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Road to the round of 16 in UEFA Champions League: Key in-game statistics for advancing from the group stages
UEFA Şampiyonlar Ligi'nde son 16 yolu: Grup aşamalarından yükselmek için anahtar oyun içi istatistikler

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Alp Kaan KİLCİ[**1]
Serhat YALÇINER[2]
Nahit ÖZDAYI[3]
Gökhan AYDIN[4]

ABSTRACT: The objective of this study was to identify the in-game statistics that help differentiate between the teams in the UEFA Champions League (UCL) group stage that advance to the round of 16. The research examined all matches (n=288) played by 57 teams during the UCL group stages from the 2019/2020 to 2021/2022 seasons. Discriminant analysis was utilized to evaluate the contribution and classification of each in-game statistic in determining team progression, while decision tree analysis helped identify critical cut-off points. Results showed that winning home games, winning away games, and the number of goals conceded effectively predicted a team's advancement to the last 16. Specifically, decision tree analysis indicated that teams with at least two home wins and at least one away win are highly likely to progress to the knockout stage. Additionally, teams with only one or no home wins must achieve at least two away wins to advance. The discriminant function demonstrated a high accuracy rate, correctly classifying 94.8% of the teams that moved on from the group stages to the last 16. Moreover, teams that conceded nine or fewer goals in the group stages were also successful in advancing to the round of 16.
Keywords: Champions league, Discriminant analysis, Group stages, In-game statistics, Decision tree analysis

ÖZ: Bu çalışmanın amacı, UEFA Şampiyonlar Ligi (UCL) gruplarında hangi takımların son 16 tura ilerlediğini ayırt eden oyun içi istatistikleri belirlemektir. Araştırma, 2019/2020 ile 2021/2022 sezonları arasında oynanan 288 maçı (n=288) ve 57 takımı analiz etmiştir. Diskriminant analizi, takım ilerlemesini belirlemede her bir oyun içi istatistiğin katkısını ve sınıflandırmasını değerlendirmek için kullanılmış, karar ağaçları analizi ise kritik kesim noktalarını tanımlamada yardımcı olmuştur. Sonuçlar, ev sahibi olduğu maçları kazanmanın, deplasman maçlarını kazanmanın ve yenilen gol sayısının, bir takımın son 16 tura ilerlemesini etkili bir şekilde tahmin ettiğini göstermiştir. Özellikle, karar ağaçları analizi, en az iki ev sahibi galibiyeti ve en az bir deplasman galibiyeti olan takımların, eleme aşamasına ilerleme olasılığının çok yüksek olduğunu belirtmiştir. Ayrıca, sadece bir veya hiç ev sahibi galibiyeti olan takımların, ilerlemek için en az iki deplasman galibiyeti elde etmesi gerektiği ortaya çıkmıştır. Ayırt edici fonksiyon, grup aşamalarından son 16'ya geçen takımları doğru bir şekilde sınıflandırarak %94,8'lik yüksek bir doğruluk oranı göstermiştir. Ayrıca, grup aşamalarında dokuz veya daha az gol yiyen takımların da son 16'ya ilerlemede başarılı olduğu bulunmuştur.
Anahtar Kelimeler: Şampiyonlar ligi, Ayırt edici analiz, Grup aşaması, Oyun içi istatistikler, Ağaç analizi

** Sorumlu Yazar / Corresponding Author
[1] Dr. Öğr. Üyesi, Balıkesir Üniversitesi/Spor Bilimleri Fakültesi/Spor Yöneticiliği Bölümü/Spor Yöneticiliği Anabilim Dalı, alpkaankilci@balikesir.edu.tr, https://orcid.org/0000-0001-6445-6400
[2] Dr. Öğr. Üyesi, Balıkesir Üniversitesi/Spor Bilimleri Fakültesi/Antrenörlük Eğitimi Bölümü/Antrenörlük Eğitimi Anabilim Dalı, serhat.yalciner@balikesir.edu.tr, https://orcid.org/0000-0002-9888-4777
[3] Doç. Dr., Balıkesir Üniversitesi/Spor Bilimleri Fakültesi/Antrenörlük Eğitimi Bölümü/Antrenörlük Eğitimi Anabilim Dalı, nahitozdayi@balikesir.edu.tr, https://orcid.org/0000-0002-5534-3153
[4] Dr., Doktora Sonrası Araştırmacı, gokhan.aydin@baun.edu.tr, https://orcid.org/0000-0001-5575-3200

GENİŞLETİLMİŞ ÖZET

Literatür taraması

Futbol müsabakalarında başarıyı etkileyen performans göstergeleri, literatürde geniş yer bulmaktadır. Özellikle ev sahibi avantajı ve teknik becerilerin galibiyet üzerindeki etkisi çeşitli çalışmalarda öne çıkmaktadır. Ev sahibi takımların, deplasman takımlarına kıyasla daha fazla topa sahip olma ve daha fazla hücum girişiminde bulunma eğiliminde oldukları ortaya konulmuştur (Lago ve Martin, 2007; Lago-Penas ve Dellal, 2010). Taylor vd. (2010) ile Tucker vd. (2005), ev sahibi takımların daha fazla şut girişimi, gol ve hücum aksiyonları gerçekleştirdiğini belirlemişlerdir. Bu durum, ev sahibi olmanın teknik, taktik ve stratejik anlamda takımlara önemli bir avantaj sağladığını göstermektedir.

Bunun yanında, teknik becerilerin de maç kazanma olasılığı üzerinde belirleyici olduğu görülmektedir. Taylor vd. (2008), başarılı pas sayısının ve top sürme becerilerinin, Armatas vd. (2009) ise ilk golü atmanın galibiyet üzerinde önemli bir etkisi olduğunu bulmuşlardır. Broich vd. (2014) şut sayısının, Ruiz-Ruiz vd. (2013) ise rakip ceza sahasına girme sıklığının, maç kazanma olasılığını artıran önemli faktörler arasında yer aldığını ortaya koymuşlardır. Ayrıca, Liu vd. (2015) ve Rampinini vd. (2009), toplam şut sayısı ve başarılı şut oranlarının takımların performansı üzerinde büyük bir etkiye sahip olduğunu belirtmişlerdir.

Bu bağlamda UEFA Şampiyonlar Ligi (UCL-UEFA Champions League) gibi üst düzey bir turnuvada oynanan maçlardan elde edilen maç içi istatistiklerin (topa sahip olma oranı, isabetli pas sayısı, şut sayısı, atılan gol vb.) takımların son 16 turuna yükselme olasılığı üzerindeki etkilerini incelemektir. UCL grup aşamalarına odaklanan bu çalışma, sınırlı sayıda maç üzerinden ilerleyen turnuva yapısında takımların bir üst tura yükselmesinde etkili olan oyun içi performans göstergelerini ele almaktadır. Bu yönüyle, literatürde çoğunlukla yerel liglerdeki uzun dönemli performanslara ve maç kazanma oranlarına odaklanan önceki çalışmalardan ayrışmaktadır. Ayrıca turnuva formatında başarıya etki eden somut değişkenleri ortaya koyarak maç içi performansa yönelik literatüre katkı sağlamaktadır.

Yöntem

Bu çalışmada, UCL 2019/2020 ile 2021/2022 sezonları arasında oynanan toplam 288 maçın verileri analiz edilmiştir. Analiz kapsamına yalnızca grup aşamasında oynanan maçlar dahil edilmiş, eleme turları dışarıda bırakılmıştır. Takımlar, grup aşamalarındaki sıralamalarına göre iki gruba ayrılmıştır: Son 16 turuna yükselen (1.ve 2.sıradaki) takımlar ve yükselmeyen (3. ve 4. sıradaki) takımlar. Maçlarla ilgili istatistiksel veriler bu çalışmada maç içi performans göstergeleri olarak belirlenmiş ve literatürde sıkça incelenen topa sahip olma, isabetli pas ve şut gibi göstergelerin yanı sıra ilk golü atan takım, ilk yarı ve ikinci yarıda atılan goller gibi literatürde daha az değinilen maç içi göstergeler de eklenmiştir. Veriler OPTA Sports Data'dan elde edilmiş ve güvenilirliği daha önce yapılan çalışmalarla doğrulanmıştır (Liu vd., 2013).

Verilerin analizinde, takımların gruptan çıkıp çıkmamasını öngören değişkenleri belirlemek amacıyla diskriminant analiz uygulanmıştır. Wilks' lambda ve kanonik korelasyon indeksleri hesaplanarak, grup içi ve grup dışı farklılıklar değerlendirilmiştir. Ayrıca, karar ağacı yöntemlerinden CHAID (Chi-squared Automatic Interaction Detection) algoritması kullanılarak, maçla ilgili istatistiklerin Son 16 turuna yükselme üzerindeki etkisi analiz edilmiştir. İstatistiksel analizler SPSS 26.0 versiyonu kullanılarak yapılmış, anlamlılık değeri 0,05 olarak kabul edilmiştir.

Bulgular ve tartışma

Bu çalışmada UCL grup aşamalarında takımların Son 16 turuna yükselme olasılığını etkileyen değişkenler analiz edilmiştir. Diskriminant analiz sonuçlarına göre, takımların Son 16 turuna yükselmesini belirleyen en önemli değişkenlerin ev sahibi galibiyeti, deplasman galibiyeti ve yenilen goller olduğu bulunmuştur. Ev sahibi galibiyeti en yüksek yapı katsayısına (Structure Coefficient=SC) sahipken (SC=0.677), bunu yenilen goller (SC=-0.590) ve deplasman galibiyeti (SC=0.556) izlemiştir. Ayrıca, sınıflandırma ağacı analizi, doğru sınıflandırma oranının %96.9 olduğunu göstermiştir. Bu, ev sahibi galibiyetlerinin Son 16 turuna yükselme üzerinde büyük bir etkiye sahip olduğunu doğrulamaktadır. Ayrıca, deplasman galibiyetleri ve ikinci yarıda atılan goller de takımların başarısına katkıda bulunmuştur.

Karar ağacı analizine göre 1 veya daha az ev sahibi galibiyeti olan takımların yalnızca %13.2'si Son 16 turuna yükselebilirken, 1'den fazla ev sahibi galibiyeti olan takımların %95.3'ü son 16 turuna yükselmiştir. Deplasman galibiyeti 1'den fazla olan takımların %100'ü son 16 turuna yükselmiş, ancak deplasmanda 1 veya daha az maç kazanan takımların sadece %4.2'si bu başarıyı elde edebilmiştir.

Literatürde ev sahibi olmanın, takımlara taraftar desteği ve düşük stres ortamı sayesinde önemli bir avantaj sağladığı ve bu durumun başarıya katkıda bulunduğu vurgulanmaktadır (Pollard, 1986; Fowler vd., 2014; Lago-Penas vd., 2016). Araştırmamız da ev sahibi galibiyetlerinin Son 16 turuna yükselme açısından kritik olduğunu doğrulamaktadır. Ayrıca deplasman galibiyetleri de başarıda önemli bir rol oynamakta olup, deplasmanda alınan puanlar takımların genel performansını artırmaktadır (Boscá vd., 2009). Bununla birlikte, topa sahip olma, isabetli pas oranı ve şut sayısı gibi bazı istatistiklerin belirleyici olmadığı görülmüştür. Bu farklılık, UCL'de yer alan takımların farklı liglerden gelerek çeşitli oyun tarzları benimsemeleriyle açıklanabilir. Sonuç olarak, takımların grup aşamalarında ev sahibi avantajını etkili kullanmaları ve deplasman maçlarında daha agresif stratejiler izlemeleri, Son 16 turuna yükselme başarısını artırmaktadır.

Sonuç ve öneriler

Şampiyonlar Ligi grup aşamalarında başarı, birkaç temel faktöre dayanmaktadır. Ev sahibi maçlarında güçlü performans sergileyen ve deplasman maçlarında olumlu sonuçlar alabilen takımlar, son 16 turuna yükselme şanslarını önemli ölçüde artırmaktadır. Ayrıca daha az gol yeme stratejisine odaklanmak da başarının kritik bir unsurudur. Bu stratejileri etkili bir şekilde birleştiren takımlar, zorlu Şampiyonlar Ligi ortamında daha avantajlı bir konum elde ederek başarıya giden yolu açabilirler.

Bu çalışmanın bulgularına dayanarak, UCL grup aşamalarından son 16 turuna yükselmeyi hedefleyen takımların, ev sahibi avantajını etkili bir şekilde kullanmaları ve deplasman maçlarında güçlü bir şekilde rekabet etmeleri önerilmektedir. Ev sahibi maçlarını kazanmanın önemi, taraftar desteği ve daha az stresli bir ortamda performans gösterme fırsatı ile bağlantılıdır. Ayrıca takımlar, deplasman maçlarından puan/puanlar almayı hedefleyen stratejilere öncelik verilmelidir. Takımların savunma tedbirlerini güçlendirerek, yedikleri gol sayısını azaltmaları başarı şanslarını artıracak ve grup aşamasında daha fazla puan toplayarak üst sıralara yerleşmelerine yardımcı olacaktır. Bunun yanı sıra, takımlar rakiplerinin farklı liglerden gelmesi nedeniyle, sürekli olarak maç analizlerini güncellemeli ve oyun stratejilerini geliştirerek uluslararası alanda daha rekabetçi hale gelmelidirler.

Introduction

Football is among the most popular team sports worldwide. Followed with great interest by millions of people around the world, it has evolved from being just a popular sport to becoming a vast industry where teams with enormous budgets compete. The Union of European Football Associations (UEFA), established in 1952, is the primary governing body responsible for regulating football at both club and national team levels throughout Europe (Devecioğlu, Çoban & Karakaya, 2014). UEFA organizes competitions involving both club teams and national teams from its member countries on an international scale. The UEFA Champions League (UCL) has emerged as one of the most prominent and esteemed club tournaments in Europe over the past fifty years, bringing together clubs competing at the national level within their respective federations. The UCL is held annually, featuring the top-performing clubs from each nation, with more slots allocated to more successful national clubs (Schokkaert & Swinnen, 2016; Boczon & Wilson, 2018). First played in the 1955-56 season as the European Cup, the competition was rebranded as the UCL in the 1992-93 season and has since been regarded as Europe's most prestigious inter-club tournament (Sönmeyenmakas, 2008).

The UCL consists of a qualifying round, a group stage comprising four teams and four knockout rounds for each season. Each team in the group stage plays a total of six matches, one at home and one away against each opponent in their group. The leading two teams in each group progress to the round of 16, while the teams finishing third drop down to the UEFA Europa League, beginning with the round of 32, and the bottom-placed teams are eliminated from European competitions (Papahristodoulou, 2008). Therefore, during the early stage of the tournament known as the group stage consists of four teams the teams aim to finish in the top two of their group to advance to the round of 16. To be successful in the UCL, teams need to win as many matches as possible and accumulate points to finish in the top two of their group. While football provides entertainment for spectators, it is a domain of analysis and observation for coaches. A key responsibility for a coach in pursuing success is the ability to closely monitor and analyze the movements that take place during matches (Franks & Hughes, 2016). At this point the significance of performance analysis within the realm of sports becomes increasingly evident. Performance indicators that are both valid and dependable can be utilized to determine teams' performances and conduct sports performance analyses. Performance analyses conducted on data obtained from multiple matches can determine which variables are significant in teams' successes (Hughes et al., 2001; O'Donoghue, 2013). The dynamic and multifaceted nature of football creates difficulties in identifying reliable performance indicators (Vilar et al., 2012), this complexity can be reduced through performance analysis (Cushion, 2007; Memmert & Raabe, 2018).

There have been numerous studies in the literature regarding the factors that influence winning in football matches. For instance, Lago (2009) and Taylor et al. (2010) have noted the positive impact of being the home team on teams' performances. Studies have shown that home teams have an advantage over away teams in terms of technical, tactical, and strategic aspects. For example Lago and Martin (2007) and Lago-Penas and Dellal (2010), discovered that teams playing at home tend to have higher ball possession compared to their opponents playing away. According to Taylor et al. (2010) and Tucker et al. (2005) home teams are more active in attacking zones (shots on goal, crosses, goals scored, etc.). Therefore, being the home team is considered an important variable in winning matches. Moreover, studies on winning matches and earning more points in the literature have revealed that Taylor et al. (2008) found ball dribbling and successful passes, Armatas et al. (2009) found scoring the first goal, Broich et al. (2014) calculated the overall number of shots and passes, Kapidžić et al. (2010) determined the quantity of accurate passes and shots made from inside the penalty area, Ruiz-Ruiz et al. (2013) found entering the opponent's penalty area more often, Moura et al. (2014) and Jankovic et al. (2011) found the percentage of successful passes and ball possession, Luhtanen et al. (2001) calculated the percentage of successful passes, Oberstone (2009) found the overall shots, passes and committing fewer fouls, Rampinini et al. (2009) and Liu et al. (2015) found the total number of shots, number of successful shots, and running distance, Torgler (2004) identified the home advantage and the number of successful shots, Mechtel et al. (2011) found playing with a numerical advantage (opponent receiving a red card), Castellano et al. (2012), Liu et al. (2016) and Mao et al. (2016) found the overall count of shots and accurate shots, Collet (2013) found the overall count of accurate shots, overall count successful passes and average ball possession to be significant variables in winning matches and being in the top positions

of their respective leagues. Additionally, studies conducted on top-level leagues of different difficulty levels suggest that teams that take the lead by scoring the first goal in matches have a higher probability of winning. Moreover, it has been observed that home teams have a higher likelihood of scoring the first goal in these encounters (Tenga, 2012; Pratas et al., 2016; Işıkdemir, 2020).

In addition to technical and tactical performance indicators, it is well-established that the performance of teams in football also varies according to situational conditions such as the location of the match, weather conditions, match type (league/cup, friendly match, etc.), and match period (1st half/2nd half) (Taylor et al., 2010; Gómez et al., 2012; Lago-Peñas, 2012; Mackenzie & Cushion, 2013; Sarmento et al., 2014). In this study we use in-game match statistics from the UCL. The objective of this study is to determine the distinctiveness of in-game statistics (goals scored, goals conceded, shoot accuracy rate (%), offside, ball possession (%), total successful passes, distance covered, balls recovered, clearances completed, yellow card, red card, fouls, matches scored first, total goals scored 1st half, total goals scored 2nd half, away win, home win) obtained from matches played in the UCL group stages in predicting the advancement of teams to the round of 16. On the other hand, this study, which focuses on the UCL group stages, differs from previous studies that generally focus on long-term performance and match winning rates in local leagues in that it examines in-game performance indicators that influence teams' advancement to the next round in a tournament structure that progresses with a limited number of matches. Additionally, by identifying concrete variables that influence success in a tournament format, it contributes to the literature on in-game performance.

Methodology

Sample and variables

Statistics related to match data for all games (n=288) played between teams in attendance (n=57) in the UCL from the seasons 2019/2020 to 2021/2022 were collected for analysis. Due to the scope of the research, data from qualification rounds were not included in the analysis. The teams were categorized into two groups according to their rankings within the group stage: the top two ranked teams (1st and 2nd), which advanced to the round of 16, and the bottom two teams (3rd and 4th), which did not advance to the round of 16. These two groups were used as dependent variables in the study. The statistics presented in Table 1 are in-game performance indicators determined by reviewing the relevant literature discussed in the introduction. Additionally, the authors chose the following independent variables, which have not yet been mentioned in the literature but are believed to have a significant contribution: (a) matches scored first; (b) total goals scored 1st half; and (c) total goals scored 2nd half. These variables were also included in Table 1.

Table 1: Explanations of game-related variables

Variable	Definition
Goals scored	Number of goals scored in group stage played in a season
Goals conceded	The total number of goals allowed in group stage played in a season
Shoot accuracy rate (%)	Successful shot attempts on goal post in group stage in a season (shots on goal post / total shot attempts)
Offside	Number of offside in group stage in a season
Ball possession (%)	Average percentage of ball possessions per game in group stage in a season
Total successful passes	Average numbers of successful passes in matches group stage in a season
Distance	Total distance covered by per match in group in a season
Balls recovered	Total number of balls recovered in group in a season
Clearances completed	Total number of clearances completed in group stage in a season
Yellow card	Overall count of yellow cards in group stage in a season
Red card	Overall count of red cards in group stage in a season
Fouls	Total number of fouls committed in group stage in a season
Matches scored first	Number of games scored first in the group stages in a season
Scored 1st half	Goals scored in 1st half in group stages in a season
Scored 2nd half	Goals scored during 2nd half in group stages in a season
Away won	Total away matches won during the group stage in a season
Home win	Total home matches won during the group stage in a season

Data collection and procedure

The data of the matches analyzed in this study were sourced from OPTA Sports Data (StatsPerform). The evaluation of the reliability and validity of the OPTA Client system has been conducted (Liu et al., 2013). Numerous articles utilizing OPTA data have been released (Tunaru and Viney, 2010; Oberstone, 2011; Lago-Peñas et al., 2016; Konefał et al., 2018; Gai et al., 2019). To ensure data reliability, each author watched and collected statistics from randomly selected 5 matches, resulting in data from a total of 20 matches being compared using the data available on the official website for the same matches. It was observed that there was 100% consistency across all variables. This analysis illustrates the dependability of the data sourced from the official website. Since the dataset is publicly available and no studies were conducted on humans or animals, an ethic committee approval was not required.

Statistical analysis

The main descriptors including mean and standard deviation, were calculated for the teams that advanced and did not advance to the round of 16 from the UCL group stages. The independent sample t-test was used to assess the significance of the descriptors that distinguish between the two groups. Cohen's d was computed to evaluate the effect size of the observed differences and the interpretation of these values followed the guidelines suggested by Cohen (1998) and expanded by Sawilowsky (2009), where values less than 0.01 are considered very small, less than 0.20 small, less than 0.50 medium, less than 0.8 large, less than 1.20 very large, and less than 2 huge.

To determine the predictor variables (game-related statistics), discriminant analysis was used based on the matches played in the group stages with split. Wilks' lambda (λ) which assesses the variations within each group in relation to the overall variations was calculated along with the canonical correlation index (which represents the variations in between-group discriminant scores in relation to total variations) and the percentage of accurately classified teams (those advancing to the round of 16 and others).

Statistical analysis was conducted using SPSS version 26.0, with a p-value of less than 0.05 considered statistically significant. Discriminant analysis is a multivariate statistical method based on the linear combination of predictor variables, aiming to best classify individuals into their respective categories. A model developed using linear multivariate discriminant analysis is the linear combination of independent variables that provides the best distinction between unsuccessful and successful groups (Kalaycı, 2018; Çokluk vd., 2018). Discriminant analysis can be divided into two types: linear discriminant analysis (LDA) and quadratic discriminant analysis (QDA). Linear discriminant analysis operates under the assumption that the covariance matrices across all groups are homogeneous (Özdamar, 2010). In this investigation, The Box's M test revealed that the covariance matrices of the groups were homogeneous ($F=0.272$, $p>0.05$). Consequently, LDA was used in this research.

Decision tree is a flow-chart-like structure in which internal nodes are represented by rectangles and leaf nodes by ovals, offering ease of implementation and interpretability compared to other classification algorithms (Yadav and Pal, 2012). Moreover, decision tree classifiers often achieve comparable or even superior accuracy relative to other classification methods. Decision tree algorithms are realized with two groups of variables: a target variable and explanatory variables to be used to explain the target variable (Koyuncugil ve Özgülbaş, 2008). The CHAID (Chi-squared Automatic Interaction Detection) algorithm, introduced by statistician Kass in the late 1970s, is among the most widely used statistically driven techniques for constructing decision trees within supervised learning frameworks. As a multivariate dependency method, CHAID is primarily employed to identify associations between a categorical dependent variable and multiple independent variables, which may be either categorical or continuous (Milanović ve Stamenković, 2016). In this research the CHAID algorithm which is one of the decision tree methods was utilized because it is regarded as an effective and significant predictor. CHAID allows multiple splits of a parent node into child nodes, it captures the (multivariate) relationship between to advance in round 16 and game-related statistics more fully. The CHAID algorithm is a method that applies the chi-square test. The capacity to utilize both categorical and continuous variables with this algorithm as well as the ability to split each node in the tree into more than two subgroups and the presence of breakpoint detection have made this algorithm popular has made this algorithm popular (Berlanga et al., 2013; Díaz-Pérez and Cejas, 2016; Gündüz and Lutfi, 2021).

Findings and discussion

Findings

Table 2 presents the basic descriptive statistics, including the mean (M) and standard deviation (SD) for each variable, alongside the t-test values, p-values, and effect sizes of the teams that advanced to round 16 and those that did not from the UCL group stages. Six variables exhibited differences between the two groups, with very large effect sizes (ES> 1.2): goals scored, goals conceded, matches scored first, overall goals scored in the 2nd half, away wins and home wins with the effect sizes of the last two variables being huge.

Table 2: Basic descriptors (mean and standard deviation) for each variable based on UCL group stages

Variables in UCL Group Stages	Advance in round 16		Not advange in round 16		ES
	M	SD	M	SD	
Goals scored	12.52	3.88	6.02	3.41	1.78
Goals conceded	6.12	2.53	12.41	3.99	1.88
Shoot accuracy rate (%)	39.92	4.79	33.41	6.76	1.11
Offside	12.12	4.33	12.31	6.41	0.03
Ball possession (%)	52.47	5.51	47.49	6.02	0.86
Total successful passes	467.9	106.24	405.0	165.30	0.45
Distance covered	112.0	6.90	112.3	6.17	0.04
Balls recovered	42.14	4.99	41.48	5.25	0.13
Clearances completed	11.77	3.86	13.28	4.43	0.36
Yellow card	11.54	4.16	13.35	4.03	0.44
Red card	0.41	0.64	0.68	0.80	0.38
Fouls	11.23	2.35	11.52	2.63	0.11
Matches scored first	3.72	1.14	1.85	1.20	1.60
Scored 1st half	5.50	2.39	2.97	2.02	1.14
Scored 2nd half	7.02	2.80	3.04	1.98	1.64
Away win	1.62	0.91	0.33	0.47	1.78
Home win	2.16	0.78	0.66	0.59	2.16

Table 3: The results of the discriminant analysis for game-related statistics in the UCL group stages

Discriminant Function Coefficients		Structure Coefficients
Variables	**Coefficients**	**Function 1**
Goals scored*		0.525
Goals conceded (X_1)	***-0.127***	***-0.590***
Shoot accuracy rate (%)*		0.265
Offside*		0.051
Ball possession (%)*		0.270
Total successful passes*		0.181
Distance covered (per match)*		0.157
Balls recovered*		0.109
Clearances completed*		-0.089
Yellow card*		-0.124
Red card*		0.050
Fouls*		0.088
Matches scored first*		0.532
Scored 1st half*		0.370
Scored 2nd half*		0.451
Away win (X_2)	***0.800***	***0.556***
Home win (X_3)	***1.161***	***0.677***
Constant	**2.604**	
Wilk's Lambda	0.278	
Eigenvalue	2.597	
Chi-Square	117.760	
p	0.000	

Canonical Correlation	0.706
Reclassification (%)	94.8

*These variables not used in the analysis.

The findings of the discriminant analysis are presented in Table 3. As illustrated in Table 3, the discriminant function based on the data was found to have significant discrimination ($p<0.05$). Furthermore, the precision of the discriminant function was determined to be 94.8%. The coefficients of the discriminant function enable the function to be represented in the following way:

$$\text{Discriminant Function}=[Y_1 = 2.604 - X_1\,(0.127) + X_2\,(0.800) + X_3\,(1.161)].$$

During the process of deriving the discriminant function, variables such as goals scored, shot accuracy rate (%), offside, ball possession (%), total successful passes, distance covered (per match), balls recovered, clearances completed, yellow card, red card, fouls, matches scored first, scored in the first half, and scored in the second half were not used in the analysis.
In the 2019-2020, 2020-2021, and 2021-2022 UCL group stages, the variable with the greatest contribution to advancing to round 16 was home win (SC=0.677). Additionally, the other variables that contributed to advancing to round 16 were goals conceded (SC=-0.590) and away win (SC=0.556), respectively.

Figure 1 illustrates the classification tree, highlighting the variables with the greatest significance in its construction. The results correctly classified 96.9% of the teams that advanced to round 16 and those that did not. In the initial module of the tree structure, the dependent variable is round 16 (categorical variable: rising and eliminated teams). As the dependent variable is categorical, the percentage distribution of each category is provided within the module. At node 0, data was taken for a total of 96 teams (48 *advanced round 16*, 48 *eliminated*) as the last three seasons of the UCL Champions League were examined.

Level 1 Split: Home Wins (Node 0 → Node 1 & Node 2)
Figure 1 illustrates the classification tree, highlighting the variables with the greatest significance in its structure. The model accurately classified 96.9% of the teams that advanced to the Round of 16 and those that did not. At the initial level of the tree (Node 0), the dependent variable was advancement to the Round of 16, categorized as "advanced" or "eliminated." Since the dependent variable was categorical, the percentage distribution for each category was presented within the module. The data comprised a total of 96 teams drawn from the UCL group stages over the last three seasons (48 advanced; 48 eliminated). The most influential factor in predicting advancement was identified as the number of home match wins during the group stage. The relationship between home victories and progression was statistically significant at the 1% level ($p < 0.01$; $\chi^2 = 64.07$). Teams were split based on a cutoff value of 1 home win:

- Among teams that won 1 or fewer home matches ([≤1.0]), only 13.2% (7 teams) advanced (Node 1).
- Among those that won more than 1 home match ([>1]), 95.3% (41 teams) advanced to the Round of 16 (Node 2).

Level 2 Split: Away Wins and Goals Conceded (Node 1 → Node 3 & 4; Node 2 → Node 5, 6 & 7)
A. From Node 1: The Role of Away Match Victories For the 46 teams classified under Node 1 (≤1 home win), the next significant predictor was the number of away victories. This variable was also statistically significant at the 1% level ($p < 0.01$; $\chi^2 = 36.28$): Teams with 1 or fewer away wins ([≤1]) had an advancement rate of only 4.2% (2 teams) (Node 3). In contrast, teams with more than 1 away win ([>1]) advanced at a rate of 100% (5 teams) (Node 4). No additional variables showed a significant relationship for teams in Node 4, thus this became a terminal node.

B. From Node 2: The Effect of Goals Conceded Among the 43 teams in Node 2 (>1 home win), the variable with the next highest discriminative power was the total number of goals conceded in the group stage, which also yielded statistically significant results at the 1% level ($p < 0.01$; $\chi^2 = 27.96$). The data was divided into three goal concession categories:

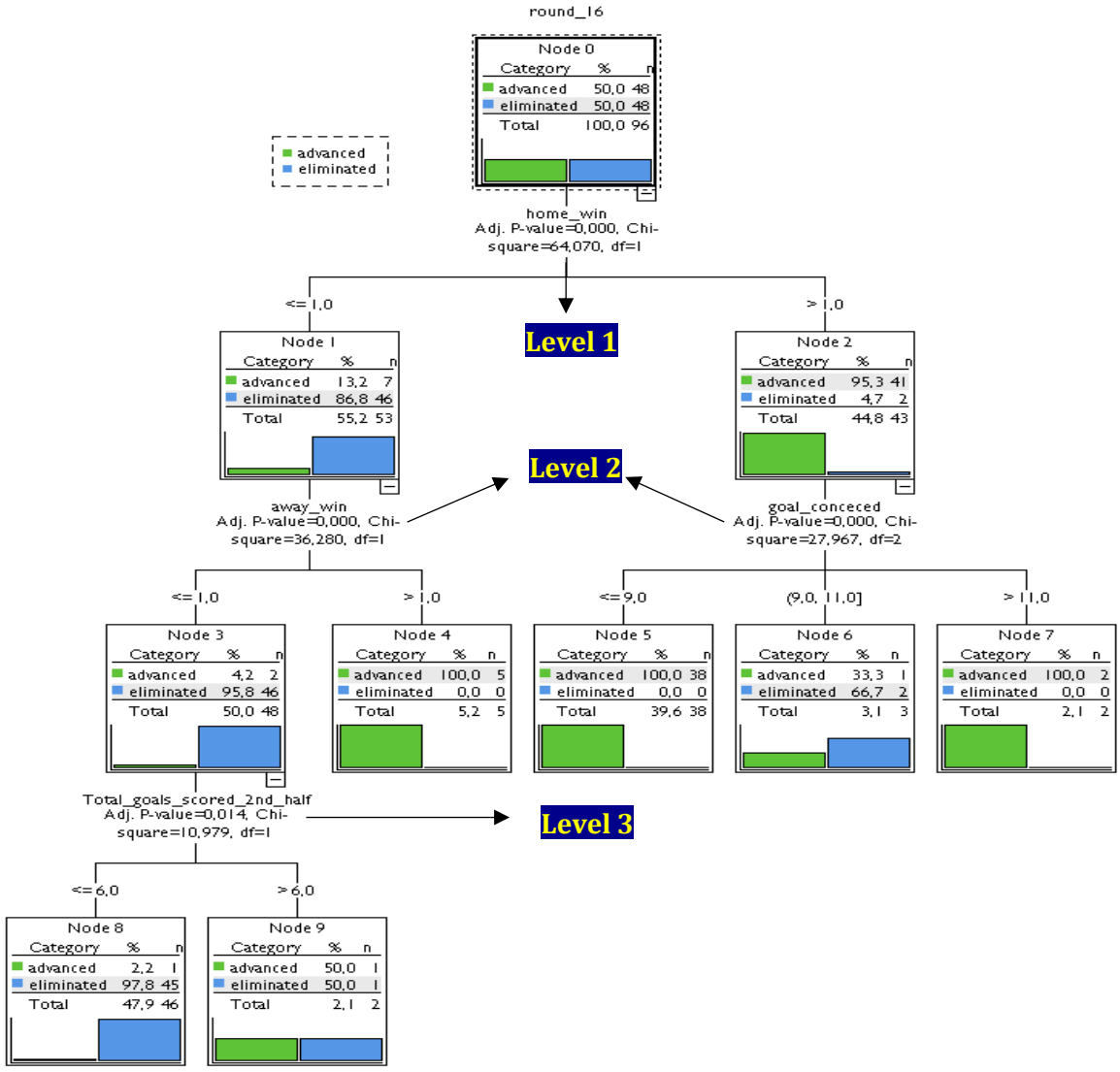
- Teams that conceded 9 or fewer goals progressed at a rate of 100% (Node 5).
- Teams that conceded between 9 and 11 goals had an advancement rate of 33.3% (Node 6).
- Teams that conceded more than 11 goals also advanced at a rate of 100% (Node 7).

Level 3 Division: Second-Half Goal Scoring (Node 3 → Node 8 & 9)

For the teams in Node 3 (≤1 home win and ≤1 away win), the third-level division was based on total goals scored in the second halves of group matches. This variable was found to be significant at the 5% level ($p < 0.05$; $\chi^2 = 10.97$).

- Teams that scored 6 or fewer goals in the second halves ([≤6]) failed to progress in 97.8% of cases (Node 8).
- Teams that scored more than 6 goals in second halves ([>6]) advanced in 50% of the cases (Node 9).

Figure 1: Decision tree analysis which discriminate teams that advanced to the round of 16 and those eliminated from the UCL



Discussion

Considering that weather conditions, referee decisions, coaching ability and tactical decisions can be important parameters in UCL, which is one of the biggest football organisations in the world and Europe, it is difficult to explain precisely which variables explain wins/losses and advance the round 16 from the groups. As noted in earlier studies (Lago-Peñas & Lago-Ballesteros, 2011; Gómez et al., 2012; Mackenzie & Cushion, 2013; Almeida et al., 2014), situational variables including aspects such as weather, game location, and the importance of the competition play a crucial role in performance during football matches. In addition, it would not be correct to compare in-game statistics during the group stage and the knockouts. This is because the strategies and tactics of the teams when playing for points in the group stages will probably differ from the competitions in the knockout rounds. In this study, the discriminating variables in the advancement of the teams that compete in the UCL from the group stages to the last 16 round are analysed.

In this study, it was determined that the variables that discriminate the teams that advanced to the last 16 round of the UCL from the group stages and the teams that did not were; winning home matches, winning away matches and conceding goals. Pollard (1986), Pollard et al. (2008), Armatas and Pollard (2014), Lago-Penas et al. (2016) and Özçilingir and Bozdoğan (2021), and stated in their studies that home ownership in football competitions is a highly important variable for teams to win matches and points. In addition, it was reported that a large proportion of the points collected during the season came from home matches. Poulter (2009) and Fowler et al. (2014) indicated that home teams have higher in-game statistics than away teams, which reflects positively on the result of the competition. Torgler (2004), Charalampos et al. (2013), Saavedra García et al. (2015) and García-Rubio et al. (2015), and found that home teams have better results according to discriminant analysis. The fact that winning home matches, which is found to be a discriminator in our study, has an important role in the advancement from the group stages to the last 16 is further corroborated by the literature. Considering that teams need to collect as many points as possible to advance to the round of 16, it is expected that teams will play with less stress and higher concentration in home matches with fan support than in away matches. For this reason, it is of great importance for teams to win their home matches. The main criterion for the teams to advance from the group stage to the last 16 round is to finish in the top two places in their group, which is based on the total points obtained by the teams after six matches. Winning away matches is just as important as winning home matches, as the highest score in football is a win (3 points). In our study, away wins were also found to be a discriminating variable in the advance of teams from the group stages to the last 16 round of the UCL. Boscá et al. (2009) stated that teams should play more offensively at home in order to be at the top of the leagues they are in, and they should also increase their offensive efficiency in away matches. Tütüncü and Yolgörmez (2021) mentioned the importance of the pressure generated by the fans on the away teams for the home teams. As a consequence of the research they carried out on the competitions played without spectators during the COVID-19 period, performance of away teams improved.

In-game statistics of goals scored, shooting accuracy rate (%), offside, ball possession (%), total successful passes, distance covered, balls recovered, clearances completed, yellow cards, red cards, fouls, matches scored first, total goals scored in the 1st half, total goals scored in the 2nd half were not found to be discriminating variables determining advance to the last 16 round of UCL.

In contrast to the findings presented in earlier studies, the number of total and accurate shots (Torgler, 2004; Szwarc, 2007; Rampinini et al., 2009; Oberstone, 2009; Lago-Ballesteros and Lago-Peñas, 2010; Lago-Penas et al., 2010; Lago-Penas et al., 2011; Castellano et al., 2012; Collet, 2013; Broich et al., 2014; Moura et al., 2014; Liu et al., 2015; Liu et al., 2016; Mao et al., 2016), total number of successful passes (Luhtanen et al., 2001; Oberstone, 2009; Kapidžić et al., 2010; Janković et al., 2011; Lago-Penas et al., 2011; Collet, 2013; Broich et al., 2014), possession rate (Janković et al., 2011; Lago-Penas et al., 2011; Collet, 2013; Almeida et al., 2014; Moura et al., 2014; Vogelbein et al., 2014; Liu et al., 2015), number of fouls committed (Oberstone, 2009), overall distances covered during the match (Rampinini et al., 2009), ball recovery (Gómez et al, 2012; Vogelbein et al., 2014), scoring the first goal (Armatas et al., 2009; García-Rubio et al., 2015), goals scored (Lago-Penas et al., 2010; Sgrò et al, 2015; Allister et al., 2018), offside (Lago-Peñas et al., 2010; Zambom-Ferraresi et al., 2018), goalkeeper saves

(Carmichael et al., 2000), successful clearances (Carmichael et al., 2000), first-half goals (Evangelos et al., 2018) are important and distinctive variables in winning matches and ranking in leagues. In addition, there are also studies indicating that having a red card is a major handicap for teams to win the matches (Bar-Eli et al., 2006; Lago-Penas et al., 2010; Mechtel et al., 2011; Lago-Penas et al., 2011). The fact that these variables, which affect winning the match in the previous studies, were not found as discriminating variables in our study can be clarified by the observation that the teams competing in different countries based on national leagues have different game approaches and there are different variables affecting winning in these matches. In the case of UCL, it can be said that the best teams from different leagues should participate in the event and create diversity in their gameplay in order to win by competing against different game approaches. Therefore, it can be said that it is expected to differ from the results of the studies conducted on local leagues.

According to the literature, offside (Lago-Penas et al., 2011; Sgrò et al. 2015), yellow card (Mao et al. 2016), successful ball clearance (Lago-Penas et al., 2011), goals scored in both the 1st and 2nd halves (Armatas et al., 2007; Michailidis et al., 2013) have no discriminative effect on winning the matches. In the changing and developing football culture from year to year and the teams in UCL are the best teams in the national leagues, it can be said that the teams are relatively equal to each other and all teams plan their training based on scientific methods. The findings from this study indicate that match location (home vs. away victories) and the total goals conceded are crucial factors in determining whether teams progress from the group stage to the round of 16 in the Champions League.

Based on the findings of this study, it is recommended that teams aiming to progress from the group stages to the round of 16 in the Champions League effectively utilize their home advantage and compete vigorously in away matches. The importance of winning home games is linked to the support of fans and the opportunity for enhanced performance in a lower-stress environment. Furthermore, teams should prioritize strategies to secure points in away matches. Strengthening defensive measures to reduce the number of goals conceded will also enhance the chances of success and help accumulate the necessary points to rank high in the group stage. Additionally, teams should continuously update their match analyses and game strategies to improve their ability to compete against opponents from different leagues, which will enable them to be more competitive on the international stage.

Results and recommendation

In conclusion, success in the UCL group stage depends on a combination of several important performance factors. Teams that achieve multiple home wins significantly increase their chances of advancing to the round of 16. In addition, even a small number of away wins play a critical role in advancing. Another important factor is defensive strength; teams that concede fewer goals are more likely to succeed. These findings highlight the importance of combining consistent performance at home and away with a strong defensive strategy. By focusing on these areas, teams can improve their position in their group and increase their chances of advancing to the knockout stages.

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Ethical approval

This study is among the studies that do not require ethics committee approval due to it utilized publicly available data, which poses no risk of personal privacy violations and is sourced from information accessible to the public.

Contribution rate of researchers

1st author contributed 50%, 2nd author contributed 10%, 3rd author contributed 20% and 4th author contributed 20% to the study.

Conflict of interest

There is no potential conflict of interest in this study.