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SOSYAL BİLİMLER ENSTİTÜSÜ

İKTİSAT ANA BİLİM DALI

İKTİSAT (İNGİLİZCE) BİLİM DALI

AN ESSAY ON THE IMPACT OF VIDEO ASSISTANT REFEREE (VAR) ON HOME BIAS: THE CASE OF TURKISH SUPER LEAGUE

Master's Thesis

METEHAN DEMİRCİ

İstanbul, 2024

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ÖZET

VİDEO YARDIMCI HAKEM (VAR) SİSTEMİNİN SÜPER LİG BAZINDA EV SAHİBİ KAYIRILMASI (HOME BİAS) DURUMUNA OLAN ETKİSİ

Bu çalışma, Türkiye Süper Ligi'nde (TSL) Video Yardımcı Hakem (VAR) uygulamasının ev sahibi kayırılması açısından etkisini incelemektedir. Araştırma, Türk futbolunun en üst kademesi olan TSL'de ev sahibi avantajı (ev sahibi kayırılması) sorununa odaklanacak. Her türlü ev sahibi kayırılmasını ve hakem hatasını en aza indirmek amacıyla, Video Yardımcı Hakem (VAR) dünya çapındaki profesyonel futbol liglerinde tanıtıldı ve dünya çapındaki profesyonel liglerin çoğunda resmi olarak uygulandı. VAR sistemi, 2018-19 sezonunun başından beri TSL'de resmi olarak kullanılıyor. VAR'ın ev sahibi kayırılmasını azaltıp azaltmadığını görmek için VAR öncesi ve VAR sezonlarını analiz ettik ve karşılaştırdık. Türkiye Süper Ligine ilişkin verilerimiz VAR öncesi dönem ve esas olarak çalışmamızın merkezini oluşturacak VAR dönemi olmak üzere iki farklı döneme sahiptir. 2012/13 sezonundan 2017/18 sezonuna kadar VAR öncesi dönemi, 2018/19 sezonundan 2023/24 sezonunun ilk yarısının sonuna kadar ise VAR dönemini belirledik. VAR'ın dışında, seyahat yorgunluğu, tribün yoğunluğu ve hakem kararları gibi ev sahibi kayırılmasını potansiyel olarak etkileyebilecek diğer belirleyicileri de dikkate aldık. Her iki döneme ait verileri toplamak için Transfermarkt.com ve Google'ı kullandık. Bu çalışma, ev sahibi takımın galibiyetleri, deplasmandaki kırmızı kartlar vb. gibi değişkenler arasında karşılaştırma yapmak için t-testlerini kullandı ve hangi faktörlerin ev sahibi kayırılması düzeyini azalttığına ilişkin ilişkileri bulmak için panel veri analizini kullandı. Futbolda ev sahibi kayırılması sorunu, TSL analizleri de dahil olmak üzere yıllar boyunca iyi bir şekilde araştırıldı, ancak VAR'ın getirilmesi ve uygulanması, ev sahibi kayırılmasında dikkate alınması gereken yolu değiştirdi. Dolayısıyla VAR uygulaması oldukça yeni olduğundan VAR ile ilgili yapılmış çok fazla çalışma bulunmamaktadır. Bu anlamda, çalışma muhtemelen TSL için video yardımcı hakem (VAR) sistemini içeren ev sahibi kayırılması konusunda ilk olacak ve dolayısıyla TSL analizlerini içeren önceki ev sahibi kayırılması çalışmaları ile karşılaştırıldığında daha modern bir çalışma olacaktır. Çalışmadan elde ettiğimiz bulgular, VAR döneminde ev sahibi kayırılması oranının önemli ölçüde azaldığını ve VAR'ın hakem kararlarındaki desteğinin, deplasman takımının maçları kazanmasına kesinlikle yardımcı olduğunu gösteriyor. Ancak VAR'ın yardımıyla verilen her hakem kararı deplasman takımlarının lehine olmadı. COVID-19 salgını, VAR döneminde gerçekleştiğinden beri bulgularımıza bir dereceye kadar katkıda bulunmuş olabilir, ancak COVID-19 salgınının sonuçlarımız üzerinde ne kadar etkili olduğunu ileriki çalışmalar gösterecek.

JEL Kodları: Z20, Y10, C33

Anahtar Kelimeler: Türkiye Süper Ligi(TSL), Video Yardımcı Hakem(VAR), iç saha avantajı, ev sahibi kayırılması.

ABSTRACT

AN ESSAY ON THE IMPACT OF VIDEO ASSISTANT REFEREE (VAR) ON HOME BIAS: THE CASE OF TURKISH SUPER LEAGUE

This study examines the impact of the implementation of Video Assistant Referee (VAR) in the Turkish Super League (TSL) in terms of home bias. The research will focus on the home advantage (home bias) problem in TSL, the top tier of Turkish football. In order to reduce and minimize any sort of referee bias or mistake, the Video Assistant Referee (VAR) was introduced to professional football leagues across the world, and it has been officially implemented in most of the professional leagues around the world. The VAR system has been used officially in TSL since the start of the 2018–19 season. We have analyzed and compared the pre-VAR and VAR seasons to see if the VAR reduced the rate of home bias. Our data for the Turkish Super League has two different periods, i.e., the pre-VAR period and the VAR period, which essentially will be the central part of our study. We've set the pre-VAR period from the 2012/13 season to the 2017/18 season, and we've set the VAR period from the 2018/19 season to the end of the first half of the 2023/24 season. Other than VAR, we've also checked for other determinants that could potentially affect the level of home bias, such as travel fatigue, crowd density, and referee decisions. We used Transfermarkt.com and Google to gather data for both periods. This study used t-tests for comparison between variables such as home wins, away red cards, etc., and used panel data analysis to find relationships as to what factors have reduced the level of home bias. The home bias issue in football has been well studied over the years, including the analyses for TSL, but the introduction and implementation of VAR have changed the way that one should consider home bias. Hence, there are not many studies that have been done regards to VAR, since the implementation of VAR is quite new. In this sense, the study will probably be the first on home bias that includes a video assistant referee (VAR) system for TSL and thus will be contemporary compared to previous home bias studies that have included analyses of TSL. Our findings from the study indicate that the rate of home bias has been significantly reduced in the VAR period, and VAR's assistance in referee decisions has definitely helped the away sides win matches. However, not every referee decision made with VAR's assistance has favored the away teams. The COVID-19 pandemic might've contributed to our findings to some degree since it happened during the VAR period, but how influential the COVID-19 pandemic was to our results remains to be seen.

JEL Codes: Z20, Y10, C33

Keywords: Turkish Super League(TSL), Video Assistant Referee(VAR), home advantage, home bias.

PREFACE

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LIST OF ABBREVIATIONS

ADF	Augmented Dickey-Fuller
FIFA	International Federation of Association Football
LLC	Levin-Lin-Chu
IFAB	International Football Association Board
IPS	Im-Pesaran-Shin
OFR	On-Field Review
PP	Phillips-Perron
TFF	Turkish Football Federation
TSL	Turkish Super League
VAR	Video Assistant Referee

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1. INTRODUCTION

The Video Assistant Referee (VAR) has been introduced to the professional football leagues across the world, and it is officially implemented in most of the professional leagues around the world. The VAR system was officially implemented in the Turkish Super League (TSL) at the start of the 2018/19 season, and since then, TSL referees have used the VAR system to check crucial moments of the game and correct their mistakes if they were not exactly sure of their decisions. The VAR was implemented in many professional leagues in order to reduce and minimize any home and referee bias or mistakes that can happen during professional football matches. It does not necessarily mean that the VAR system can eliminate all kinds of home and referee bias; therefore, we will consider other determinants that might contribute to the home bias persisting to some degree, such as crowd density, travel fatigue, and additional time given after 90 minutes of football played. Our main issue with the VAR system is to determine whether it is significantly successful in countering some of the home bias. Since the VAR system was implemented very recently in professional leagues, including the TSL, there have been only a few studies conducted with respect to the VAR system's impact on home bias.

This thesis implements VAR into the home bias literature, and since the implementation of the VAR system is quite new in soccer, this study will probably be one of the few studies that includes VAR in the home bias question and will probably be the first on home bias that includes a video assistant referee (VAR) system for TSL, thus being contemporary compared to previous home bias studies that have included analyses of TSL.

Similar to literature such as Dilger & Vischer (2020), the study compares the potential determinants of home bias between pre-VAR and VAR periods using t-test analysis. The t-test analysis will tell us whether the rate of home bias has significantly decreased. Then, similar to Govdeli & Gungor (2022), the study applies panel data analysis to investigate the potential relationships that might have contributed to the drop in the level of home bias.

The remainder of this paper is organized as follows: The next section explains the rules of the VAR system and how they can be applied during soccer matches. Section 3 briefly reviews the literature on the home bias issue in sports. Section 4 describes the data and the TSL's structural and historical changes. Section 5 introduces the methodologies and the empirical results. Section 6 concludes the thesis, followed by references and an appendix.

2. HOW VAR WORKS

The VAR stands for Video Assistant Referee, which is a system that assists the main referee by evaluating the decisions of the main referee based on the usage of video footage of the incidents on the soccer pitch. After it was conceptualized in the early 2010's by the Royal Dutch Football Association (KNVB) and tested in various tournaments and friendlies, it was officially started to be implemented across leagues in 2017, with the A-League, Major League Soccer (MLS), Serie A, and Bundesliga being the first professional leagues to implement the VAR. Other leagues followed suit soon after, especially after FIFA and the International Football Association Board (IFAB) included VAR in their "Laws of the Game" in 2018 (FIFA, 2018; IFAB, 2018).

The VAR system reviews the incidences of the game under four different categories. These are:

1) Checking whether the goal was valid (whether there is a missed call for offside or not, or whether a foul has been committed before the leadup to a goal).
2) Checking whether the incident is a penalty or not.
3) Checking for possible straight red-card incidents.
4) Checking whether the yellow or red card was given to the wrong player or not.

For VAR to be able to assist the referee in matches, the referee must make a decision regarding the incident, or if a dangerous incident, such as violent conduct or a dangerous tackle, is missed by the referee. After the referee decides to make a decision regarding the incident, the VAR might communicate with the referee to assess the final decision. While assessing the final decision, the VAR might suggest reviewing it in case the referee made a wrong decision or missed the incident entirely. If that's the case, the referee might stop the game for a moment while the decision is checked and initiate a review of the incident with VAR officials. After the review, the referee might reverse his or her original decision based on the suggestions from the VAR, or VAR officials might suggest the referee do an "on-field review" (OFR) check, especially if the judgment of the incident calls for a subjective decision. There's no time limit for these checks, as the primary objective of the VAR system is to minimize the number of referee mistakes as much as possible. However, the decision to use the VAR on incidents rests with the referees, as they do not necessarily have to use the VAR system, and they can ignore the recommendations made by the VAR officials if the referees are fine with their decision.

3. LITERATURE REVIEW

One of the earliest studies that conducted the "home advantage" was Edwards (1979), who conducted the "home advantage" analysis on various different sports in his article titled "The Home-Field Advantage". This article was very rudimentary in the sense that it mostly focused on the home-winning ratios of different sports activities that were mostly native to the United States. Since the sports activities that were analyzed were predominantly American, soccer was not one of the sports activities that were analyzed in the case of the home advantage issue. However, the article has put the "home advantage" issue on the map among successive scholars, as the home advantage issue in soccer was put into question two years later by Desmond Morris (1981). He found that the teams won "54.4% of their home games in professional football" (American football), "58.6% of their home games in college football", and "55.6% of their home games in professional baseball" (Edwards, 1979).

The first study that quantitatively analyzed the "home advantage" issue in soccer was by Desmond Morris (1981), who wrote such an analysis in his book called "The Soccer Tribe". This was a very detailed analysis of soccer, defining and explaining every aspect of soccer from inside the soccer field to the off-the-field soccer events, including footballers' livelihood and background, soccer mascots, backroom staff, and fans' psychological behaviors when an important game comes up. Since this was a very detailed book about soccer, it also mentioned the home advantage in a quantitative analysis as he examined and compared the home and away wins between the English First Division and English Fourth Division. For the English First Division, between seasons 1946–47 and 1978–79 were taken into consideration, and for the English Fourth Division, between seasons 1958–59 and 1978–79 were taken into consideration, as the English Fourth Division was first started in the 1958–59 season (Morris, 1981). Morris found that home-to-away win ratios for the English First Division and English Fourth Division were found to be 2.1 to 1 and 2.5 to 1, respectively, quantitatively mentioning the home advantage in the process, as referred to in his book as "Away-itis". He also briefly mentioned the potential referee biases when he defined the different personality types of referees; however, he did not go beyond explaining the referee types (Morris, 1981).

Dowie (1982) was one of the first researchers to analyze the home advantage issue with respect to the World Cup host teams. Dowie tried to find which factor favored the most on the home side/host nation from his data on the World Cup, English Football Leagues, and other sports leagues. In order to reach that aim, he compared three factors that would've potentially give the home side an advantage: "travel fatigue", "familiarity" and "fan size". His hypothesis for the travel fatigue was that the fatigue should affect more on the away side, as the probability of scoring more away goals should be less towards the end of the

game. However, this was not found to be the case, as he deemed "travel fatigue" an unimportant determinant for this reason. For "familiarity", he found that the size of the pitch might be the reason for the changes in home and away teams' performance, but he found it difficult to consider without the crowd effect. Therefore, he found fan size to be the most effective determinant out of all three determinants. Along with the host nations' previous World Cup records, Spain's level of team quality at that time, and the larger fan size (since Spain was a host nation in the 1982 World Cup), the author predicted that Spain should win the World Cup with respect to his findings. (Dowie, 1982).

The study by Baumeister & Steinhilber (1984) had some interesting outcomes with respect to figuring out the home advantage issue. The focus of the study was on home teams' performances and results with respect to earlier games in the season and later games into the latter part of the season, including the decisive games where the home team might have a chance to claim the league title. The tournaments that were investigated were the World Series for baseball and the NBA Championship & Playoffs for basketball. The investigation of the study was whether the home teams lose a lot of games and perform worse when they reach the final games of the season, especially when there is a possibility of clinching the title. The authors' findings from the match results show that the home teams tend to lose a lot of home games, and players from the home side tend to underperform when they reach the final games of the season, especially when these games become decisive for the home team when there's a possibility to win the title. In other words, the home team tends to choke, and individual performances by home team players tend to slump when home teams play their title decider matches. The authors refer to this situation as "The Home-Field Disadvantage" (Baumeister & Steinhilber, 1984).

Pollard (1986) also studied the "home advantage" issue and analyzed it retrospectively in European Cup competitions and the top 5 English soccer divisions, from the English First Division (currently the Premier League) to the Vauxhall Conference (currently the Vanarama National League). Cup competitions that were retrospectively analyzed were the FA Cup, FA Trophy, FA Vase, and FA Sunday Cup. Pollard's retrospective analysis on home advantage was largely based on points accumulated rather than simply comparing home wins and losses, as he was the first researcher to do such an analysis. He was also the first researcher to pay attention to the introduction of the 3-point system and compare it to the previous system of the 2-point system in football in terms of getting the overall percentage of home advantage across specific time periods. His analysis indicated that the home advantage increased as we headed towards the lower tiers of English soccer. The only exception to this finding was that the Vauxhall Conference, the fifth tier of English soccer, was found to have lower rates of home advantage than the rest of the English leagues, although this might be due to the different points system that had been in effect since the 1983/84 season in the Vauxhall Conference: 3 points for an away win, 2 points for a home win,

and 1 point for a draw. He concluded that the home bias issue needed a lot of work to be done despite the study's findings (Pollard, 1986).

Nevill et al. (1996) undertook an analysis of the home bias issue in relation to referees across eight different football leagues in England and Scotland. They employed chi-squared independence tests to determine if the red cards awarded by referees and penalties scored by players significantly indicated a home bias issue. They also observed the level of attendance across leagues. Their study discovered that both red cards and penalty decisions tended to favor the home side, although this was contingent on the crowd level in the stadium. They found the English Premier League to have a much higher rate of home bias overall than the other English and Scottish Leagues, which could potentially be due to the higher crowd attendance (Nevill et al., 1996).

Nevill (1999) analyzed the issue of home advantage in four main categories comprehensively. He included balanced and unbalanced competitions, the game's location, psychological factors, and behavioral factors. He defined balanced and unbalanced competitions as the tournaments that follow a proper home and away system, such as the UEFA Champions League, and the tournaments that have one or two host nations, like the World Cup or European Championship, respectively. He defined the "game's location" as a combination of factors such as the crowd effect, familiarity, travel fatigue, and the game rules. Nevill considered psychological factors as the impact on an individual player's morale or general psychological behavior from outside factors like home or away crowd support and referee decisions. He mentioned behavioral factors such as team performances, the style of play for both home and away teams, and referee decisions. He had investigated five different sports activities under balanced competition: baseball, ice hockey, basketball, American football, and soccer. His findings, along with those of previous studies, showed soccer had the highest home advantage among the five sports activities, with a percentage rate of 68.3% excluding draws. Meanwhile, baseball had the lowest home advantage rate at 54.3% (Nevill, 1999). For the unbalanced competition, he tried to identify if France, the host nation, experienced a perennial home advantage during the 1998 World Cup. To answer this question, he investigated the correlation between the world rankings of nations before and after the 1998 World Cup, which would have served as a measure of how the national teams performed during that tournament. The result showed that only two nations—France and Croatia—performed exceptionally well, with host nation France winning the World Cup'98, contradicting Baumeister & Steinhilber's (1984) study in the process. He had studied four subcategories for the game's location: crowd size, different sizes of the pitch, travel fatigue, and game rules. He discovered that the home advantage peaked when the crowd reached a certain attendance level. The different sizes of the pitch did not significantly affect the level of home advantage, while the results for travel fatigue differed across various studies. One interesting result found in a study showed that, in

NBA matches, time zone differences led to home teams having a disadvantage, as they scored fewer free throws than the away team. Regarding game rules, the study investigated and calculated the advantage rate for the last batter in a baseball game, finding little advantage. Regarding psychological factors, he found that players feel more confident playing in front of an "active home crowd" than an away crowd. The study attributed the players' confidence and optimism about winning when playing before a home crowd as the reasons for their home game victories. Regarding behavioral factors, the study found that referees tend to penalize away teams more severely while making more favorable decisions for home teams. However, how much crowd size and its behavior influence referees' decisions remained unclear (Nevill, 1999).

Nevill et al. (2002) have investigated whether the home crowds influence the referees' decision-making when assessing fouls. To assess such an investigation, 40 different soccer referees with varying levels of experience have reviewed the footage of a Premier League game between Liverpool and Leicester City during the 1998/99 season, in which all 40 referees reviewed 47 fouls in that match and assessed whether each of these fouls given was valid. To investigate whether the crowd noise influences the referees' decisions, 22 of the 40 referees have watched that footage with crowd noise on, while the remaining 18 have watched that footage in silent mode. They had estimated the referees' response by using the binary logistic regression method since the referees' response to that footage can only be categorized as the "categorical response". In the categorical response, they had four options to choose from: "home foul (Liverpool), away foul (Leicester City), no foul, and uncertain". The results from the pioneer logistic regression have indicated that referees who watched the footage with crowd noise tend to give significantly fewer fouls than those who watched the footage in silence. Years of refereeing experience have not been found to be significant with respect to the influence of crowd noise. However, the number of home fouls given was found to be increased until "16 years of experience" and then declined afterwards (Nevill et al., 2002). For the away fouls, none of the variables have been found to be significant with the influence of the home crowd. However, the referees who watched the footage with crowd noise made more uncertain decisions than the referees who watched the footage silently. Therefore, the paper concluded that referees tend to be lenient towards the home team when there is crowd noise, effectively confirming the home bias with respect to crowd noise. In order to tackle such an issue, they suggested that the officials should judge decisions on "soundproof booths", with one official assisting the on-pitch referee with "contentious replays", which kind of predated the VAR implementation in soccer (Nevill et al., 2002).

Sutter & Kocher (2004) studied the home bias issue based on two important determinants: added times given by the 4th official after 90 minutes played and penalty decisions. Their study was based on a dataset collected from the German Bundesliga in the 2000/01 season. The main objective of their study was to

determine what factors were contributing to the home bias and favoritism towards the home team. Their study found that referees tend to award penalty kicks more significantly to the home side. Away teams were found to be largely ignored by the referees when it comes to awarding penalty kicks, as 21 out of 76 penalties in that season were found to be given to the away side. Extra time-wise, their study has established that referees tend to give significantly more injury time when the home team is losing by a single goal after 90 minutes. Overall, the study concluded that the home advantage played an important role in referees' behavior in the match, and they argued that referee biases on penalty decisions had been more significant than injury time decisions after 90 minutes of football played (Sutter & Kocher, 2004).

Boyko et al. (2007) investigated whether referee bias contributed to the home advantage in the English Premier League, the top tier of English soccer, for the seasons between 1992/93 and 2004/05. The study also examined whether individual referees had varying levels of home advantage. Four variables were examined in the study as these were; referee experience, crowd attendance, and referees' behaviors and decisions. Various regression analyses were used to determine the factors contributing to home advantage and whether the rates of referee bias differed among individual referees. The study concluded that the Premier League referees did contribute to the home advantage to some extent, and that the degree of home advantage have found to be varied among individual referees. The study also found a correlation between referee experience and home advantage, with more experienced referees have found to be committed fewer home advantages (Boyko et al., 2007).

Pollard (2008) has further defined the meaning of home advantage over the works of Morris (1981), who first defined the term "home advantage" in quantitative terms in his book "The Soccer Tribe". Pollard argued that home advantage in football was the result of a combination of many factors, including travel effects, familiarity with the home team's surroundings, special tactics, psychological factors, and crowd effects. Pollard (2008) has explained these factors one by one in terms of what they actually mean and highlighted the potential effects of home bias based on the findings of the preceding studies on the home bias issue. He concluded that the home bias issue was an ongoing piece of literature that needed to be worked on more in order to grasp the determinants of home bias and its effects on sports overall (Pollard, 2008).

Dohmen (2008) analyzed the referee decisions and their behaviors for the home bias analysis. His dataset was based on the Bundesliga, the top tier of the German football league, from the start of the 1992/93 season to the end of the first half of the 2003/04 season. Some of the referee decisions that were analyzed included penalties given and stoppage times after 90 minutes. For home bias analysis, away football fan size and even football stadium types were mentioned. Dohmen's study has underlined that referee bias

has a large occurrence when the home team is losing by a small margin, as referees were found to be given more stoppage times after 90 minutes. The study also concluded that referees tend to give more biased decisions to the home side if the match is played in a stadium without a running track (Dohmen, 2008).

Seckin & Pollard (2008) analyzed the home bias issue for the Turkish Super League (TSL). This was one of the earliest studies that focused on the home bias issue for the TSL. This study was very rudimentary with respect to methods, as the vast majority of the study was based on two-tailed t-tests. The database for TSL consisted of 12 seasons, from the start of the 1993/94 season until the end of the 2005/06 season. In terms of points gained by the home team, 12 seasons-worth of match results were analyzed for the English Premier League and the TSL between seasons 1993/94 and 2005/06. In terms of analyzing match performances, they conducted a comparative analysis between TSL and the English Premier League for the 2005/06 season. They found that the home advantage rate between Turkish and English soccer divisions was very close to each other, at 61.5% and 61%, respectively. The home advantage for Istanbul and London-based derby games was found to be several percent lower than the average. Remote places in Turkey, such as Van and Diyarbakır, were found to have an even higher average level of home advantage rate compared to the leagues' average. In terms of referee bias, they found English Premier League referees to be giving more freekicks and cards in favor of the home team than TSL referees (Seckin & Pollard, 2008).

Dewenter & Namini (2011) have investigated whether the home bias and changes in the point system (from a 2-point rule to a 3-point rule) allowed the home team to play defensively rather than playing an attacking style of football. The study was quite different compared to previous studies in the sense that it focused more on the changes in the team's attacking or defensive playing style than the team's home and away performances for calculating the percentages of the home advantage for each team or league. The study focused on the German Bundesliga, the top flight of German soccer, for the seasons between 1982/83 and 2007/08. They stated that the introduction of the 3-point system has made the away teams play more offensively as the number of away goals have increased since the three-point system was introduced in the German Bundesliga. Away teams also have been found to collect more points after the three-point system was initiated. Therefore, one can argue that since the introduction of the three-point system has rewarded victories a lot more for all teams concerned, away teams tend to play more offensively and home teams tend to play more defensively (Dewenter & Namini, 2011).

Yewell et al. (2014) studied the home bias issue for Major League Soccer (MLS). They tried to investigate whether the home bias influenced the referees' decisions over stoppage times. To investigate this question,

they analyzed two different seasons in the MLS - the 2011 and 2012 seasons. They used variables such as stoppage times, yellow cards, red cards, results before the stoppage time, and TV broadcasting for estimation purposes. They used OLS, groups data, and partially adaptive estimation methods to estimate these variables and identify which ones were significant to the question of home bias for each of the 2011 and 2012 seasons. For the 2011 season, they found no significant effect of home bias on referee decisions on stoppage times, but discovered that televised games were on average 14 seconds longer than the non-televised games. For the 2012 season, they found that televised games on average lasted shorter than non-televised matches. The 2011 season estimations showed TV broadcasting might have influenced referee decisions on stoppage times rather than the home bias itself. However, the 2012 season estimations showed that the home bias significantly affected the referee's decisions on stoppage times, as referees added 33 seconds more on average in the case of a home team that was one goal behind after 90 minutes than the away team that was one goal behind after 90 minutes. (Yewell et al., 2014).

Gürkan et al. (2017) have carried out a home advantage analysis for the TFF First League (T1L), the second tier of Turkish soccer. This was one of the pioneer studies to focus specifically on the TFF First League. The objective of the study was to simply calculate the rate of home advantage for all T1L teams between the seasons 2005/06 and 2014/15. The calculation of home advantage was simply based on the analysis of the results of home and away games, which made the study quite rudimentary. The findings from the calculations revealed that the average home advantage rate for T1L was 61.1%, higher than most of the countries' soccer leagues in comparison. In terms of individual teams, rates of home advantage have varied between 48.95% and 85.71%. For the teams with at least five seasons of experience at T1L, the rates of home advantage were between 53.14% and 67.5%, effectively discarding the extreme variations that the inexperienced T1L soccer teams had experienced. (Gürkan et al., 2017).

Endrich & Gesche (2020) have studied the effect of the COVID-19 pandemic in order to investigate the impact of home bias on referee decisions in the Bundesliga and Bundesliga 2, the top two tiers of German soccer. The objective of the paper was to determine whether the crowd size affected the referee decisions and thus caused home bias by comparing the pre-Covid and post-Covid match statistics, such as fouls committed and yellow cards given by the referees for both home and away teams. The length of the data was one single season, the 2019/20 season. The authors used the ordinary least squares (OLS) method in order to compare the findings of the normal and COVID-ridden parts of the season. They concluded that the referee decisions with respect to fouls and yellow cards given had been less harsh once we got to the COVID-ridden stages of the season. They also found that the matches with stronger home support tended to have a lot more home bias compared to games with weaker home support, effectively backing the notion that the "ghost games" had much fewer home biases than the matches from the pre-COVID-19 period.

(Endrich & Gesche, 2020).

Dilger & Vischer (2020) studied the home bias differences between “regular games” and “ghost games” for the 2019/20 season of the Bundesliga, the highest tier of German football. The distinction between “regular games” and “ghost games” was because of the impact of the COVID-19 pandemic, as after the COVID-19 pandemic took the world by storm, the remaining matches of the 2019/20 season had to be played behind closed doors. They used one-tailed and two-tailed t-tests and chi-square tests for comparing variables between “regular” and “ghost” games in order to find whether the impact of the COVID-19 pandemic on football has reduced the level of home bias. They found that the home bias in “ghost games” had been statistically significant in terms of reduction, which accounted for the lack of spectators and thus reduced the bias of referees as the reason for their findings. (Dilger & Vischer, 2020).

Subak & Kaya (2021) conducted a comparative analysis between the pre-COVID-19 pandemic and the post-COVID-19 pandemic in terms of crowd support for the 2019–20 season. They investigated the TSL (Turkish Super League), the German Bundesliga, the English Premier League, the Italian Serie A, and the Spanish La Liga. The quantitative analysis was based on the paired sample t-test and sample correlation methods. For TSL, variables like “home points accumulated” and “home and away goals scored” slightly increased after the COVID-19 pandemic, while “away points accumulated” had slightly decreased. For the Premier League, they found variables such as ‘home points accumulated’ and ‘home goals scored’ to be slightly higher in the COVID-19 era. They considered the findings from the TSL and the Premier League as “unusual,” considering the lack of support for the home team during soccer matches. For the Bundesliga and La Liga, however, the variables for the home team considerably decreased and were deemed statistically insignificant. They concluded the study by finding that the overall home advantage had decreased while the overall match performance for away teams had increased when they combined the data for all five leagues, thus confirming the effects of home advantage during the COVID-19 period. (Subak & Kaya, 2021).

Sors et al. (2021) also conducted a study on the effect of COVID-19 on home advantage and referee bias. They aimed to test their hypothesis and determine whether home advantage and referee bias significantly decreased after the COVID-19 period. Their study centered on the top two divisions of the top four leagues in Europe according to the UEFA country rankings. They considered the seasons from the start of the 2016/17 season through to the 2018/19 season for regular games and the 2019/20 season for games affected by COVID-19, when they had to play part of these games behind closed doors. To achieve their objective, they considered multiple variables under two main categories: “home advantage variables” and “referee bias variables.” They also considered team performances, focusing on the points per game for

each team across leagues. To achieve their objective, they used various methods, with the “equivalence method” proving most critical throughout the study, as it eliminated the “large sample bias issue,” a prevalent problem in the study. Their statistical analysis showed a reduction in home advantage in the matches that they had to play behind closed doors. This finding was particularly noticeable with regards to a significant drop in home advantage rates in the 2019/20 season (only accounting for matches with no spectators) compared to the previous seasons with spectators. They observed a 5% drop in the home advantage rate between seasons with spectators and seasons without spectators, confirming that the home crowd and/or crowd noise significantly contributed to the home advantage. The “referee bias variables” were not found to significantly affect the level of home bias during the COVID-19 period, however (Sors et al., 2021).

Holder et al. (2021) studied the effect of the implementation of Video Assistant Referee (VAR) on home bias. They tried to find out whether the VAR system reduces the chance of home bias, especially in head-to-head matches with red cards or penalty kicks given by referees. Their dataset was based on the leagues of the Bundesliga and Serie A, the top tiers of German and Italian soccer, respectively. The length of the dataset with all collected variables consists of 4 seasons: from 2015/16 to 2018/19, with the pre-VAR periods being the 2015/16 and 2016/17 seasons, and the post-VAR period consisting of the seasons 2017/18 and 2018/19, respectively, for both the Bundesliga and Serie A. Holder et al.’s findings concluded that the VAR system definitely affected the decisions of the referees, especially with respect to penalty kicks and red cards, as referees gave fewer penalty kicks and red cards directly without the VAR intervention. They also found that added time biases were not present in the post-VAR period, and the referees’ “level of experience” had no effect on home bias overall (Holder et al., 2021).

Kim et al. (2022) also studied the effect of the implementation of Video Assistant Referee (VAR) on home bias. Unlike Holder et al.’s (2021) study, they had a much larger database, which included 53 professional football leagues. Since the implementation of VAR did not happen simultaneously to all leagues in the same season, they made a distinction between early VAR adopters of leagues and late VAR adopters, distinguishing them as “control group” and “treatment group," respectively. The length of the dataset was also larger than Holder et al.’s 2021 study, stretching from 2013 to 2021. The main focus of the study, however, was trying to find the differences in home and away goals scored across seasons using the “differences-in-differences” method. Kim et al. (2022) concluded that the number of away goals scored has increased overall in the post-VAR period, which was from 2018 to 2021. The number of “home goals scored” had not changed overall, but since the away goals increased after the implementation of VAR, they concluded that the VAR system might have helped to reduce some of the bias (Kim et al., 2022).

Govdeli & Gungor (2022) investigated the potential contributing factors of the "home crowd effect" for the top 5 major leagues in Europe, which include the English Premier League, Spanish La Liga, German Bundesliga, Italian Serie A, and French Ligue 1. They identified six different variables in their conceptual framework to determine the “home crowd effect." Namely, the countries’ GDP, total transfer fee spent for each league, total market value of each league, goals per match for each league, leagues’ UEFA country rankings, and crowd density rates. The data they used spanned 15 seasons, starting from the 2005–06 season to the 2019–20 season. They used panel stationarity tests, Pedroni panel cointegration tests, and panel causality tests to ascertain which variables were the determinants of the “home crowd effect." Their findings highlight the countries' GDP, number of goals per game, expenditure of transfer fees, and UEFA country rankings as determinants of the home crowd effect. Furthermore, the panel causality test results suggested bidirectional causality between the crowd density rate and the GDP. They also observed a one-way relationship between goals per game and crowd density rate, UEFA country rankings and crowd density rate, and between the expenditure of transfer fees and crowd density rates. According to their study, the increase in UEFA country rankings, goals per game in the league, and the expenditure of transfer fees lead to an increase in crowd density in stadiums (Govdeli & Gungor, 2022).

Kuvvetli & Cilengiroglu (2023) analyzed the home bias issue in relation to teams that participated in the Turkish Super League (TSL) over the past 22 years, stretching from the start of the 2000/01 season to the end of the 2021/22 season. They have based their calculations of home advantage for the respective TSL teams on goals scored and conceded during home and away games. The TSL teams chosen for the study met the criterion of remaining in the league for at least three seasons out of 22, and based on this criterion, they have selected 34 TSL soccer teams for analysis. They aimed to calculate the rate of home advantage and the rate of away disadvantage for each selected team by considering goals scored and conceded in both home and away games. The study used “Poisson regression” to calculate both the rate of home advantage and the rate of away disadvantage by analyzing the home and away matches of each selected TSL team. Unlike many previous studies, they chose not to calculate home advantage based on points accumulated in home games (or home matches won) because they felt that such calculations had skewed the perception of teams’ quality level. The use of Poisson regression showed that almost all the TSL teams enjoyed a significant degree of home advantage, ranging from 56.2% to 81.8%. There was also a predominance of away disadvantage among most TSL teams, except for nine soccer teams that did not experience a statistically significant level of away disadvantage. Interestingly, most of these nine soccer teams were TSL veterans and TSL title holders. They hypothesized that the lack of away disadvantage for most of the larger teams could be due to the quality of these teams and the extent of their crowd support, which led to these findings. (Kuvvetli & Cilengiroglu, 2023).

4. THE DATA AND DESCRIPTIVE STATISTICS

As we can see from the studies in the "literature review" section, there have been just a few studies conducted with respect to the VAR's impact on home bias, and none of the studies have focused on the Turkish Super League (TSL) with regards to the impact of the VAR on home bias. Therefore, this study will be the first to focus on the TSL with regards to the VAR's impact on home bias.

The data consists of 11 and a half seasons of TSL matches, from the start of 2012/13 season until the first half of the 2023/24 season. The data is split into two parts: the pre-VAR period and the VAR period. The pre-VAR period will consist of the period from the start of the 2012/13 season to the end of the 2017/18 season, while the VAR period will consist of the period from the start of the 2018/19 season to the first half of the 2023/24 season. To compare between these periods, variables such as penalties given, yellow and red cards for both home and away teams, score differences between home and away teams without added injury time, added time after 90 minutes, crowd size, and its density rate were collected across the seasons. Apart from these data, we also collected data for the VAR period with respect to VAR decisions and regular versus non-regular games (games that have been affected by the COVID-19 pandemic). We will use Transfermarkt.com and Google for gathering the data. At first, we will conduct t-tests on several variables regarding the home bias for both periods. After that, we will conduct panel-data analysis as to whether the VAR has significantly reduced the rate of home bias overall. The reason why we are conducting the panel data analysis is due to missing values occurring with regards to some variables, such as crowd size and added time after 90 minutes. Some matches were not played at all due to the 2023 Turkey-Syria earthquakes, as clubs such as Hatayspor and Gaziantep FK decided to withdraw from the league as these clubs were severely affected by the earthquake. This means that we have to treat almost all variables as missing values in that scenario, which is another reason why we have decided to conduct a panel-data analysis.

Table 1: Descriptive Statistics of Variables for pre-VAR period

Variables	Obs(N)	Mean	Std. Dev.	Skewness	Kurtosis
HomeWin	1836	0,4635	0,4988	0,1463	1,0214
HomeAdv	1836	0,5477	0,4378	-0,0746	1,2391
Away RC	1836	0,1498	0,4148	3,3511	18,1618
Crowdsize	1486	11574	11808	1,6459	5,5188
HomePens	1836	0,1803	0,4185	2,2499	7,7225
HomeRC	1836	0,1230	0,3526	2,9128	11,8293
T-Fatigue	1836	0,8050	0,3963	-1,5397	3,3707
AwayWin	1836	0,2838	0,4509	0,9593	1,9202
AwayPens	1836	0,1165	0,3359	2,7712	9,9758
Density (%)	1486	0,4043	0,2786	0,4776	2,1747

Source: Our calculation based on match reports.

Table 2: Descriptive Statistics of Variables for VAR period

Variables	Obs(N)	Mean	Std.Dev.	Skewness	Kurtosis
AwayWin	1944	0,2978	0,4574	0,8841	1,7817
VAR_rule	1915	0,4157	0,493	0,3422	1,1171
HomeAdv	1944	0,5293	0,4377	0,0007	1,2403
AwayPens	1915	0,176	0,4138	2,2836	7,8888
Crowdsize	1826	8683	11086	1,6954	5,1048
HomeWin	1944	0,4429	0,4968	0,2299	1,0528
HomePens	1915	0,2355	0,4864	2,0351	6,8778
HomeRC	1915	0,1211	0,3496	2,9310	11,9328
T-Fatigue	1944	0,8256	0,3795	-1,7163	3,9457
AwayRC	1915	0,1441	0,3826	2,6784	10,2118
Density (%)	1826	0,2739	0,2802	0,8301	2,5192

VAR_AwayPen	1915	0,0741	0,2719	3,6344	15,8669
VAR_HomePen	1915	0,0846	0,2894	3,3672	13,8756
VAR_AwayRC	1915	0,0318	0,1844	5,0639	32,0638
VAR_HomeRC	1915	0,0266	0,1823	4,4716	33,6647
VAR_HomeGoal	1915	0,0422	0,2064	4,9004	27,0975
VAR_AwayGoal	1915	0,0277	0,1641	5,7585	34,1605
VAR_HomeNG	1915	0,0752	0,2754	3,8137	19,3694
VAR_AwayNG	1915	0,0694	0,2721	4,0658	20,1331
VAR_HomeNP	1915	0,0496	0,2219	4,4324	22,2290
VAR_AwayNP	1915	0,0350	0,1894	5,5164	34,3122

Source: Our calculation based on match reports.

4.1.Changes in the TSL

4.1.1. Number of Teams Participated in the TSL

As seen in Table 3, 39 different teams have participated in the Turkish Super League (TSL) across 12 seasons. Only five of them have survived across all 12 seasons in the TSL. All five non-relegated teams happen to be based in Istanbul, except Trabzonspor. All title holders in the TSL also retain their place in the league currently, except Bursaspor, which were relegated at the end of the 2018–19 season. They currently reside in the 3rd tier of Turkish football, with another relegation possibly on the cards this season.

Of the 19 relegated teams, four of them no longer exist as of 2024. Teams that went extinct failed to survive as football clubs in less than five years after they got relegated from the TSL. Orduspor currently resides in the Ordu 1st Amateur League (6th tier), while Eskişehirspor currently resides in the Regional Amateur League (5th tier). Elazığspor, Akhisarspor, and Balıkesirspor currently play their trade in the 4th-tier leagues. Bursaspor, Ankaraspor, and Denizlispor, on the other hand, play their trade in 3rd-tier leagues. The rest of the teams retain their place in the TFF 1st League (2nd tier) except for Yeni Malatyaspor, which declined to participate due to the negative effects of the 2023 Turkey-Syria earthquakes.

Table 3: Teams participated in the TSL from 2012-13 to 2023-24 season.

Teams	Seasons at TSL	Last Season at TSL	Current League Status
Galatasaray	12	Current	Turkish Super League
Beşiktaş	12	Current	Turkish Super League
Fenerbahçe	12	Current	Turkish Super League
Trabzonspor	12	Current	Turkish Super League
Bursaspor	7	2018/19	2nd League White Group (3rd tier)
Kayserispor	11	Current	Turkish Super League
Kasımpaşa	12	Current	Turkish Super League
Antalyaspor	11	Current	Turkish Super League
Eskişehirspor	4	2015/16	Regional Amateur League (5th tier)
Gaziantepspor	5	2016/17	Extinct (no longer exist)
Gençlerbirliği	8	2020/21	TFF 1st League (2nd tier)
Sivasspor	11	Current	Turkish Super League
Elazığspor	2	2013/14	3rd League Group 2 (4th tier)
Akhisarspor	7	2018/19	3rd League Group 3 (4th tier)
Kardemir Karabükspor	5	2017/18	Extinct (no longer exist)
Başakşehir (ex: İstanbul BBSK)	11	Current	Turkish Super League
Orduspor	1	2012/13	Ordu 1st Amateur League (6th tier)
Mersin İdmanyurdu	3	2015/16	Extinct (no longer exist)
Konyaspor	11	Current	Turkish Super League
Çaykur Rizespor	9	Current	Turkish Super League
Balıkesirspor	1	2014/15	3rd League Group 4 (4th tier)
Kayseri Erciyesspor	2	2014/15	Extinct (no longer exist)
Ankaraspor (ex: Osmanlıspor)	3	2017/18	2nd League White Group (3rd tier)
Adanaspor	1	2016/17	TFF 1st League (2nd tier)
Alanyaspor	8	Current	Turkish Super League
Göztepe	5	2021/22	TFF 1st League (2nd tier)
Ankaragücü	5	Current	Turkish Super League

BB Erzurumspor	2	2020/21	TFF 1st League (2nd tier)
Yeni Malatyaspor	5	2021/22	Declined to participate to the TFF 1st League
Denizlispor	2	2020/21	2nd League Red Group (3rd tier)
Gaziantep FK	5	Current	Turkish Super League
Fatih Karagümrük	4	Current	Turkish Super League
Hatayspor	4	Current	Turkish Super League
Altay	1	2021/22	TFF 1st League (2nd tier)
Giresunspor	2	2022/23	TFF 1st League (2nd tier)
Adana Demirspor	3	Current	Turkish Super League
İstanbulspor	2	Current	Turkish Super League
Ümraniyespor	1	2022/23	TFF 1st League (2nd tier)
Samsunspor	1	Current	Turkish Super League
Pendikspor	1	Current	Turkish Super League

4.1.2. Changes in the TSL Format

Until the start of the 2020–21 season, the TSL used to consist of 18 teams, which was unchanged since the start of the 1994–95 season. Since then, the number of teams in the TSL has changed every season. The 2020/21 season saw the TSL having 21 teams instead of 18 teams in the 2019/20 season; then it was reduced to 20 and 19 teams in the seasons 2021/22 and 2022/23, respectively. As of the 2023–24 season, the number of teams in the TSL has been increased to 20 again. The number of teams in the TSL will change again next season, however, as 4 teams from the TSL will be relegated this season and 3 TFF 1st League teams will gain promotion, reducing the number of teams in the TSL to 19 in the process for the next season. This information will be important to our study since the number of matches played across seasons will vary each season from the end of the 2019–20 season onwards. This means that variables such as the number of penalties given, red cards given, etc. might not get us reliable results, especially for the VAR period, as all the changes with regards to the number of teams in the league have occurred in the VAR period. Therefore, we will consider the average number of occurrences in a match (such as the average number of penalties given per game, the average number of red cards given per game, etc.) as the measurement for the home-bias issue since it will give more reliable results since we will be dealing with a different number of total matches played across seasons.

5. METHODOLOGY & EMPIRICAL RESULTS

Investigating the relationship between VAR decisions and the rate of home bias will be important in our analysis since it will give us a clue as to whether the VAR system has reduced the rate of home bias. To identify such hypotheses, first we will put some variables into the t-test. The purpose of applying the t-test is to compare the pre-VAR and VAR periods with regards to the results of the match and referee decisions, as it is applied with a similar purpose in the studies of Dilger & Vischer (2020). The t-test results can be observed in Table 5. According to t-test results, we observe a significant drop in variables such as home wins and home advantage. This means that during the VAR period, home means and home advantage (points claimed by home teams) decreased to such a degree that is statistically significant when we compare the same variables from the pre-VAR period. On the other hand, the number of average away penalties has significantly increased during the VAR period, thus making it statistically significant in the process. However, we also observe that the average number of home penalties has considerably increased in the VAR period as well. Therefore, one might speculate that before the VAR period, the TSL referees missed some of the potential penalty calls that might have affected the game for both sides if the referee decided to give a penalty. As we go towards the VAR period, potential penalty calls that might have been missed by referees have been suggested to recheck the decision thanks to the VAR advice, and the referees mostly gave positive feedback to it, thus explaining why there is a considerable hike in the averages of both the home and away penalties. With regards to match results, the COVID-19 pandemic might have been attributed to some of the results, but how influential our findings were remains to be seen.

Table 4: t-test results.

	Pre-VAR period			VAR period			
Variables	**Mean**	**Std.Dev**	**Obs**	**Mean**	**Std.Dev**	**Obs**	**Sig.Level**
HomeWin	0,4635	0,4988	1836	0,4429	0,4968	1944	0,0338**
HomeAdv	0,5477	0,4378	1836	0,5293	0,4377	1944	0,0359**
HomePens	0,1803	0,4185	1836	0,2355	0,4864	1915	0,9998
AwayRC	0,1498	0,4148	1836	0,1441	0,3826	1915	0,2589
AwayPens	0,1165	0,3359	1836	0,176	0,4138	1915	0,000***
HomeRC	0,1231	0,3526	1836	0,1211	0,3496	1915	0,5962
T-Fatigue	0,805	0,3963	1836	0,8256	0,3795	1944	0,9916

** refers to 5% significance level, and *** refers to 1% significance level.

After we've applied t-tests, we will apply unit root tests to the variables in tables 1 and 2. By applying unit root tests, we can be sure as to whether the variables have stationarity in them. We have two different panel datasets: one for the pre-VAR period and one for the VAR period. Both panel data sets have six different time periods in them. However, both panel data sets have differences with regards to the panel structure and the number of variables that have been put into the unit root test. With regards to panel structure, the one for the pre-VAR period has been structured as a balanced panel since the pre-VAR period has no changes when it comes to the TSL's team size. The VAR period, however, has an unbalanced panel structure. When it comes to TSL's team size, it has fluctuated since the 2020–21 season. The fluctuation of the TSL's team size also affects the number of matches played within a season. For instance, in the 2019–20 season, the TSL was played with 18 teams, and 306 matches were played in that season. In the 2020–21 season, however, the TSL was played with 21 teams, and therefore 420 matches were played in that season. The fact that the number of matches played across seasons has been different since the 2020–21 season and only the first half of the 2023–24 season was considered for analysis makes the structure of the panel dataset for the VAR period an unbalanced one. The difference in panel structures between these panel datasets will be important, as this means that the type of unit root test that will be performed will be different between these panel datasets. Another difference between them is the number of variables that have been put into unit-root tests. For the pre-VAR period, we applied 10 different variables to the unit root tests. For the VAR period, it's a double amount compared to the pre-VAR period, as we put the VAR decisions into question. Considering these differences, we will employ four different panel unit tests: the Augmented Dicky-Fuller (ADF) test, the Phillips-Perron (PP) test, the Im-Pesaran-Shin (IPS) test, and the Levin, Lin, and Chu (LLC) test. We will employ panel unit root tests in order to determine whether the variables have unit roots in them. If the unit roots are found to be stationary, the datasets are found to be predictable and will give reliable results, meaning that the dependent variables regarding the relationship will give reliable results, and thus we can confidently determine the relationship. If unit root results are found to be non-stationary, however, this means that the datasets are unpredictable and will give unreliable results, meaning that the dependent variables regarding the relationship will give unreliable results, and we cannot truly determine such a relationship.

The results of the unit root tests can be observed in tables 6 and 7. For all panel unit root tests, we have tested the variables as to whether they fall at the 5% significance level. If the variables fall at the 5% significance level, this means that they do not have unit roots in them; therefore, the variables are stationary, and we can reject the null hypothesis. If the variables do not fall at the 5% significance level, this means that they have unit roots in them; therefore, the variables are non-stationary, and we fail to reject the null hypothesis. The maximum number of lags is chosen to 1. All panel unit root tests in tables 6 and 7 contain the intercept (no difference) only.

Table 5: Unit root test results for pre-VAR period.

Variables	IPS intercept	LLC intercept*
HomeWin	(-4,47827)***	(-20,1955)***
HomeAdv	(-16,6596)***	(-60,8805)***
Away RC	(-2,61675)***	(-8,39843)***
Crowdsize	(-122,619)***	(-172,168)***
HomePens	(-2,85545)***	(-11,0966)***
T-Fatigue	(-3,94098)***	(-16,1514)***
AwayPens	(-3,12690)***	(-12,4084)***
AwayWin	(-3,68527)***	(-16,9170)***
HomeRC	(-2,37714)***	(-9,95193)***
Density (%)	(-93,6564)***	(-68,4995)***

** refers to 5% significance level. *** refers to 1% significance level. * refers to our main focus of interest. Lag length was based on Schwarz info criterion (SIC) and maximum lags were set to 1. In all types of unit root tests, the bandwidth is based on Newey-West with Barnett kernel.

Table 6: Unit root test results for VAR period.

Variables	IPS intercept*	LLC intercept
HomeWin	(-3,69052)***	(-16,3795)***
AwayWin	(-3,76427)***	(-15,4958)***
VAR_rule	(-3,67238)***	(-17,6564)***
AwayPens	(-3,24133)***	(-11,7195)***
HomePens	(-2,83643)***	(-10,4998)***
Crowdsize	(-207,901)***	(-98,5849)***
HomeAdv	(-14,9269)***	(-68,5064)***
T-Fatigue	(-2,54984)***	(-11,4474)***
AwayRC	(-2,01500)***	(-7,47757)***

HomeRC	(-2,76193)***	(-8,51273)***
Density (%)	(-102,805)***	(-292,938)***
VAR_AwayPen	(-0,96400)	(-4,80759)***
VAR_HomePen	(-2,45567)***	(-8,86941)***
VAR_AwayRC	(-0,94661)	(-3,57431)***
VAR_HomeRC	(-1,01629)	(-3,90842)***
VAR_HomeGoal	(-1,48154)*	(-5,91187)***
VAR_AwayGoal	(-0,47060)	(-2,31126)**
VAR_HomeNG	(-1,85779)**	(-6,78097)***
VAR_AwayNG	(-0,87742)	(-3,82261)***
VAR_HomeNP	(-0,46664)	(-2,29254)**
VAR_AwayNP	0,36595	0,01717

** refers to 5% significance level. *** refers to 1% significance level. * refers to 10% significance level as well as it refers to our main focus of interest. Lag length was based on Schwarz info criterion (SIC) and maximum lags were set to 1. In all types of unit root tests, the bandwidth is based on Newey-West with Barnett kernel.

Variables	IPS intercept*	LLC intercept
VAR_AwayPen	(-8,58766)***	(-40,8992)***
VAR_HomePen	(-9,24196)***	(-41,2404)***
VAR_AwayRC	(-14,5378)***	(-65,3091)***
VAR_HomeRC	(-1,45590)*	(-5,65128)***
VAR_HomeGoal	(-10,1199)***	(-51,5009)***
VAR_AwayGoal	(-20,9660)***	(-78,6769)***
VAR_HomeNG	(-8,79177)***	(-40,4151)***
VAR_AwayNG	(-11,4313)***	(-49,8306)***
VAR_HomeNP	(-6,91548)***	(-43,1225)***
VAR_AwayNP	(-1,86247)**	(-4,76150)***

** refers to 5% significance level. *** refers to 1% significance level. * refers to 10% significance level as well as it refers to our main focus of interest. Lag length was based on Schwarz info criterion (SIC) and maximum lags were set to 0. In all types of unit root tests, the bandwidth is based on Newey-West with Barnett kernel.

For all panel unit root tests, the hypothesis is the following:

H0: The dataset is stationary (no unit root).

H1: The dataset is non-stationary (unit root).

For the pre-VAR period, all of the variables were observed to be significant at the 5% level in all types of unit root tests, meaning that none of the variables had unit roots in them. Since the pre-VAR period is a balanced panel dataset, the results from the LLC panel unit root test become more important than the IPS panel unit root test, in which all the variables from the previous periods have been found to be statistically significant at the 5% level (Levin et al., 2002).

For the VAR period, not all of the variables are observed to be significant at the 5% level in all of the unit root tests, meaning that some of the variables have unit roots in them. Since the VAR period is an unbalanced panel dataset, the results from the IPS panel unit root test become more important than the LLC panel unit root test. The variables that have unit roots in them are related to VAR decisions such as away penalties, red cards, goal decisions, and overturned penalties by the VAR's assistance. This means that some of the variables that are related to VAR's assistance have unit roots in them, making them non-stationary. This problem can be resolved once we set the lag length to 0. By changing the lag length to zero, almost all of the variables for the VAR period become stationary, and therefore we can determine reliable relationships between all variables listed in tables 5 and 6.

Table 7: Pedroni cointegration test results for pre-VAR period

Variables (Relationships)	Panel PP Stat	Group PP Stat	Panel ADF Stat	Group ADF Stat
HomeWin - Crowdsize	(-25,34507)***	(-69,17615)***	(-28,40722)***	(-90,96296)***
HomeAdv - Crowdsize	(-25,29082)***	(-36,28119)***	(-28,29989)***	(-58,68767)***
HomeWin - AwayRC	(-17,52664)***	(-24,02883)***	(-22,52688)***	(-1,730537)***
HomeWin - HomePens	(-19,54708)***	(-23,00685)***	(-19,54708)***	(-1,056190)***
AwayPen - AwayWin	(-14,14170)***	(-16,70340)***	(-14,95859)***	(-1,831830)***
HomeRC - AwayWin	(-13,62887)***	(-16,43579)***	(-14,46032)***	(-16,96456)***
HomeWin - T-Fatigue	(-20,37823)***	(-3,789491)***	(-22,72938)***	(-1,537696)***
Density (%) - HomeWin	(-21,42689)***	(-26,16506)***	(-25,95297)***	(-40,37628)***

*** refers to 1% significance level. Lag length was based on Schwarz info criterion (SIC) and maximum lags were set to 1. In all types of unit root tests, the bandwidth is based on Newey-West with Barnett kernel.

Table 8: Pedroni cointegration test results for VAR period.

Variables (Relationships)	Panel PP Stat	Group PP Stat	Panel ADF Stat	Group ADF Stat
HomeWin - Crowdsize	(-23,98780)***	(-31,22674)***	(-27,40180)***	(-181,2753)***
VAR_rule - AwayWin	(-21,99834)***	(-28,17368)***	(-26,59002)***	(-3,837342)***
HomeWin - AwayRC	(-14,84904)***	(-18,15243)***	(-18,52633)***	(-1,647526)***
HomeWin - HomePens	(-21,24951)***	(-24,59367)***	(-21,74058)***	(-1,340909)***
AwayPens - AwayWin	(-15,88256)***	(-18,80815)***	(-17,22468)***	(-8,339770)***
HomeRC - AwayWin	(-15,02953)***	(-16,38962)***	(-14,55614)***	(-2,706161)***
HomeAdv - Crowdsize	(-24,72751)***	(-30,66660)***	(-26,94280)***	(-176,7542)***
HomeWin - T-Fatigue	(-18,84795)***	(-22,30124)***	(-21,65099)***	(-5,193434)***
VAR_AwayPen - AwayWin	(-12,89986)***	(-13,89737)***	(-12,31057)***	(-5,693229)***
VAR_HomePen - HomeWin	(-13,81243)***	(-15,55197)***	(-13,55045)***	(-14,95251)***
VAR_AwayRC - HomeWin	(-7,564824)***	(-4,860576)***	(-8,620379)***	(-8,680879)***
VAR_HomeRC - AwayWin	(-10,88527)***	(-8,692400)***	(-10,38721)***	(-13,19662)***
VAR_HomeGoal - HomeWin	(-13,25931)***	(-11,19749)***	(-13,04279)***	(-5,687560)***
VAR_AwayGoal -AwayWin	(-9,015914)***	(-6,573437)***	(-7,992810)***	(-6,928404)***
VAR_AwayNG - HomeWin	(-11,23677)***	(-11,78987)***	(-12,34974)***	(-5,034391)***
VAR_HomeNG - AwayWin	(-12,95301)***	(-12,47012)***	(-12,40327)***	(-5,732433)***
VAR_AwayNP - HomeWin	(-10,59253)***	(-12,62966)***	(-8,922443)***	(-6,625807)***
VAR_HomeNP - AwayWin	(-9,013513)***	(-6,867839)***	(-9,897579)***	(-3,145354)***
Density (%) - HomeWin	(-19,46573)***	(-25,69246)***	(-25,99237)***	(-78,35489)***

*** refers to 1% significance level. Lag length was based on Schwarz info criterion (SIC) and maximum lags were set to 1. In all types of unit root tests, the bandwidth is based on Newey-West with Barnett kernel.

In order to determine a long-term relationship between variables, we need to apply configuration tests in order to find such a relationship. We will employ Pedroni cointegration tests since we have fewer time periods for both panel datasets. Also, as in Govdeli & Gungor (2022), which have investigated the potential factors of the home crowd effect.

Results from the Pedroni cointegration tests can be observed in tables 8 and 9. All the potential relationships that can affect the home bias issue have been found to be significant—that is, 5% level for both panel datasets—meaning that there's a stable long-run relationship between such relationships that can affect the rate of home bias, such as the relationships between crowd size and home win, home win and away red cards, and away penalties given by the VAR and away win.

Lastly, we will employ the Pairwise Granger Causality Test to further detect the stability of the relationship, as tested by previous studies such as Govdeli and Gungor (2022). The results from the pairwise Granger causality tests can be observed in tables 10 and 11. For the pre-VAR period, none of the causal relationships were found to be at a 5% significance level. According to our findings in Table 10, the home team's crowd size (the number of fans who participated in the football match) causes home advantage at the 5% significance level during the VAR period. With regards to VAR-assisted decisions, there are three one-way relationships that were found to be significant, at least at a 5% level. Away penalties given via VAR's assistance cause away teams to win matches at the 5% significance level. Home wins cause the disallowance of away penalties via VAR's assistance at the 5% significance level. Disallowance of home penalties via VAR's assistance causes away teams to win matches at the 1% significance level. We also have found that the home team's crowd size causes home wins at a p-value of 5,22%, which is quite notable despite being slightly off at 5% significance level.

These results tell us that some of the referee decisions via VAR check helped reduce the level of home bias in the TSL, but not all of the decisions with VAR assistance did help contribute to the away teams' favor, as the causal relationships such as between VAR-assisted home red cards and away wins and VAR-assisted disallowance of home goals and away wins were not found to be significant at the 5% level.

One of the most interesting findings from the causality tests from both periods is that for the VAR period, the level of crowd size causes the home advantage rate to increase, while the same relationship does not seem to be statistically significant for the pre-VAR period. This might be attributed to the fact that, with regards to crowd size, we have a lot more missing data for the pre-VAR period than for the VAR period. In fact, just below 20% of the data for the crowd size during the pre-VAR period was missing, as the attendance numbers for some of the pre-VAR matches are unknown. For the VAR period, however, the missing data for the crowd size was few and far between in comparison. For that reason, the causal relationship between the crowd size and the rate of home advantage might have been affected by the amount of missing data with regards to the pre-VAR period (Zanin, 2021). However, that still means that the level of crowd size is the determinant of the rate of home advantage, thus contributing to earning wins and draws for the home team during the VAR period. Other factors such as away red cards, home penalties (including without VAR assistance), and travel fatigue did not contribute to the home bias to a significant degree, as no causal relationships for these relationships were found for both periods. On the other hand,

the assistance of the VAR has helped reduce the level of home bias with regards to some of the decisions. VAR-assisted decisions such as away penalties given and disallowed home penalties have contributed to away teams winning matches, as evidenced by causal relationships between VAR-assisted away penalties given and away wins and between VAR-assisted disallowed home penalties and away wins, which were found to be significant at 5% significance level for the former and 1% significance level for the latter, respectively. This means that the home teams, on average, have lost around 2% of the home wins and around 1,84% of the home advantage during the VAR period, thanks to some of the VAR-assisted decisions. By comparing the average rate of home wins and draws for both periods, we have found that the home teams in the VAR period have lost 40 more matches and earned 13 more than they should have in the VAR period. This information is important since, on average, the home teams have lost some prize money based on the match results. As of the current season, the prize money for each win and draw was set to be 2.488 million Turkish liras and 1.244 million Turkish liras, respectively, and its accumulated form across the entire season represents around 46% of TSL's total prize money (Cumhuriyet, 2023). Assuming that the amount of prize money for each win and draw was the same over the VAR period, this means that the home teams have lost 83.348 million Turkish Liras over the last 5 and a half seasons based on the match performances alone, effectively revealing the cost of the home teams' earnings during the VAR period.

6. CONCLUSION

The study finds that the home bias in the TSL has been significantly reduced in the VAR period, and some of the referee decisions made via VAR's assistance have helped away teams win matches and therefore helped to curb some of the home bias, as evidenced by t-test results for home win and home advantage rate. Since we have different amounts of variables between pre-VAR and VAR periods for our analysis and we have a considerable amount of missing data with regards to crowd size and added time after 90 minutes, we had to use panel data analysis with two different panel datasets in order to investigate the relationships as to what factors with regards to VAR decisions contributed to the rate of home bias decreasing at a statistically significant level. The panel data analysis is methodologically similar to the studies conducted by Kuvvetli and Gungor (2022), with different relationships compared to that study, as the objective between our study and Kuvvetli and Gungor's (2022) study is somewhat different with regards to the home bias issue. Pedroni cointegration test results tell us that all the relationships that might potentially affect the rate of home bias do have a stable, long-run relationship between them, which includes potential factors such as crowd size, referee decisions, and travel fatigue.

The study and its findings can shed light on the literature, as the study will probably be one of the fewer studies that focuses on VAR's impact on home bias, and the study will probably be the first on home bias that includes the VAR technology for TSL and thus will be contemporary compared to previous home bias studies that have included analyses of TSL. Compared to other studies that have analyzed the VAR's impact on home bias, our study has the highest number of seasons, as we have 11 and a half seasons' worth of TSL data in it. We have investigated the home bias issue by using a population dataset for all matches and paying attention to most of the match statistics with regards to our investigation rather than considering certain sample variables such as red cards and penalties or paying attention to home and away goals for investigating VAR's impact on home bias. The study's conclusions may open further avenues for additional research in the future. For instance, it might be possible for a researcher to compare our results with those of other leagues to determine whether the league's VAR system is more effective at mitigating home bias. This analysis may also contribute to being the gateway between sports economics literature and other fields such as behavioral economics and finance. For instance, it might be possible for a researcher to investigate the relationship between the share prices of football clubs on the stock exchanges and their match performances.

The results from the Pairwise Granger Causality Test suggest that none of the causal relationships were found to be significant at the 5% level. For the VAR period, one-way causal relationships such as between away penalties awarded via VAR's assistance and away wins, between crowd size and home

advantage, between home wins and away penalties disallowed via VAR's assistance, and between home penalties disallowed via VAR's assistance and away wins were found to be statistically significant at least at the 5% level. This means that by referees paying attention to the suggestions made by the VAR, the decisions made by the referees and the VAR system have helped to curb some of the home bias, as evidenced by some of the causality test results and t-test results. The decline in the rate of home bias and the rate of home advantage has cost home teams some of the prize money. By comparing the average number of home wins and draws between both periods and assuming that the current prize money for each home win and draw is the same throughout the VAR period, we've calculated that the home teams have lost 83.348 million Turkish Liras in the VAR period based on the match performances alone. However, not all of the VAR decisions have resulted in away teams' favor, as causal relationships such as between VAR-assisted home red cards and away wins and VAR-assisted disallowance of home goals and away wins were not found to be significant at the 5% level. Lastly, some of our results might have been affected by the COVID-19 pandemic to some degree since the COVID-19 pandemic took place during the VAR period, but how influential the COVID-19 pandemic was to our results remains to be seen.

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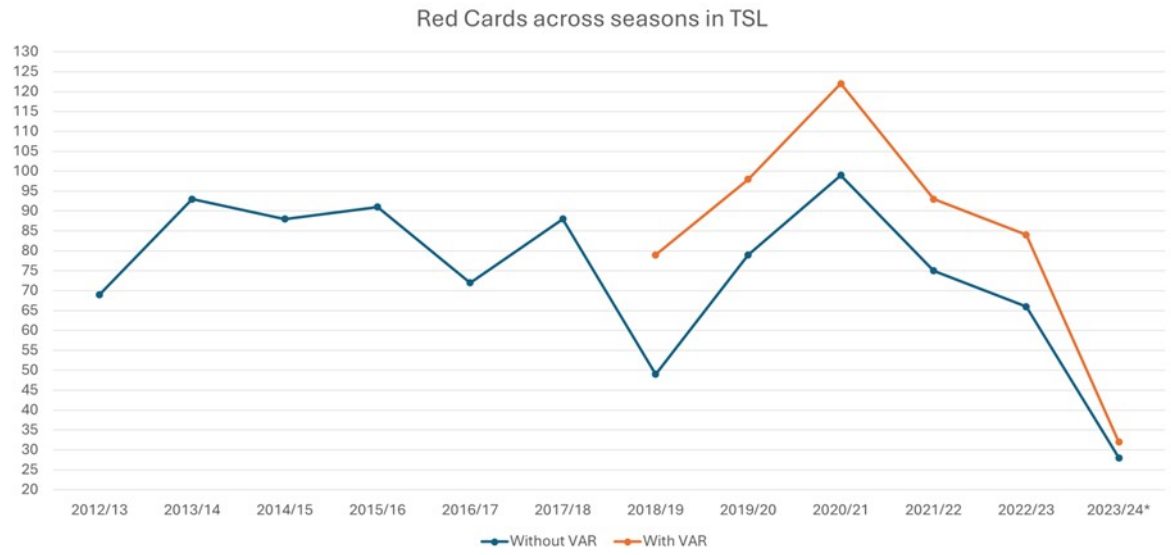
APPENDIX

Appendix 1: Comparison Between Total Red Cards & Penalties and Average Red Cards & Penalties in TSL

Graph 1. Penalties across seasons in TSL

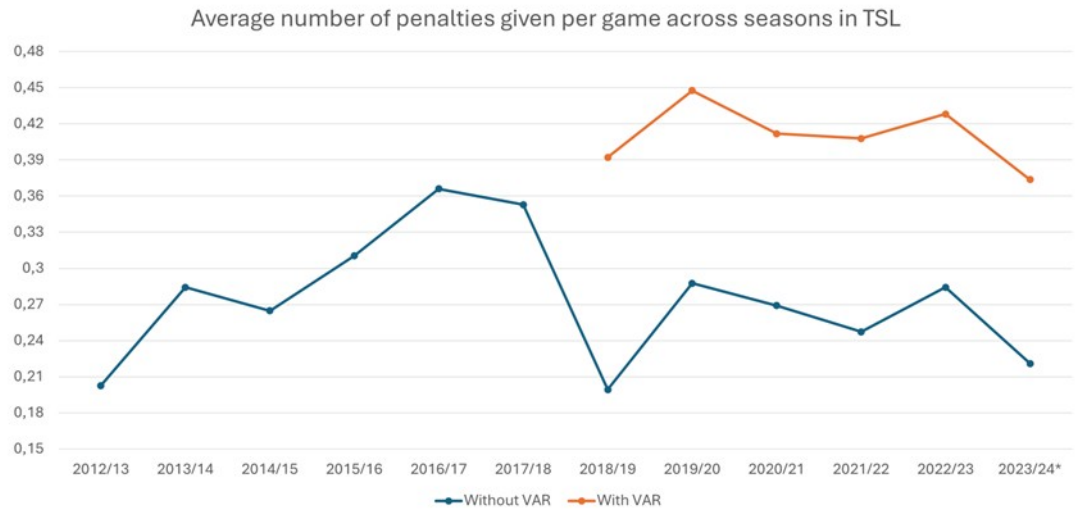


Graph 2: Red Cards across seasons in TSL



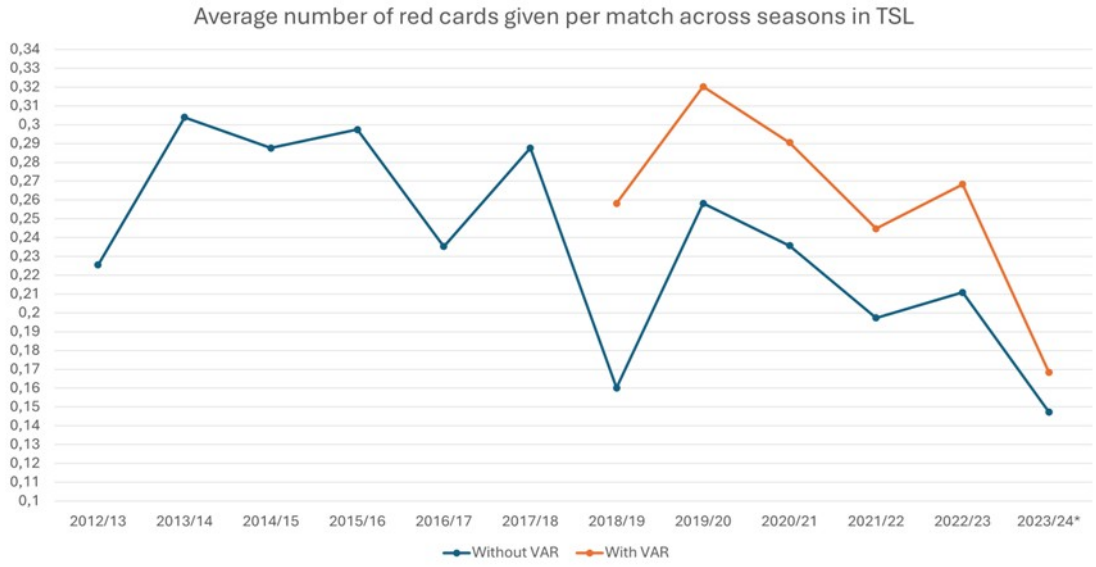
* Only the first half of the season's data were gathered.

Graph 3: Average number of penalties across seasons in TSL



*Only the first half of the season's worth of data collected.

Graph 4: Average number of red cards across seasons in TSL



*Only the first half of the season's worth of data collected.

Appendix 2: Pairwise Granger Causality Test Results

Table 9: Pairwise Granger Causality Test Results for the pre-VAR period

Variables (Relationships)	Statistic	p-value
HomeWin ---> Crowdsize	0,51686	0,5965
Crowdsize ---> HomeWin	1,07939	0,3401
HomeWin ---> AwayRC	2,69374	0,0680
AwayRC ---> HomeWin	0,50504	0,6036
HomeAdv ---> Crowdsize	0,17899	0,8361
Crowdsize ---> HomeAdv	1,24300	0,2889
HomeWin ---> HomePen	2,11100	0,1215
HomePen ---> HomeWin	0,97912	0,3759
AwayPen ---> AwayWin	0,50942	0,601
AwayWin ---> AwayPen	0,85475	0,4256
HomeRC ---> AwayWin	1,29968	0,273
AwayWin ---> HomeRC	1,34296	0,2615
HomeWin ---> T-Fatigue	1,82358	0,1619
T-Fatigue ---> HomeWin	2,09238	0,1238
Density (%) ---> HomeWin	2,22484	0,1085
HomeWin ---> Density (%)	2,18268	0,1132

Table 10: Pairwise Granger Causality Test Results for the VAR period

Variables (Relationships)	Statistic	p-value
HomeWin → Crowdsize	0,30017	0,7408
Crowdsize → HomeWin	2,96059	0,0522
HomeWin → AwayRC	0,97749	0,3766
AwayRC → HomeWin	0,4079	0,6651
HomeAdv → Crowdsize	0,34262	0,71
Crowdsize → HomeAdv	3,44599	0,0322**
HomeWin → HomePens	0,21072	0,81
HomePens → HomeWin	0,14197	0,8677
AwayPen → AwayWins	0,38494	0,6806
AwayWins → AwayPen	0,62363	0,5362
HomeRC → AwayWin	0,79416	0,4522
AwayWin → HomeRC	0,68231	0,5057
HomeWin → T-Fatigue	0,80353	0,448
T-Fatigue → HomeWin	0,79832	0,4503
VAR_rule → AwayWin	0,6801	0,5068
AwayWin → VAR_rule	1,17461	0,3093
AwayWin → VAR_AwayPen	0,72297	0,4855
VAR_AwayPen → AwayWin	3,69329	0,0252**
HomeWin → VAR_HomePen	1,00614	0,3660
VAR_HomePen → HomeWin	0,2487	0,7799

HomeWin → VAR_AwayRC	0,30699	0,7357
VAR_AwayRC → HomeWin	1,60065	0,2022
AwayWin → VAR_HomeRC	0,66135	0,5164
VAR_HomeRC → AwayWin	1,10611	0,3312
HomeWin → VAR_HomeGoal	0,39493	0,6738
VAR_HomeGoal → HomeWin	0,58638	0,5565
AwayWin → VAR_AwayGoal	1,15146	0,3165
VAR_AwayGoal → AwayWin	0,44985	0,6378
HomeWin → VAR_AwayNG	0,0641	0,9379
VAR_AwayNG → HomeWin	2,80744	0,0608
AwayWin → VAR_HomeNG	1,98694	0,1376
VAR_HomeNG → AwayWin	0,16038	0,8518
HomeWin → VAR_AwayNP	3,88175	0,0209**
VAR_AwayNP → HomeWin	0,5335	0,5867
AwayWin → VAR_HomeNP	0,5632	0,5695
VAR_HomeNP → AwayWin	5,50364	0,0042***
Density (%) → HomeWin	1,54662	0,2134
HomeWin → Density (%)	1,26309	0,2832

** refers to 5% significance level. *** refers to 1% significance level.

Appendix 3: Further Statistics

Table 11: Home advantage rates of TSL Teams

Home Advantage Rates of Turkish Super League (TSL) Teams from 2012/13 to 2023/24

Teams	Number of Seasons at TSL	Home Adv. Rate (%)
Galatasaray*	12	77,01
Beşiktaş*	12	73,43
Fenerbahçe*	12	73,1
Trabzonspor*	12	64,03

Adana Demirspor*	3	59,57
Başakşehir*	11	56,22
Bursaspor	7	54,06
Sivasspor*	11	52,97
Antalyaspor*	11	50,81
Kasımpaşa*	12	50
Gençlerbirliği	8	49,76
Fatih Karagümrük*	4	49,25
Alanyaspor*	8	48,15
Eskişehirspor	4	47,06
Kayserispor*	11	47,06
Samsunspor*	1	44,44
Konyaspor*	11	43,24
Hatayspor*	4	40,91
Gaziantepspor	5	40,39
Kardemir Karabükspor	5	38,82
Akhisarspor	7	38,65
Gaziantep FK*	5	38,27
Göztepe	5	37,78
Çaykur Rizespor*	9	37,09
Elazığspor	2	35,29
Orduspor	1	35,29
Giresunspor	2	35,13
Yeni Malatyaspor	5	34,06
Ankaraspor	3	32,69
Ankaragücü*	5	31,71
Mersin İdmanyurdu	3	31,37
Kayseri Erciyesspor	2	29,41
İstanbulspor*	2	28,57
Altay	1	26,31
Denizlispor	2	24,32
Balıkesirspor	1	23,53
Adanaspor	1	23,53
BB Erzurumspor	2	21,62
Ümraniyespor	1	16,67
Pendikspor*	1	11,11

* Denotes current TSL teams.