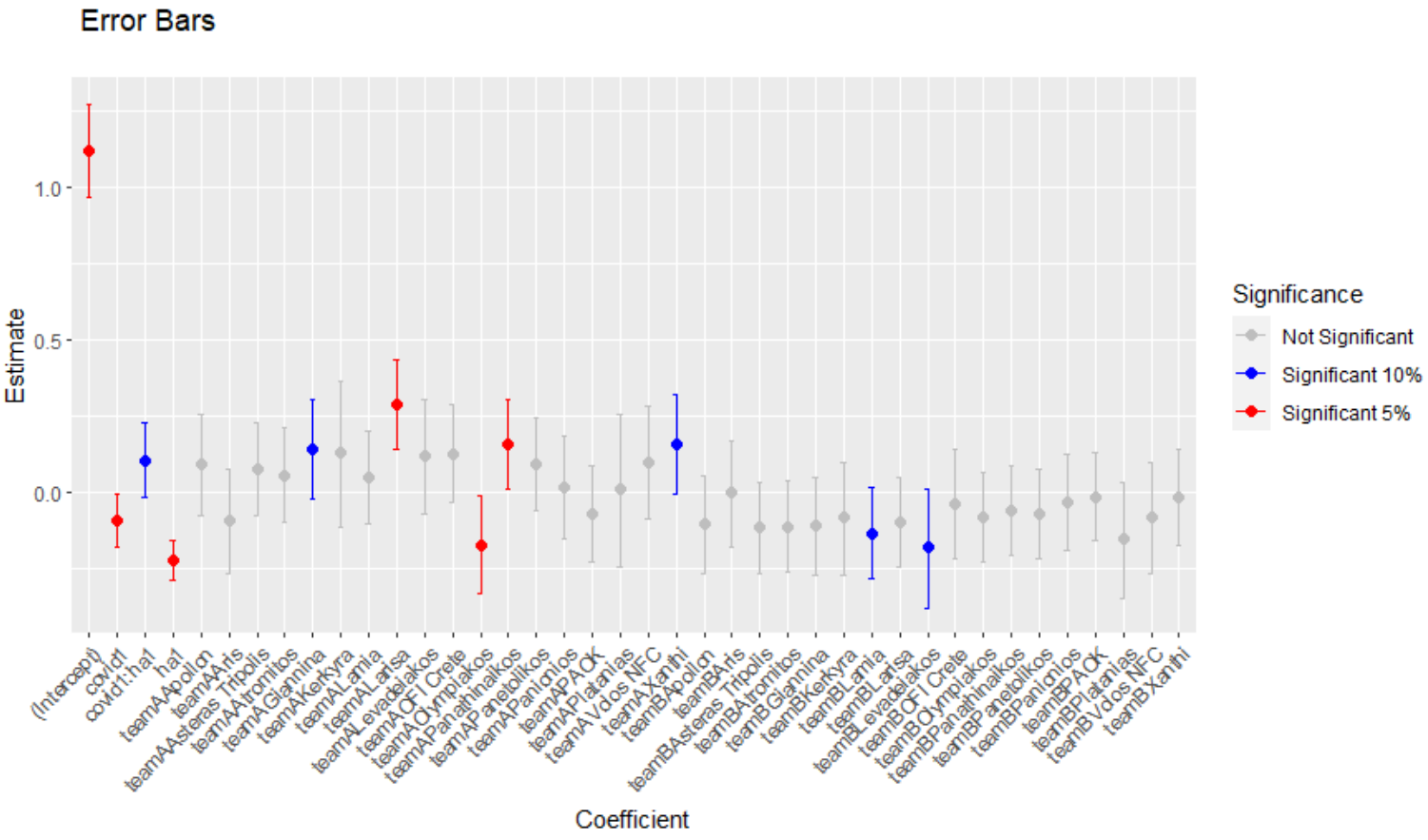

Figure 23 Error Bar Plot | Yellow cards and Covid-19

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Regarding outcome variable penalties, home advantage, covid effect as well as the interaction term between these two variables, were statistically significant at a 5% significance level. The respective 95% confidence intervals for the point estimates are relatively narrow. The expected number of penalties during the pandemic is about 63% higher than expected number of penalties before the pandemic, assuming all the other variables remain constant. Additionally, for a home team during the Covid-19 pandemic and the absence of the crowds, the expected number of penalties is approximately 36.7% lower compared to an away team during the pandemic, assuming the other variables are constant. The residual deviance for this model is 1143.4 on 1868 degrees of freedom and the comparison to the null model suggests a good fit.

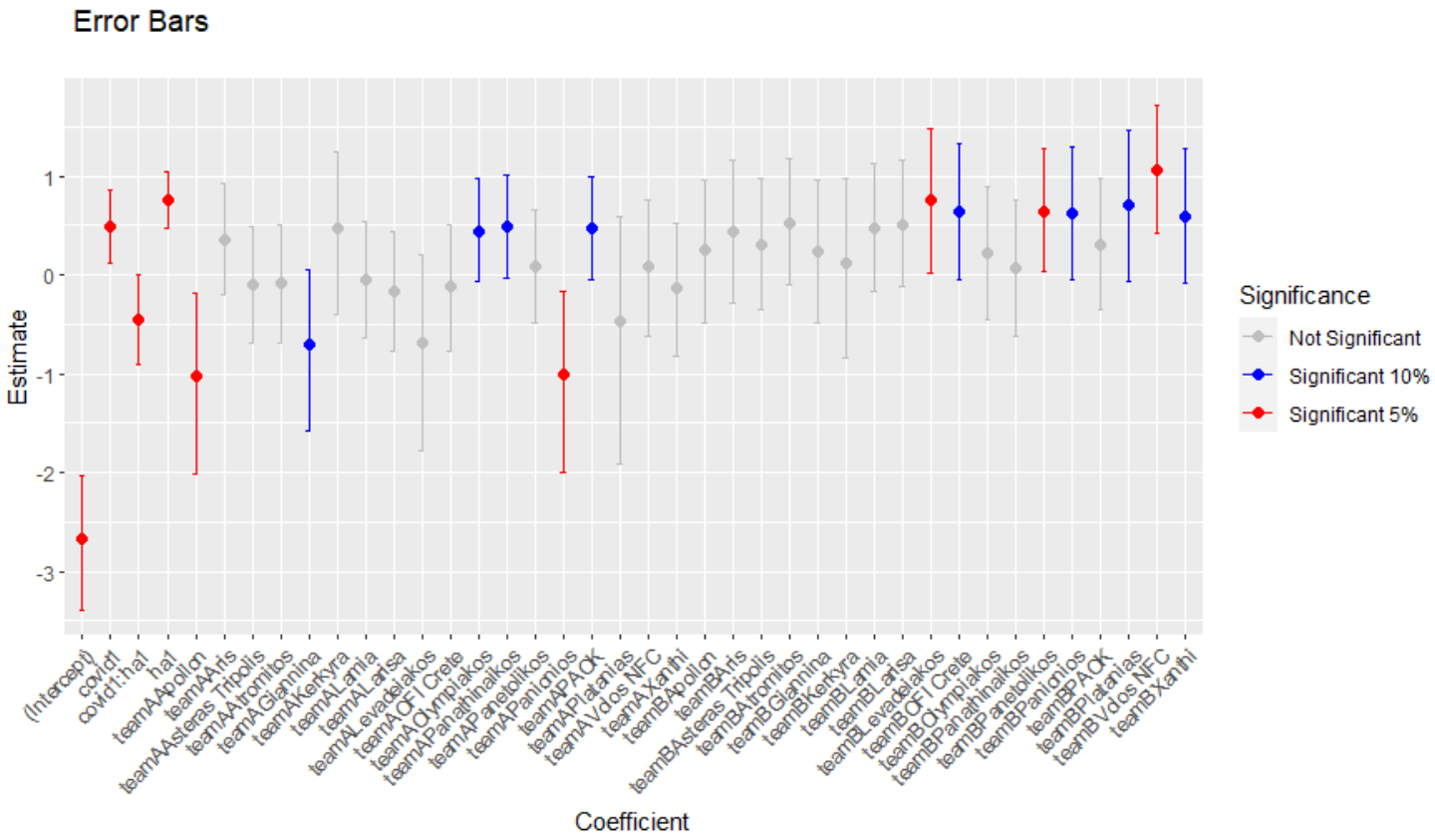

Figure 24 Error Bars | Penalties and Covid-19

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In relation to offsides, the effects of home advantage, Covid-19 and their interaction term were not found to be statistically significant at a 5% significance level. The corresponding 95% confidence intervals include zero. Thus, we do not have enough evidence to reject the null hypotheses that these coefficients may be equal to zero. The residual deviance for this model is 1143.4 on 1868 degrees of freedom and the comparison to the null model suggests a good fit.

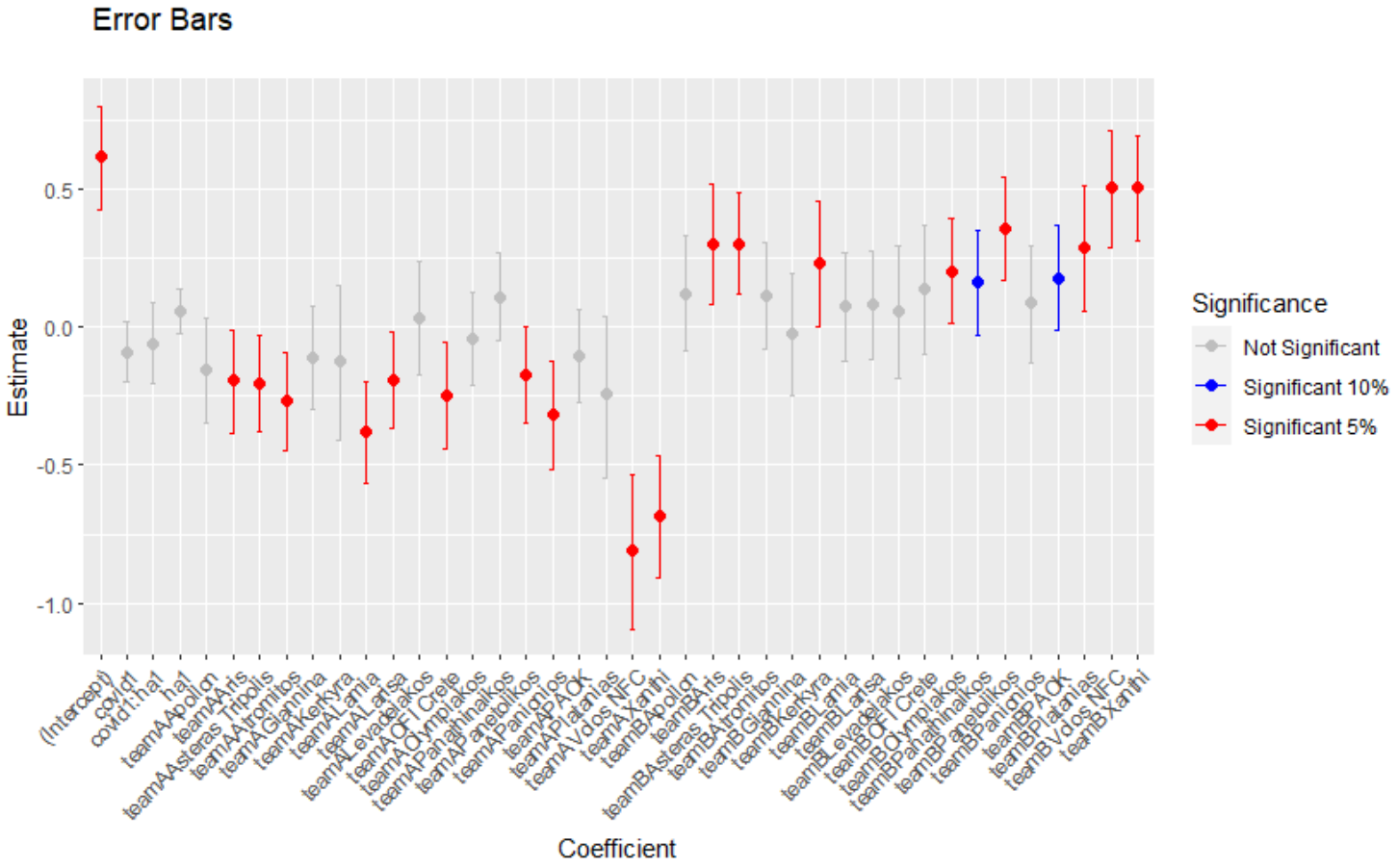

Figure 25 Error bars | Offsides and Covid-19

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Regarding fouls, the effects of home advantage and Covid-19 were statistically significant at a 5% significance level, their interaction term was not found to be statistically significant at a 5% significance level. The expected number of fouls during the pandemic was 6.9% higher than the expected number of fouls before the pandemic, assuming the rest of the rest variables are constant. The residual deviance for this model is 2223.0 on 1868 degrees of freedom and the comparison to the null model suggests a good fit.

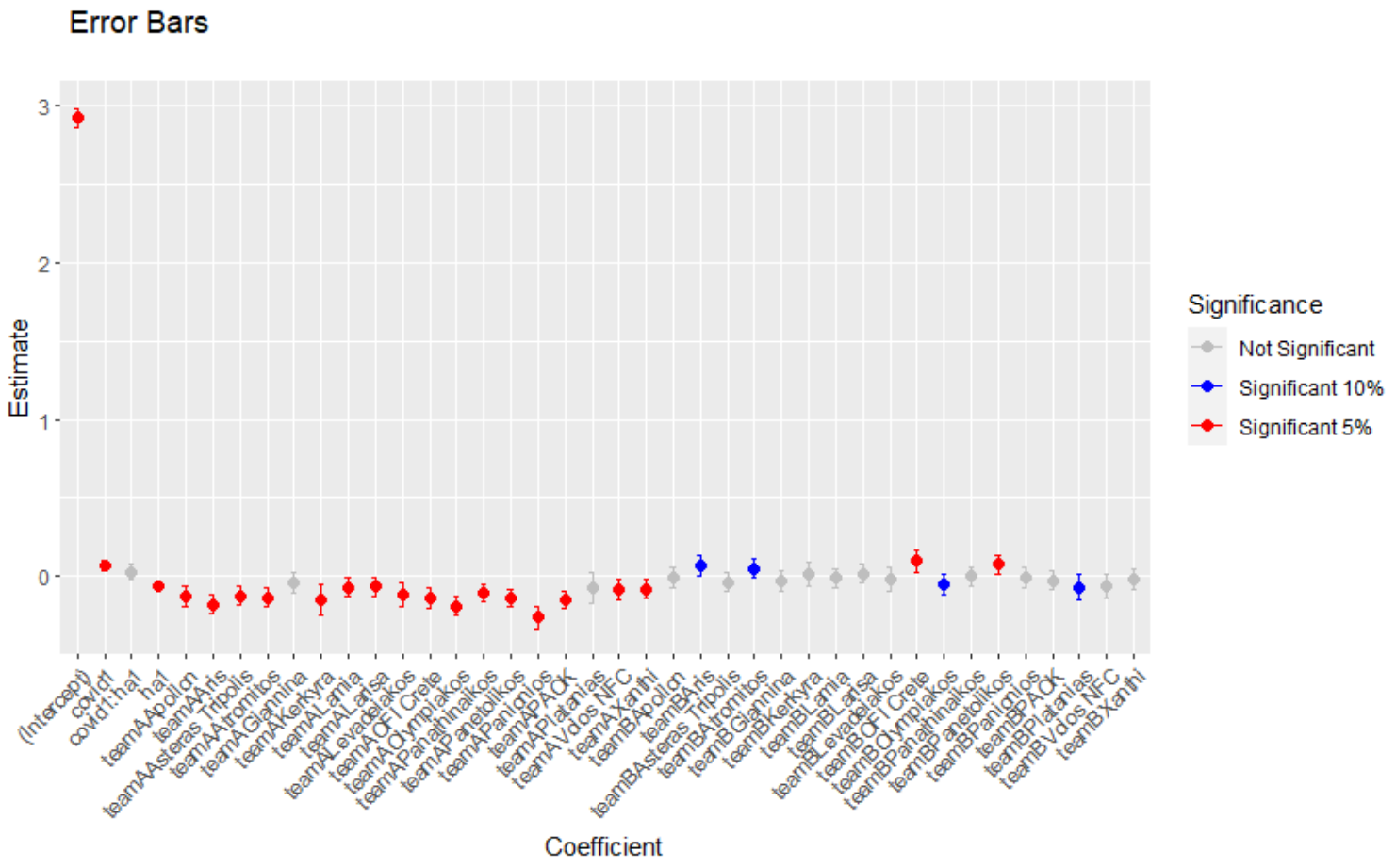

Figure 26 Error bar | Fouls and Covid-19

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In this chapter we applied generalized linear models' theory to examine crowd support effect on home advantage in the Greek football. We analyzed data two years before and after Covid-19 pandemic, when the matches were played with no spectators. We examined crowd support effect on the match variables such as goals, penalties, fouls, offsides, red and yellow cards.

Summarizing the results, crowd support absence had a significant impact on most of the match variables - outcomes. Both teams' performance and referees' decisions were affected by the absence of crowd support. Before Covid-19 pandemic, when fans were present, home teams scored more frequently than the away teams. According to the generalized linear models results, home teams scored less compared to the away teams during the pandemic. The total number of red and yellow cards given decreased during the pandemic. Furthermore, the number of penalties awarded increased during the pandemic. Home teams awarded fewer penalties than the away teams when the fans were absent. This was not the case before the pandemic, when crowd was present, referees awarded penalties to home teams more frequently compared to away teams. The number of fouls given were slightly increased during the pandemic. Home effect on offsides was not significant when the crowd support is present or absent and there was no significant change on the number of offsides given.

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Chapter 6

6.1 Conclusion

The present thesis' purpose was to examine whether home advantage effect in the first division of Greek football was affected by the introduction of video assistant referee system and by the absence of home teams' fans from the stadiums during the COVID–19 pandemic. We examined home advantage effect, investigating its impact on several important match variables such as goals scored, yellow and red cards, penalties, fouls and offsides awarded. We used data from matches played in seasons 2017/18, 2018/19, 2019/20, 2020/21, two years before and after both VAR introduction, as well as COVID-19 pandemic. Pollard's formula was used to calculate home advantage in the Greek Super League and generalized linear models' theory was applied to study home effect in the Greek league. Separate generalized linear models for var and crowd support absence (covid) effects were applied, since these two variables were correlated.

Previous research findings related to home advantage in the Greek football confirmed. Referees tend to favor the home teams in the Greek Super league, award fewer fouls, red and yellow cards against the home teams. More penalties are awarded against the away teams. Home teams score more frequently than the away teams do. According to Pollard's formula home advantage is over 60% in the Greek league. During season 2020/21 when matches were held behind closed doors, home advantage in the Greek Super league was approximately 53%, almost eliminated. Additionally, home effect was either not statistically significant for most of the match variables of interest or only marginally statistically significant.

Video assistant referee intervenes on specific match changing incidents such as goals, red cards, penalties, offsides and mistaken identity. Generalized linear models results indicated that following VAR implementation the expected number of offsides decreased but penalties and fouls awarded increased. A non - significant decrease in the expected number

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of red and yellow cards was observed. This decrease could be interpreted as players adopted a more cautious play style after VAR. Additionally, goals increased following VAR introduction, but this was not, also a statistically significant result. Home advantage effect was not impacted by VAR introduction. Literature results on VAR are conflicting and differ depending on the league and country. For instance, there are cases where red cards increased following VAR implementation, and cases where they decreased. Thus, comparison is not feasible and more extensive research on VAR effect in the Greek football is needed. In general, according to the literature in most cases, goals and fouls decreased after Var. In the Greek football, as aforementioned, fouls increased, and a non-significant increase in goals was also observed.

Crowd support absence due to the pandemic, since March of 2020 until the end of 2020/21 season, had a greater impact on home effect in the Greek football. More specifically, during the pandemic, home teams scored fewer goals compared to away teams. Additionally, fewer penalties were awarded, on average, against the away teams than against home teams. The expected number of yellow and red cards decreased during the pandemic, but penalties and fouls increased. No impact on the offsides awarded was observed during COVID-19. Results suggest that the crowd absence affected mostly home and away teams' performance. Referee decisions did not change drastically during the period when fans were absent. Overall, our results are consistent with the relevant literature. Home advantage effect during fans' absence was not eliminated but drastically reduced. The dominant team during the football game, even with the fans absent was the home team.

Future studies emphasizing in the Greek football could include more data related to VAR usage since in the current study we only added a dummy variable indicating its existence or not. Thus, we do not have any insight on how Greek referees take advantage of this new system. During 2019/20 season, the system of playoffs/play outs, during which the champions and relegations are decided, was introduced in the Greek league. As home advantage varies according to the criticality of the match, future research could include the league stage. Additionally, not all referees are affected on the same level from the crowd noise and density, thus an extra variable for the referee's name per match could give useful insights.

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6.3 Appendix

Generalized Linear model Results – Goals and VAR

Predictor	Estimate	Std. Error	z value	Pr (>|z|)
(Intercept)	0.0133276	0.12724329	0.104741	0.916581407
VAR1	0.0080467	0.07334967	0.109703	0.912644882
ha1	0.4003312	0.06245571	6.409841	1.46E-10
Team A Apollon	-0.888571	0.1460498	-6.08403	1.17E-09
Team A Aris	-0.132118	0.11162624	-1.18357	0.23658192
Team A Asteras Tripolis	-0.364226	0.1090693	-3.3394	0.000839591
Team A Atromitos	-0.290463	0.10663711	-2.72385	0.006452581
Team A Giannina	-0.66716	0.13421672	-4.97077	6.67E-07
Team A Kerkyra	-0.958163	0.24102432	-3.97538	7.03E-05
Team A Lamia	-0.805691	0.12553384	-6.41812	1.38E-10
Team A Larisa	-0.641888	0.11988227	-5.35432	8.59E-08
Team A Levadeiakos	-1.028672	0.17845711	-5.76425	8.20E-09
Team A OFI Crete	-0.393789	0.12113711	-3.25077	0.001150942
Team A Olympiakos	0.2986713	0.09178396	3.254069	0.001137648
Team A Panathinaikos	-0.31421	0.10699288	-2.93674	0.00331684
Team A Panetolikos	-0.545704	0.11678016	-4.67292	2.97E-06
Team A Panionios	-0.674556	0.13278643	-5.08001	3.77E-07
Team A PAOK	0.154006	0.09483761	1.623892	0.104398914
Team A Platanias	-1.255022	0.27729272	-4.52598	6.01E-06
Team A Volos NFC	-0.487058	0.14883291	-3.27251	0.001065956
Team A Xanthi	-0.669898	0.13326906	-5.02666	4.99E-07
Team B Apollon	0.2029927	0.13899858	1.460394	0.144181814
Team B Aris	0.1888705	0.14783517	1.277575	0.201399435
Team B Asteras Tripolis	0.237659	0.12766953	1.861517	0.06267119
Team B Atromitos	0.22605	0.12774052	1.769603	0.076793338
Team B Giannina	0.2600484	0.13729573	1.894075	0.058215017
Team B Kerkyra	0.5659142	0.14517854	3.898057	9.70E-05
Team B Lamia	0.2684524	0.12634991	2.124674	0.033613792
Team B Larisa	0.4147087	0.12321465	3.365742	0.000763382
Team B Levadeiakos	0.263544	0.15469926	1.703589	0.088457848
Team B OFI Crete	0.3669699	0.14252851	2.574713	0.010032341
Team B Olympiakos	0.0025722	0.13504232	0.019048	0.984803039
Team B Panathinaikos	0.060822	0.13007265	0.4676	0.640070694
Team B Panetolikos	0.4472427	0.12242512	3.653194	0.000258998
Team B Panionios	0.3532378	0.13345753	2.646818	0.008125307
Team B PAOK	0.1154384	0.13062035	0.88377	0.376820303
Team B Platanias	0.6562183	0.14255734	4.603189	4.16E-06
Team B Volos NFC	0.5377951	0.14056916	3.82584	0.000130327
Team B Xanthi	0.2928489	0.13501056	2.169082	0.030076483
VAR1:ha1	-0.125356	0.08751268	-1.43243	0.152020572

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Generalized Linear model Results – Red cards and VAR

Predictor	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-1.49949	0.35920144	-4.17451	2.99E-05
VAR1	-0.264507	0.19480034	-1.35784	0.1745151
ha1	-0.506225	0.18866051	-2.68326	0.0072908
Team A Apollon	-0.143167	0.42951337	-0.33332	0.7388902
Team A Aris	-0.184908	0.43087785	-0.42914	0.6678199
Team A Asteras Tripolis	0.104132	0.37384424	0.278544	0.7805949
Team A Atromitos	-0.227266	0.40502479	-0.56112	0.5747177
Team A Giannina	0.0655359	0.40682927	0.161089	0.872023
Team A Kerkyra	0.6361229	0.49596974	1.282584	0.1996378
Team A Lamia	0.3261557	0.35417492	0.920889	0.3571085
Team A Larisa	-0.017229	0.38632183	-0.0446	0.964428
Team A Levadeiakos	0.3823353	0.42436174	0.900966	0.3676066
Team A OFI Crete	0.1572359	0.39601875	0.397042	0.6913367
Team A Olympiakos	-0.434832	0.42836203	-1.0151	0.3100565
Team A Panathinaikos	0.3772339	0.34708922	1.08685	0.2771031
Team A Panetolikos	0.1464196	0.36755502	0.398361	0.690364
Team A Panionios	0.3368342	0.38051455	0.885207	0.376045
Team A PAOK	-0.062998	0.38683561	-0.16285	0.8706332
Team A Platanias	0.5578759	0.49538909	1.126137	0.2601076
Team A Volos NFC	0.6111264	0.40226058	1.51923	0.1287046
Team A Xanthi	0.2668636	0.38739631	0.688865	0.4909085
Team B Apollon	-0.797453	0.410403	-1.9431	0.0520044
Team B Aris	-0.241555	0.40049172	-0.60315	0.5464113
Team B Asteras Tripolis	-0.222033	0.30817456	-0.72048	0.4712306
Team B Atromitos	-0.596734	0.34566693	-1.72633	0.0842888
Team B Giannina	-0.813203	0.41078741	-1.97962	0.0477462
Team B Kerkyra	-0.122559	0.37425823	-0.32747	0.7433104
Team B Lamia	-0.417878	0.33087231	-1.26296	0.2066042
Team B Larisa	0.0553977	0.28711702	0.192945	0.8470023
Team B Levadeiakos	-1.080106	0.54637864	-1.97685	0.0480591
Team B OFI Crete	0.0132344	0.37419093	0.035368	0.9717862
Team B Olympiakos	-0.597445	0.34571882	-1.72813	0.0839658
Team B Panathinaikos	-0.592336	0.3453877	-1.71499	0.0863475
Team B Panetolikos	-0.755822	0.36524403	-2.06936	0.0385122
Team B Panionios	-0.81043	0.40989292	-1.97718	0.0480217
Team B PAOK	-0.25973	0.31364276	-0.82811	0.4076097
Team B Platanias	-1.818891	0.74064536	-2.45582	0.0140564
Team B Volos NFC	0.000198	0.38700759	0.000512	0.9995919
Team B Xanthi	-0.469973	0.36602948	-1.28398	0.1991502
VAR1:ha1	0.1613721	0.26842658	0.601178	0.5477217

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Generalized Linear model Results – Yellow cards and VAR

Predictor	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	1.1256631	0.08054168	13.97616	2.18E-44
VAR1	-0.073163	0.04231062	-1.72919	0.0837752
ha1	-0.238933	0.03956182	-6.03949	1.55E-09
Team A Apollon	0.0839846	0.0843206	0.996015	0.3192426
Team A Aris	-0.095778	0.08654322	-1.1067	0.2684215
Team A Asteras Tripolis	0.0759352	0.07747129	0.980172	0.3270014
Team A Atromitos	0.0559353	0.07821627	0.715137	0.4745246
Team A Giannina	0.1346842	0.08341858	1.614559	0.1064062
Team A Kerkyra	0.1260768	0.12246451	1.029496	0.3032465
Team A Lamia	0.0467447	0.0781665	0.598014	0.5498306
Team A Larisa	0.2860882	0.07386593	3.873074	0.0001075
Team A Levadeiakos	0.1165915	0.0966031	1.206913	0.2274657
Team A OFI Crete	0.1262796	0.08177019	1.544324	0.12251
Team A Olympiakos	-0.173283	0.08225087	-2.10676	0.0351384
Team A Panathinaikos	0.1555339	0.07547874	2.060632	0.0393382
Team A Panetolikos	0.0895334	0.07751984	1.154973	0.2481013
Team A Panionios	0.0211795	0.08555239	0.247562	0.8044733
Team A PAOK	-0.071844	0.07985888	-0.89964	0.3683104
Team A Platanias	0.0109656	0.12788571	0.085745	0.9316689
Team A Volos NFC	0.0998998	0.09444699	1.057734	0.2901767
Team A Xanthi	0.1625352	0.08213683	1.978835	0.0478346
Team B Apollon	-0.113491	0.08281442	-1.37042	0.1705551
Team B Aris	-0.00263	0.08897514	-0.02956	0.9764209
Team B Asteras Tripolis	-0.11799	0.07516942	-1.56966	0.1164946
Team B Atromitos	-0.112858	0.07582268	-1.48844	0.1366343
Team B Giannina	-0.119471	0.08298384	-1.43968	0.1499568
Team B Kerkyra	-0.085807	0.09538558	-0.89958	0.3683439
Team B Lamia	-0.135755	0.07618994	-1.78179	0.0747832
Team B Larisa	-0.099612	0.07558728	-1.31784	0.1875584
Team B Levadeiakos	-0.183994	0.09964291	-1.84653	0.0648149
Team B OFI Crete	-0.035573	0.09146646	-0.38892	0.6973359
Team B Olympiakos	-0.082261	0.07441243	-1.10547	0.2689558
Team B Panathinaikos	-0.062163	0.07395813	-0.84052	0.4006165
Team B Panetolikos	-0.074122	0.07516577	-0.98612	0.324076
Team B Panionios	-0.027171	0.08063983	-0.33694	0.7361596
Team B PAOK	-0.016716	0.07374831	-0.22666	0.8206899
Team B Platanias	-0.156945	0.09796564	-1.60204	0.1091473
Team B Volos NFC	-0.082784	0.09408051	-0.87993	0.3788993
Team B Xanthi	-0.012464	0.08039444	-0.15503	0.8767952
VAR1:ha1	0.0904258	0.05617646	1.609674	0.107469

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Generalized Linear model Results – Penalties and VAR

Predictor	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-2.74334	0.35803659	-7.66218	1.83E-14
VAR1	0.4311754	0.20159934	2.138774	0.032454
ha1	0.6653259	0.17971156	3.702187	0.0002137
Team A Apollon	-0.963756	0.45753947	-2.10639	0.0351706
Team A Aris	0.3158239	0.28551732	1.106146	0.2686633
Team A Asteras Tripolis	-0.105193	0.29992148	-0.35073	0.7257878
Team A Atromitos	-0.098437	0.30021477	-0.32789	0.742997
Team A Giannina	-0.657685	0.41012548	-1.60362	0.1087982
Team A Kerkyra	0.5642579	0.41552052	1.357954	0.1744782
Team A Lamia	-0.048874	0.29630283	-0.16495	0.8689865
Team A Larisa	-0.170574	0.30773552	-0.55429	0.5793811
Team A Levadeiakos	-0.599668	0.49815604	-1.20378	0.2286763
Team A OFI Crete	-0.151624	0.32427554	-0.46758	0.6400873
Team A Olympiakos	0.4411133	0.26287906	1.678009	0.0933454
Team A Panathinaikos	0.4695987	0.26295394	1.785859	0.0741221
Team A Panetolikos	0.082875	0.2896289	0.286142	0.7747694
Team A Panionios	-1.012848	0.45775023	-2.21266	0.0269208
Team A PAOK	0.4616407	0.26314925	1.754292	0.0793804
Team A Platanias	-0.373399	0.61745885	-0.60474	0.5453548
Team A Volos NFC	0.0005672	0.34927056	0.001624	0.9987044
Team A Xanthi	-0.138901	0.3378783	-0.4111	0.6810007
Team B Apollon	0.317203	0.36759438	0.862916	0.3881838
Team B Aris	0.3740673	0.3633295	1.029554	0.3032195
Team B Asteras Tripolis	0.2932453	0.33628161	0.872023	0.3831958
Team B Atromitos	0.532352	0.32126268	1.657061	0.0975071
Team B Giannina	0.3171535	0.36848868	0.860687	0.3894103
Team B Kerkyra	0.2430872	0.462895	0.525146	0.599482
Team B Lamia	0.4735131	0.32632212	1.45106	0.1467631
Team B Larisa	0.5118159	0.32360846	1.58159	0.1137432
Team B Levadeiakos	0.8743645	0.37734734	2.317134	0.0204964
Team B OFI Crete	0.5701593	0.34706619	1.642797	0.100425
Team B Olympiakos	0.2176826	0.3402227	0.639824	0.5222872
Team B Panathinaikos	0.073876	0.34911856	0.211607	0.8324135
Team B Panetolikos	0.6465805	0.31624686	2.044544	0.0408999
Team B Panionios	0.6150428	0.34104726	1.803395	0.0713263
Team B PAOK	0.3068172	0.33303875	0.921266	0.3569117
Team B Platanias	0.8283719	0.39264428	2.109726	0.034882
Team B Volos NFC	0.9837527	0.32949119	2.985672	0.0028296
Team B Xanthi	0.5982222	0.3413515	1.752511	0.079686
VAR1:ha1	-0.146098	0.22973948	-0.63593	0.524822

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Generalized Linear model Results – Fouls and VAR

Predictor	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	2.9268679	0.03186223	91.86009	0
VAR1	0.0407642	0.01751386	2.327538	0.0199367
ha1	-0.061527	0.01617536	-3.80373	0.0001425
Team A Apollon	-0.114294	0.03292006	-3.47187	0.0005169
Team A Aris	-0.177276	0.03244642	-5.46366	4.66E-08
Team A Asteras Tripolis	-0.126282	0.02987339	-4.22725	2.37E-05
Team A Atromitos	-0.135779	0.03013993	-4.50495	6.64E-06
Team A Giannina	-0.031845	0.03220126	-0.98894	0.3226943
Team A Kerkyra	-0.150753	0.05116464	-2.94642	0.0032147
Team A Lamia	-0.072066	0.02954735	-2.43901	0.0147276
Team A Larisa	-0.067302	0.02948925	-2.28225	0.0224743
Team A Levadeiakos	-0.119327	0.0388607	-3.07064	0.002136
Team A OFI Crete	-0.138559	0.03218657	-4.30486	1.67E-05
Team A Olympiakos	-0.190096	0.030221	-6.29019	3.17E-10
Team A Panathinaikos	-0.106303	0.02949857	-3.60368	0.0003137
Team A Panetolikos	-0.138879	0.030125	-4.6101	4.02E-06
Team A Panionios	-0.274335	0.03444294	-7.96492	1.65E-15
Team A PAOK	-0.149348	0.02984417	-5.00426	5.61E-07
Team A Platanias	-0.071777	0.04942137	-1.45236	0.1464028
Team A Volos NFC	-0.08619	0.03629568	-2.37467	0.0175648
Team A Xanthi	-0.092121	0.03252724	-2.83212	0.004624
Team B Apollon	0.0070621	0.03353898	0.210563	0.8332281
Team B Aris	0.0674241	0.03570308	1.888467	0.0589633
Team B Asteras Tripolis	-0.035739	0.03080728	-1.16008	0.2460166
Team B Atromitos	0.0513397	0.0303844	1.689673	0.0910905
Team B Giannina	-0.014123	0.03385262	-0.4172	0.6765338
Team B Kerkyra	0.0190213	0.03918088	0.485473	0.627341
Team B Lamia	-0.013109	0.03088396	-0.42446	0.6712338
Team B Larisa	0.0135373	0.03066933	0.441394	0.6589278
Team B Levadeiakos	-0.013781	0.03975951	-0.34661	0.7288843
Team B OFI Crete	0.0965017	0.03575947	2.698632	0.0069625
Team B Olympiakos	-0.052056	0.03087507	-1.68602	0.0917913
Team B Panathinaikos	-0.000642	0.03037908	-0.02113	0.9831395
Team B Panetolikos	0.0783368	0.03026261	2.588566	0.0096377
Team B Panionios	-0.016409	0.03373908	-0.48636	0.6267139
Team B PAOK	-0.026278	0.03090021	-0.85042	0.3950943
Team B Platanias	-0.068181	0.04058512	-1.67996	0.0929648
Team B Volos NFC	-0.061946	0.03833213	-1.61602	0.1060892
Team B Xanthi	-0.026591	0.03385541	-0.78542	0.4322052
VAR1:ha1	0.0259213	0.02250392	1.151858	0.2493793

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Generalized Linear model Results – Offsides and VAR

Predictor	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	0.6807653	0.09831846	6.924084	4.39E-12
VAR1	-0.189382	0.05369406	-3.52705	0.0004202
ha1	0.0332199	0.04591256	0.723547	0.4693439
Team A Apollon	-0.189084	0.0964457	-1.96052	0.0499347
Team A Aris	-0.17584	0.09530641	-1.845	0.0650382
Team A Asteras Tripolis	-0.202296	0.08833478	-2.29011	0.0220149
Team A Atromitos	-0.264704	0.09007446	-2.93873	0.0032956
Team A Giannina	-0.143571	0.09522863	-1.50765	0.1316445
Team A Kerkyra	-0.1689	0.14317307	-1.17969	0.2381235
Team A Lamia	-0.379829	0.09308931	-4.08026	4.50E-05
Team A Larisa	-0.188749	0.08800082	-2.14486	0.0319643
Team A Levadeiakos	-0.007093	0.10505368	-0.06752	0.94617
Team A OFI Crete	-0.228246	0.0973254	-2.34519	0.0190175
Team A Olympiakos	-0.040912	0.08448957	-0.48422	0.628227
Team A Panathinaikos	0.1131103	0.0809813	1.396746	0.1624899
Team A Panetolikos	-0.172797	0.08852058	-1.95205	0.0509318
Team A Panionios	-0.315927	0.09951551	-3.17465	0.0015002
Team A PAOK	-0.105488	0.08573543	-1.23039	0.21855
Team A Platanias	-0.28905	0.15066734	-1.91846	0.0550523
Team A Volos NFC	-0.753188	0.14232285	-5.29211	1.21E-07
Team A Xanthi	-0.679688	0.11341531	-5.99291	2.06E-09
Team B Apollon	0.0897024	0.10673854	0.840393	0.4006879
Team B Aris	0.3432445	0.11200997	3.06441	0.002181
Team B Asteras Tripolis	0.3017868	0.09413045	3.206049	0.0013457
Team B Atromitos	0.1102182	0.09916947	1.111413	0.2663908
Team B Giannina	-0.061464	0.11232312	-0.54721	0.5842356
Team B Kerkyra	0.1801462	0.1161082	1.551537	0.120773
Team B Lamia	0.0744257	0.09911972	0.750867	0.4527328
Team B Larisa	0.0800052	0.0996917	0.802526	0.4222489
Team B Levadeiakos	0.0063417	0.12342316	0.051382	0.9590212
Team B OFI Crete	0.1845566	0.11861391	1.555944	0.1197215
Team B Olympiakos	0.202276	0.09589454	2.109358	0.0349137
Team B Panathinaikos	0.1587844	0.09689725	1.638688	0.1012782
Team B Panetolikos	0.3533093	0.09421472	3.750043	0.0001768
Team B Panionios	0.0824854	0.10753347	0.767067	0.4430415
Team B PAOK	0.1753471	0.09736832	1.800864	0.0717243
Team B Platanias	0.2360745	0.11593392	2.036285	0.0417218
Team B Volos NFC	0.554103	0.1088112	5.092335	3.54E-07
Team B Xanthi	0.5000167	0.09637473	5.188256	2.12E-07
VAR1:ha1	0.0135058	0.0675085	0.200061	0.8414329

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Generalized Linear model Results – Goals and Covid-19

Predictor	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	0.0001485	0.12362791	0.001201	0.9990417
covid1	0.0618728	0.07419102	0.833967	0.4042997
ha1	0.4261043	0.05265771	8.091964	5.87E-16
Team A Apollon	-0.872639	0.1458556	-5.9829	2.19E-09
Team A Aris	-0.131761	0.11136758	-1.18311	0.236764
Team A Asteras Tripolis	-0.363585	0.109069	-3.33353	0.0008575
Team A Atromitos	-0.289265	0.10662315	-2.71297	0.0066683
Team A Giannina	-0.651451	0.13410701	-4.85769	1.19E-06
Team A Kerkyra	-0.957202	0.24042538	-3.98129	6.85E-05
Team A Lamia	-0.805118	0.12552412	-6.41405	1.42E-10
Team A Larisa	-0.64187	0.11988258	-5.35415	8.60E-08
Team A Levadeiakos	-1.027451	0.17785712	-5.77683	7.61E-09
Team A OFI Crete	-0.395194	0.12094551	-3.26754	0.0010849
Team A Olympiakos	0.2989285	0.09177706	3.257116	0.0011255
Team A Panathinaikos	-0.31351	0.10698113	-2.93052	0.0033839
Team A Panetolikos	-0.545211	0.11677776	-4.66879	3.03E-06
Team A Panionios	-0.687576	0.13299599	-5.1699	2.34E-07
Team A PAOK	0.1547382	0.09483008	1.631742	0.1027338
Team A Platanias	-1.254092	0.2767657	-4.53124	5.86E-06
Team A Volos NFC	-0.488322	0.14757326	-3.30901	0.0009363
Team A Xanthi	-0.684626	0.13351981	-5.12753	2.94E-07
Team B Apollon	0.2125665	0.13877234	1.531764	0.1255807
Team B Aris	0.1915331	0.14693642	1.30351	0.1924006
Team B Asteras Tripolis	0.2356769	0.12767895	1.845856	0.0649132
Team B Atromitos	0.220324	0.12774416	1.724729	0.0845764
Team B Giannina	0.2725478	0.13671221	1.993587	0.0461972
Team B Kerkyra	0.5625183	0.1435138	3.919611	8.87E-05
Team B Lamia	0.2629275	0.12637175	2.080588	0.0374717
Team B Larisa	0.4088035	0.12322443	3.317552	0.0009081
Team B Levadeiakos	0.2609676	0.15298571	1.70583	0.0880397
Team B OFI Crete	0.3640382	0.14151657	2.572407	0.0100994
Team B Olympiakos	0.001854	0.13503314	0.01373	0.9890452
Team B Panathinaikos	0.0613606	0.13006823	0.471757	0.6371
Team B Panetolikos	0.443745	0.12242504	3.624626	0.0002894
Team B Panionios	0.3351396	0.13385876	2.503681	0.0122909
Team B PAOK	0.115715	0.13061489	0.885925	0.3756578
Team B Platanias	0.652519	0.14089624	4.631203	3.64E-06
Team B Volos NFC	0.5307959	0.13926984	3.811277	0.0001383
Team B Xanthi	0.2736455	0.13540015	2.021013	0.0432784
covid1:ha1	-0.294311	0.09494721	-3.09973	0.001937

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Generalized Linear model Results – Red cards and Covid – 19

Predictor	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-1.472707	0.35060871	-4.20043	2.66E-05
covid1	-0.530415	0.21331636	-2.48652	0.0129
ha1	-0.56964	0.15887612	-3.58543	0.0003365
Team A Apollon	-0.112521	0.42854025	-0.26257	0.7928827
Team A Aris	-0.190033	0.42984577	-0.4421	0.6584197
Team A Asteras Tripolis	0.0889113	0.37353524	0.238027	0.8118605
Team A Atromitos	-0.242666	0.40481262	-0.59945	0.5488704
Team A Giannina	0.0971369	0.40597846	0.239266	0.8108992
Team A Kerkyra	0.6344698	0.4924473	1.288401	0.1976063
Team A Lamia	0.3163972	0.35400389	0.893768	0.3714463
Team A Larisa	-0.032567	0.3862404	-0.08432	0.9328042
Team A Levadeiakos	0.3802729	0.42104173	0.903172	0.3664349
Team A OFI Crete	0.1464931	0.39511039	0.370765	0.7108126
Team A Olympiakos	-0.441361	0.42831017	-1.03047	0.3027889
Team A Panathinaikos	0.368473	0.34681659	1.062443	0.2880344
Team A Panetolikos	0.1335757	0.3674911	0.36348	0.7162462
Team A Panionios	0.2839227	0.38150664	0.744214	0.4567468
Team A PAOK	-0.073944	0.38667924	-0.19123	0.8483476
Team A Platanias	0.5558263	0.49228047	1.129085	0.2588622
Team A Volos NFC	0.581683	0.39633587	1.467652	0.1421989
Team A Xanthi	0.2157925	0.38836925	0.555637	0.5784588
Team B Apollon	-0.762339	0.40935838	-1.86228	0.062564
Team B Aris	-0.258709	0.39544294	-0.65423	0.5129659
Team B Asteras Tripolis	-0.222758	0.30804717	-0.72313	0.4696009
Team B Atromitos	-0.597984	0.34555838	-1.73049	0.0835436
Team B Giannina	-0.769885	0.40966345	-1.87931	0.0602019
Team B Kerkyra	-0.118469	0.37002462	-0.32017	0.7488423
Team B Lamia	-0.425492	0.33082041	-1.28617	0.1983829
Team B Larisa	0.0499877	0.28711193	0.174105	0.8617828
Team B Levadeiakos	-1.073222	0.54306914	-1.97622	0.0481303
Team B OFI Crete	-0.011295	0.36854232	-0.03065	0.9755513
Team B Olympiakos	-0.603732	0.34563451	-1.74673	0.0806834
Team B Panathinaikos	-0.591358	0.34533915	-1.7124	0.0868236
Team B Panetolikos	-0.752039	0.36524366	-2.05901	0.0394936
Team B Panionios	-0.844238	0.41020437	-2.05809	0.0395813
Team B PAOK	-0.263381	0.31353503	-0.84004	0.4008875
Team B Platanias	-1.812198	0.73848868	-2.45393	0.0141305
Team B Volos NFC	-0.023585	0.38048129	-0.06199	0.9505725
Team B Xanthi	-0.509134	0.36652239	-1.38909	0.1648042
covid1:ha1	0.5268635	0.3015216	1.747349	0.0805768

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Generalized Linear model Results – Yellow cards and Covid – 19

Predictor	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	1.1189404	0.07878347	14.20273	8.81E-46
covid1	-0.095331	0.04398966	-2.16712	0.0302256
ha1	-0.225409	0.03361922	-6.70475	2.02E-11
Team A Apollon	0.0899046	0.08413439	1.068583	0.2852574
Team A Aris	-0.095913	0.08640136	-1.11009	0.2669602
Team A Asteras Tripolis	0.0748199	0.07745836	0.965937	0.3340759
Team A Atromitos	0.0546063	0.07820596	0.698238	0.4850285
Team A Giannina	0.1405461	0.08327677	1.687698	0.0914692
Team A Kerkyra	0.1267565	0.12193975	1.039501	0.2985719
Team A Lamia	0.0458533	0.07816035	0.586657	0.5574343
Team A Larisa	0.2849784	0.0738625	3.858229	0.0001142
Team A Levadeiakos	0.1170631	0.0960573	1.218679	0.2229659
Team A OFI Crete	0.1252611	0.08163452	1.534414	0.1249278
Team A Olympiakos	-0.173658	0.08224624	-2.11144	0.0347342
Team A Panathinaikos	0.1553256	0.07546135	2.058346	0.0395569
Team A Panetolikos	0.0887575	0.07751571	1.145026	0.2521984
Team A Panionios	0.0142549	0.08578689	0.166166	0.8680264
Team A PAOK	-0.071824	0.07984832	-0.89951	0.3683837
Team A Platanias	0.0116647	0.12738647	0.091569	0.9270405
Team A Volos NFC	0.0983255	0.09361527	1.050315	0.2935732
Team A Xanthi	0.1557309	0.08238105	1.890373	0.058708
Team B Apollon	-0.106808	0.08264751	-1.29233	0.1962423
Team B Aris	-0.003792	0.08825179	-0.04297	0.9657289
Team B Asteras Tripolis	-0.118026	0.0751647	-1.57023	0.1163611
Team B Atromitos	-0.11304	0.07581638	-1.49097	0.1359694
Team B Giannina	-0.112374	0.0827534	-1.35793	0.1744852
Team B Kerkyra	-0.084891	0.09457782	-0.89758	0.369411
Team B Lamia	-0.136465	0.0761873	-1.79118	0.0732642
Team B Larisa	-0.099903	0.07558617	-1.32171	0.1862659
Team B Levadeiakos	-0.182831	0.09876048	-1.85126	0.0641328
Team B OFI Crete	-0.037896	0.09069677	-0.41783	0.6760687
Team B Olympiakos	-0.082597	0.07440762	-1.11006	0.2669752
Team B Panathinaikos	-0.062083	0.07395586	-0.83946	0.4012095
Team B Panetolikos	-0.073751	0.07516371	-0.98121	0.3264913
Team B Panionios	-0.033386	0.08082176	-0.41308	0.6795464
Team B PAOK	-0.016879	0.07374329	-0.22889	0.8189553
Team B Platanias	-0.155653	0.09716153	-1.602	0.1091552
Team B Volos NFC	-0.085341	0.09323883	-0.91529	0.360039
Team B Xanthi	-0.018928	0.08058981	-0.23487	0.8143063
covid1:ha1	0.1039416	0.06118411	1.698832	0.0893508

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Generalized Linear model Results – Penalties and Covid – 19

Predictor	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-2.677793	0.34435668	-7.77622	7.47E-15
covid1	0.4926606	0.18880577	2.609351	0.0090714
ha1	0.75326	0.14510885	5.191	2.09E-07
Team A Apollon	-1.018213	0.45715047	-2.2273	0.025927
Team A Aris	0.3519714	0.28526205	1.233853	0.2172577
Team A Asteras Tripolis	-0.097622	0.30006313	-0.32534	0.7449247
Team A Atromitos	-0.088269	0.30029509	-0.29394	0.7688041
Team A Giannina	-0.707118	0.40987539	-1.7252	0.0844912
Team A Kerkyra	0.472843	0.41203595	1.147577	0.2511432
Team A Lamia	-0.043621	0.29636934	-0.14719	0.8829851
Team A Larisa	-0.15986	0.3077844	-0.51939	0.6034889
Team A Levadeiakos	-0.682614	0.49567825	-1.37713	0.1684717
Team A OFI Crete	-0.123229	0.32403622	-0.38029	0.703728
Team A Olympiakos	0.4441081	0.2628695	1.689462	0.0911309
Team A Panathinaikos	0.4804223	0.26300907	1.826638	0.0677542
Team A Panetolikos	0.0829015	0.28971311	0.28615	0.774763
Team A Panionios	-1.008718	0.45847995	-2.20014	0.0277973
Team A PAOK	0.4676375	0.26321755	1.77662	0.0756308
Team A Platanias	-0.46821	0.61496336	-0.76136	0.4464409
Team A Volos NFC	0.0844898	0.34736614	0.24323	0.8078274
Team A Xanthi	-0.133242	0.33894233	-0.39311	0.6942366
Team B Apollon	0.2459448	0.36668353	0.670728	0.5023939
Team B Aris	0.4425034	0.36223828	1.221581	0.2218661
Team B Asteras Tripolis	0.2973378	0.33636978	0.883961	0.3767172
Team B Atromitos	0.5220457	0.32137589	1.624408	0.1042887
Team B Giannina	0.2432464	0.36704004	0.662724	0.507507
Team B Kerkyra	0.121944	0.45770527	0.266425	0.7899122
Team B Lamia	0.472314	0.32639637	1.447057	0.1478811
Team B Larisa	0.5100685	0.32365975	1.57594	0.1150395
Team B Levadeiakos	0.7523841	0.37105637	2.027681	0.0425928
Team B OFI Crete	0.6345344	0.34582414	1.834847	0.0665284
Team B Olympiakos	0.216785	0.34020795	0.637213	0.5239859
Team B Panathinaikos	0.0666956	0.34908754	0.191057	0.8484809
Team B Panetolikos	0.6418119	0.31629214	2.029174	0.0424405
Team B Panionios	0.6172655	0.34269995	1.801184	0.071674
Team B PAOK	0.2999021	0.33304466	0.900486	0.3678616
Team B Platanias	0.7107112	0.38695526	1.836675	0.0662578
Team B Volos NFC	1.0631687	0.32753397	3.24598	0.0011705
Team B Xanthi	0.5876073	0.34281489	1.714066	0.0865166
covid1:ha1	-0.457858	0.22979567	-1.99246	0.0463207

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Generalized Linear model Results – Fouls and Covid – 19

Predictor	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	2.925226	0.03105828	94.18507	0
covid1	0.0668608	0.01771621	3.773994	0.0001607
ha1	-0.057402	0.01374883	-4.17504	2.98E-05
Team A Apollon	-0.124706	0.0328462	-3.79665	0.0001467
Team A Aris	-0.17726	0.03239523	-5.4718	4.45E-08
Team A Asteras Tripolis	-0.125058	0.02987633	-4.18586	2.84E-05
Team A Atromitos	-0.134201	0.03014363	-4.45207	8.50E-06
Team A Giannina	-0.042443	0.03214889	-1.3202	0.1867685
Team A Kerkyra	-0.151177	0.05095405	-2.96693	0.0030079
Team A Lamia	-0.070698	0.0295514	-2.39236	0.0167404
Team A Larisa	-0.065656	0.02949074	-2.22632	0.0259926
Team A Levadeiakos	-0.119606	0.0386353	-3.09577	0.001963
Team A OFI Crete	-0.137197	0.0321395	-4.26879	1.97E-05
Team A Olympiakos	-0.18995	0.03022152	-6.28524	3.27E-10
Team A Panathinaikos	-0.106061	0.02949709	-3.59564	0.0003236
Team A Panetolikos	-0.138057	0.03012805	-4.58234	4.60E-06
Team A Panionios	-0.26198	0.0345545	-7.58165	3.41E-14
Team A PAOK	-0.14927	0.02984365	-5.00173	5.68E-07
Team A Platanias	-0.072252	0.049205	-1.46838	0.1420004
Team A Volos NFC	-0.083638	0.03599562	-2.32356	0.0201491
Team A Xanthi	-0.079663	0.03264628	-2.44018	0.01468
Team B Apollon	-0.004161	0.03347768	-0.12428	0.9010912
Team B Aris	0.0676272	0.03545842	1.907225	0.0564914
Team B Asteras Tripolis	-0.035317	0.03080971	-1.1463	0.2516716
Team B Atromitos	0.0520151	0.03038551	1.711838	0.0869264
Team B Giannina	-0.025538	0.03375008	-0.75667	0.4492447
Team B Kerkyra	0.0187073	0.03884448	0.481596	0.630093
Team B Lamia	-0.01169	0.03088595	-0.37848	0.7050746
Team B Larisa	0.0144364	0.03067127	0.470681	0.6378686
Team B Levadeiakos	-0.014648	0.03938223	-0.37194	0.7099339
Team B OFI Crete	0.0979265	0.03549269	2.75906	0.0057968
Team B Olympiakos	-0.051561	0.03087611	-1.66994	0.094932
Team B Panathinaikos	-0.000744	0.03038019	-0.02449	0.9804586
Team B Panetolikos	0.0781237	0.03026353	2.581447	0.0098387
Team B Panionios	-0.005211	0.03383448	-0.154	0.8776085
Team B PAOK	-0.026832	0.03090151	-0.8683	0.3852282
Team B Platanias	-0.069331	0.04025248	-1.72241	0.0849957
Team B Volos NFC	-0.060248	0.03804198	-1.58372	0.1132584
Team B Xanthi	-0.015135	0.03395334	-0.44574	0.6557819
covid1:ha1	0.0277662	0.02389801	1.161862	0.2452915

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Generalized Linear model Results – Offsides and Covid – 19

Predictor	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	0.6134004	0.09639337	6.363513	1.97E-10
covid1	-0.091168	0.05575418	-1.63517	0.1020131
ha1	0.0564102	0.03983936	1.41594	0.156793
Team A Apollon	-0.155055	0.09620526	-1.61171	0.1070246
Team A Aris	-0.194661	0.09509497	-2.04701	0.0406569
Team A Asteras Tripolis	-0.204687	0.08832492	-2.31743	0.0204804
Team A Atromitos	-0.267743	0.0900616	-2.97289	0.0029501
Team A Giannina	-0.112281	0.09506054	-1.18115	0.2375432
Team A Kerkyra	-0.124169	0.14261053	-0.87069	0.3839242
Team A Lamia	-0.381491	0.09308248	-4.09842	4.16E-05
Team A Larisa	-0.190914	0.08800231	-2.16942	0.0300505
Team A Levadeiakos	0.0330913	0.10446096	0.316781	0.7514095
Team A OFI Crete	-0.246932	0.09716107	-2.54148	0.0110386
Team A Olympiakos	-0.042457	0.08448724	-0.50253	0.6152949
Team A Panathinaikos	0.1091379	0.08096885	1.3479	0.1776905
Team A Panetolikos	-0.174197	0.08851478	-1.968	0.049068
Team A Panionios	-0.319287	0.0997412	-3.20115	0.0013688
Team A PAOK	-0.107755	0.08572714	-1.25695	0.2087714
Team A Platanias	-0.244168	0.1501289	-1.62639	0.1038673
Team A Volos NFC	-0.805383	0.14137882	-5.69663	1.22E-08
Team A Xanthi	-0.682122	0.11363265	-6.00287	1.94E-09
Team B Apollon	0.1207295	0.10655938	1.132979	0.2572232
Team B Aris	0.2975817	0.11100138	2.680883	0.0073428
Team B Asteras Tripolis	0.3004448	0.09413664	3.191582	0.001415
Team B Atromitos	0.1125559	0.09917155	1.134961	0.2563916
Team B Giannina	-0.025087	0.11200876	-0.22398	0.8227754
Team B Kerkyra	0.2278949	0.11531487	1.976284	0.0481226
Team B Lamia	0.0733742	0.09912693	0.740204	0.4591761
Team B Larisa	0.0788628	0.09969486	0.791042	0.4289196
Team B Levadeiakos	0.0573224	0.12252254	0.467852	0.6398908
Team B OFI Crete	0.1360986	0.11759455	1.157354	0.2471277
Team B Olympiakos	0.2010086	0.09589076	2.096225	0.0360622
Team B Panathinaikos	0.1597725	0.09690072	1.648827	0.0991831
Team B Panetolikos	0.3542033	0.09420686	3.759846	0.00017
Team B Panionios	0.0849562	0.10776608	0.788339	0.4304984
Team B PAOK	0.1768353	0.09736401	1.816229	0.0693353
Team B Platanias	0.2838807	0.11511996	2.465955	0.0136648
Team B Volos NFC	0.5013825	0.10753323	4.662582	3.12E-06
Team B Xanthi	0.5023895	0.09664236	5.19844	2.01E-07
covid1:ha1	-0.058947	0.07446997	-0.79156	0.4286172