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Appraising THE Economic Efficiency OF European FOOTBALL TEAMS: Evidence FROM Covid-19 CRISIS Using Data Envelop Analysis

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Abstract

This paper evaluates the economic efficiency of European football teams and examines the impact of COVID-19 pandemic on their performance indicators. 48 teams from Bundesliga, La Liga, Premier League, Serie A, and Ligue 1 are selected for appraising their efficiencies using the Malmquist DEA approach. The Data Envelopment Analysis (DEA) using the Malmquist index (MI) was used to evaluate the teams' performance before and during the COVID-19 pandemic, among others. The findings revealed that teams reacted differently to the pandemic's challenges. Among other results, the study found no significant difference in teams' performance before and during COVID-19 global pandemic. The findings provide insights for the economic efficiency of European football teams in providing information for comparative analysis to technical managers, investors, and other stakeholders regarding teams' performance.

Keywords: Economic Efficiency Data Envelopment Analysis, Malmquist Index, Continuous Improvement, Sport Management, COVID-19 Pandemic.

1. Introduction

The COVID-19 pandemic had a significant effect on the entire world as every country, industry, or society was affected in a way or another (Fauci et al., 2020). The pandemic has imposed restrictions on many activities to restrain the spread of the virus; this includes the shutdown of many public places where people can physically interact. Like others, the football industry was affected severely following many challenges that rose after the outbreak (Vijaykumar, 2020).

During the 2019-2020 season, many countries' football activities were suspended due to the spread of the COVID-19 global pandemic. For example, football matches in Europe were suspended from March 2020, but each league reacted differently to the outbreak (Lines, 2020). Numerous changes had to be adopted by all leagues worldwide to ensure a safe transition to start football competitions. To point out the impact of COVID-19 on teams in the top 5 major football leagues in Europe, the efficiency of these teams during the 2019-2020 season and the 2020-2021 season are calculated using the Data Envelopment Analysis (DEA) approach. Then, the MI analysis is applied over the two periods pre and post COVID-19 to check the total productivity factor change for each team. Several variables are considered in this study, including the number of matches played and

won in different competitions together with the number of goals scored during these matches.

DEA is a growing benchmarking technique (Emrouznejad, 2018; Dellnitz, 2021). It identifies the units that show best practice and compare others to them; thus, it would promote continuous improvement. Its power stems from the fact that it can handle multiple inputs and outputs of not necessarily the same type simultaneously. The DEA model relies on maximising a weighted efficiency ratio of output(s) to input(s). The second strength of this method is being non-parametric, unlike the ratio, regression, and stochastic frontier analysis, which are also used for performance evaluation (Fixler et al., 2014; Thanassoulis, 1993). Furthermore, the Malmquist Index is a DEA method that analyses the productivity change between two periods. Indeed, the MI score is a product of two factors: the deterioration in a DMU and the change in the efficient frontiers, that is, technical efficiency change multiplied by the technological change (Sánchez, 2018; Desta, 2016).

During the previous two decades sports' business has been improved specially Football. has changed. National Teams are considered as symbol of the relative country. In addition to the culture dimension, the importance of economical dimension is increased and consequently its contribution on the GDP and the economical evaluation in large.

Numerous articles and papers were found that used DEA in measuring and analysing the economic efficiency of football teams/clubs. Indeed, football clubs have become large companies that must improve their efficiency for the sake of profitability and success in the field. Furthermore, through good performance on the field, other off-the-field benefits will be generated, such as revenue, fan support, and sales. In contrast, poor performance can result in unfavourable and severe outcomes for the club.

Based on the above, this study attempts to assess the teams' relative efficiency in Europe's Top Five Football Leagues' Pre and Post COVID-19 and check the influential variables on their relative efficiency. Therefore, the current study investigates the following research questions:

RQ1. What are the economic relative efficiency scores and Malmquist Index for teams under investigation over the study period?

RQ2. Are there, on average, significant differences in the teams' economic relative efficiency scores Pre and Post COVID-19?

RQ3. Do the variables under investigation significantly influence the teams' economic relative efficiency scores over the study period?

The other aspects of this paper are organised as follows: Section 2 is an overview of the top five European leagues, following the literature review and hypothesis formulation are stated in Section 3. Then, in Section 4, the collected data are presented with the adopted methodology of benchmarking the relative efficiency scores, analysing the productivity change over the study periods, and identifying the efficiency drivers. Afterward, Section 5 involves a discussion of the obtained results. Lastly, Section 6 concludes the paper.

2. Background Information

The study involves selected five top football teams in different leagues in Europe. The leagues from which the selection was made are among the top five leagues in the Union of European Football Association (UEFA) ranking. The ranking determines the best leagues in the continent following the teams' results in current and previous European Championships. From the 2014-2015 season till the 2020-2021 season, the presented leagues in this research have consistently occupied the top five positions each season (UEFA, 2021a; UEFA, 2021b). These Leagues are Bundesliga (Germany), La Liga Santander (Spain), Premier

League (England), Serie A (Italy), and Ligue 1 (France).

Bundesliga was established in 1963, with 18 teams competing for the title every season. Throughout history, the most team to win the Bundesliga is Bayern Munich with 30 titles. Other annual domestic cups in Germany include the DFB-Pokal Cup (Footballhistory, 2021a). Besides, La Liga was founded in 1929, with 20 teams competing for the league title every season. Real Madrid is the most team to ever win the La Liga with 34 titles to their name. Plus, there are two other domestic competitions in Spain: the Copa Del Rey and the Supercopa de España (Footballhistory, 2021b).

Furthermore, The Premier League was established in 1888, with 20 teams competing for each season. Manchester United is the most team to win the league with 20 titles. Other domestic competitions in England are the FA Cup, the EFL Cup, and the FA Community Shield (Footballhistory, 2021c). Moreover, Serie A was established in 1898, with 20 teams competing for the title each season. Juventus is the most team ever to win the league with 36 titles. The Coppa Italia and the Supercoppa Italiana are other domestic competitions played in Italy (Footballhistory, 2021d). Finally, Ligue 1 was established in 1932 but was previously known as Division 1, with 20 teams competing annually. Saint-Etienne is the most team ever to win the league with ten titles. Moreover, the domestic competitions include 2 cups: The Coupe de France and the Coupe de la Ligue (Footballhistory, 2021e).

Following the COVID-19 pandemic, all Leagues suspended their work in March 2020, but on different dates. Serie A was the first league among the five that stopped football, as from March 4, 2020, all matches were played behind closed doors. However, from March 9, 2020, football stopped completely (Lines, 2020). On March 12, 2020, La Liga followed Serie A and suspended football in Spain (Ridge, 2020). While on March 13, 2020, Ligue 1, Bundesliga, and the English Premier League confirmed their suspension of football games (Lines, 2020). All leagues imposed forecasted dates of when they will be returning to function on the field, but changes were soon made to these dates due to the enormous increase of COVID-19 cases in Europe.

Each league returned to function on site on different dates, following the COVID-19 situation encountered by their countries. Practically, the Bundesliga was the first league among the five to return to football on May 16, 2020, with notable changes (Bundesliga, 2020). Then, La Liga announced the return of football games on June 12, 2020 (La Liga, 2020). The Premier League officially returned on June 17, 2020 (BBC, 2020). Serie A was last to resume by returning to function on June 20, 2020 (Football ITALIA, 2020). However, on April 28, 2020, Ligue 1 announced the cancellation of all sporting competitions in the country until September due to the problematic COVID-19 situation in France, which meant that the 2019-2020 Ligue 1 season was cancelled permanently (BBC, 2020). The league champions were decided to be Paris Saint Germain FC as they were 1st in the league before suspension (Mott, 2020).

Football is one of the most famous and popular sports in the world. It is enjoyed by people of all ages and backgrounds. This article investigates the impact of economic efficiency for the major European football clubs during the pandemic. It measures the correlations between efficiency factors. The outcomes showed that DEA as a tool is successfully explains the economic impact on the GDP (Nada W. D., Tharwat A. A.).

3. Literature review

Countless papers have utilised the DEA method, which was established by Charnes, Cooper & Rhodes (1978), to assess the performance of football teams (Barros, 2006; El-Demerdash, 2016; Guzmán-Raja, 2021; Haas, 2003; Haas, 2004; Kern, 2012; Kulikova, 2014; Pyatunin, 2016). Each of these papers

used various distinguished variables (inputs and outputs) to test different hypotheses on a set of identified teams and over a specified period.

Arsu (2021) used the bi-objective multi-criteria data envelopment analysis (BiO-MCDEA) to investigate the impact of the club's financial state on the sporting performance for ten football clubs in the Big-Five League over 2015/2016, 2016/2017, and 2017/2018 seasons. For that purpose, financial and sporting data were utilised, including the total market value. Furthermore, Guzmán-Raja (2021) examines the sport and financial performance of Spanish football clubs using DEA. The results showed that the teams with the most assets had the highest performance level.

El-Demerdash et al. (2016) analysed the relative efficiency between 64 European teams across the 2014/2015 football season using an input-oriented stochastic DEA model and, at the same time, taking into consideration domestic as well as European contributions during that season. However, Pyatunin et al. (2016) analysed football teams' economic efficiency rather than analysing performance in their study. That is relevant; economically speaking, football teams have transformed their image into profitable companies nowadays and are always required to improve their performance. Therefore, the study measured the economic efficiency of 48 European teams and used several financial and sporting indicators in terms of input variables. Moreover, the selection of teams was undertaken due to the financial criteria of the football clubs.

Djordjević et al. (2015) used a two-stage DEA model to measure the technical efficiency of national teams that competed in the qualification stages leading up to the 2010 FIFA World Cup in South Africa. The matches analysed included official qualification matches as well as friendlies. The two-stage model comprised generating inputs to outputs in the first stage and then using these outputs as inputs for the second stage.

Besides, Boscá et al. (2009) applied the DEA model over three different seasons (2000/2001, 2001/2002, and 2002/2003) to determine whether teams in the Spanish and Italian leagues are required to improve efficiency offensively or defensively. Different results were obtained for each league following their competitive nature, as during that time, the Spanish league contained more competition domestically than the Italian league.

García-Sánchez (2007) utilised a different approach that included developing a three-stage DEA model, which included analysing operating efficiency (including the attack and the defence of the teams), athletic or operating effectiveness, and finally, social effectiveness. This study was conducted to analyse the Spanish football teams during the 2004/2005 season, and only first division teams were selected for the research.

Isidoro Guzmán-Raja, Manuela Guzmán-Raja (2021) said that professional football clubs have a special characteristic that other types of companies do not share: their sporting performance (on the field) is important, as well as their economic performance (outside the field). The main factors influencing the level of team effectiveness are investigated using cluster analysis. For a sample of Spanish football clubs, the results show that the clubs achieved a relatively high level of performance over the study period and that the oldest teams with the most assets had the highest efficiency rates. These results can help club managers improve the performance of their teams.

The football industry, as other industry types, has been affected by the COVID-19 pandemic. Following our knowledge, the current study is one of the freshest attempts to benchmark the teams' economic relative efficiency scores of Football Leagues in Europe, notably before and after the suspension caused by COVID-19. Therefore, the current study would lure the decision-makers attention for insight on teams' performance compared to others, promote policies and strategies to address deficiencies

and weaknesses in performance. To this purpose, the current study strives to test the following hypotheses:

H1. The variations in the teams' economic efficiency through the pre and post COVID-19 period are statistically significant.

H2. The variables under investigation significantly influence the teams' economic relative efficiency scores over the study period. That can be formulated as follow:

H2.1 The Matches Won significantly influenced the teams' economic relative efficiency scores over the study period.

H2.2 The Goals Scored significantly influenced the teams' economic relative efficiency scores over the study period.

H2.3 The Matches Played significantly influenced the teams' economic relative efficiency scores over the study period.

4. Data and Methodology

3.1 Data Collection

The practical part of the current paper comprises data collection, identifying variables, recognising the inputs and outputs through the Malmquist DEA methodology to appraise the relative performance of teams in Europe's top five football leagues. Plus, verifying the potential statistical impact of COVID-19 on teams' performance before and after the COVID-19 pandemic.

Table 1: Sample size and characteristics

Division	Geographic locations	DMUs Numeral	Percentage
Bundesliga	Germany	10	20.8%
La Liga	Spain	8	16.7%
Premier League	England	10	20.8%
Serie A	Italy	10	20.8%
Ligue 1	France	10	20.8%
Total	**5**	**48**	**100%**

Table 1 shows the sample size and characteristics. In the current paper, 48 teams from Bundesliga, La Liga, Premier League, Serie A, and Ligue 1 are selected for appraising their efficiencies using the Malmquist DEA approach. The top 10 list in each league regarding achieving titles throughout history is considered in this study. These teams represent the decision-making units (DMUs) in the current study. Besides, the study adopted two models through the Malmquist DEA methodology. The inputs for the initial model include six variables: the number of matches played and goals scored in all competitions, whether in the Domestic League, and Cup; or in the European Competitions (Champions League and the Europa League); versus three output variables which are the number of matches won in these competitions. Whereas the inputs for the next model involve two variables: the number of total matches played and goals scored in all competitions; versus one output: the number of matches won in these competitions.

All required data were obtained from the SoccerWay website as one of the world's largest football databases and is owned and powered by digital sports media business PERFORM. Plus, the period depends on the number of matches played in Domestic League by each club after returning to football following the

suspension, until Monday, March 22, 2021. Therefore, analysis of teams' performance before the temporary suspension will be done based on the number of matches played by the clubs. The data are retrieved for two separate periods, the time pre-COVID-19 and post-COVID-19 pandemic. After the suspension, the data corresponding to the inputs and outputs for each club until Monday, March 22, 2021, is collected. However, the period involved depends on the number of matches played by each club in the Domestic League after returning to football following the suspension. Consequently, the Domestic League matches were considered as a reliable variable for identifying the period of the study following the catching the nexus for outputs and inputs under investigation. Second, Habib and Shahwan (2020) confirmed that the DEA methodology contributes necessary information for benchmarking, continual improvement and reaching the best practices. Third, as Shahwan and Habib (2020) illustrated, DEA is a non-parametric manner, where it does not need a pre assumption of pattern form of data or residuals. Finally, as Cooper et al. (2007) argued, DEA targets the best practice performance on the efficiency frontier curve rather than conventional ways, which targets central tendencies.

fact that all chosen teams are playing in the first division in the Domestic League and that the total number of matches should be completed by all the concerned teams independent of the winners.

3.2 Malmquist DEA Model

Among numerous attainable methods for assessing the DMUs efficiency scores, the DEA technique by Malmquist's index was selected to assess the efficiency of teams' relative performance under investigation due to its unique traits. First, as argued by Mourad et al. (2021), Shahwan and Habib (2021), and Tone (2016), DEA is a powerful technique in

The efficiency score for each DMU is the ratio of the weighted output to the weighted input. That produces fractional programming, which is transformed to linear programming using mathematical equivalences. The Malmquist index (MI) belongs to the category of efficiency analysis over more than a period, as the MI calculates the productivity change over time (Lin, 2015; Cooper et al., 2007). Following Sánchez (2018) and Desta (2016), the total factor productivity change (tfpch) could be mathematically expressed through the Malmquist DEA methodology, as follows:

$$MI_n = \frac{\delta^2(X_n^2,Y_n^2)}{\delta^1(X_n^1,Y_n^1)} \times \sqrt{\frac{\delta^1(X_n^1,Y_n^1) \times \delta^1(X_n^2,Y_n^2)}{\delta^2(X_n^1,Y_n^1) \times \delta^2(X_n^2,Y_n^2)}} = \sqrt{\frac{\delta^1(X_n^2,Y_n^2) \times \delta^2(X_n^2,Y_n^2)}{\delta^1(X_n^1,Y_n^1) \times \delta^2(X_n^1,Y_n^1)}} \quad (1)$$

where the $\delta^s(X_n^t, Y_n^t)$ denotes the efficiency of the n-th DMU observed in period s measured by frontier technology t, where $(X\ , Y_n^t)$ represents vectors of inputs and outputs of the n-th DMU in the period t. Indeed, the value of MI mentions the variation in productivity among two terms of production: the first term frontiers and is defined by $\sqrt{\frac{\delta^1(X_n^1,Y_n^1) \times \delta^1(X_n^2,Y_n^2)}{\delta^2(X_n^1,Y_n^1) \times \delta^2(X_n^2,Y_n^2)}}$.

Consequently, the output-oriented radial MI DEA model is obtained by the scores of θ solving the linear optimisation problem:

determine the effect of growth in a DMU and is known by the "Catch-up" term and is defined by $\frac{\delta^2(X_n^2,Y_n^2)}{\delta^1(X_n^1,Y_n^1)}$, whereas the second one is known as "Frontier-shift", it verifies the change in the efficient

$$\frac{1}{\delta^s(X_n^t, Y_n^t)} = \max_{\lambda \in \mathbb{R}_+^N}(\theta_n)$$

such that

$$\begin{aligned} -\theta_n\, y_{rn}^t + \textstyle\sum_{j=1}^N \lambda_j\, y_{rj}^s \geq 0, \qquad & r = 1, \dots, m_o \\ x_{in}^t - \textstyle\sum_{j=1}^N \lambda_j\, x_{ij}^s \geq 0, \qquad & i = 1, \dots, m_I \\ \lambda_j \geq 0 & \end{aligned} \tag{2}$$

where x_{in}^s (resp. y_{rn}^s) is the value of the i-th input (resp. r-the output) of the n-th DMU observed in period s, the $(\lambda_n)_{\{1 \leq n \leq N\}}$ are the weights corresponding to the DMUs. The DMU is considered relatively efficient in period s measured by frontier technology t if $\delta^s(X_n^t, Y_n^t) = 1$, otherwise it is inefficient. It is to be noted that, for $t = s = k$, the $e_n^k = \frac{1}{\delta^k(X_n^k, Y_n^k)}$ is the constant return to scale (CCR) efficiency score for the n-th DMU in the kth period.

3.3 Tobit Regression

Furthermore, the current study used the Tobit regression to identify the DEA efficiency scores' drivers. This model can shed light on the critical factors affecting the DEA efficiency scores. It is a valuable tool that assesses the relationship between efficiency scores and their drivers (Habib and Shahwan, 2020). Identifying the most influential variables affecting the efficiency scores will help decision-makers proceed with corrective action to improve their performance (Wang et al., 2016). Verbeek (2008) pointed out that Tobit analysis is the most recommended regression model when there is a range constraint on the dependent variable. The dependent variable in this study presents the efficiency scores, which belong to the interval [0,1]; thus, there will not be a creation of what is known by latent (non-observed) variables. Hence, the Tobit linear regression relation is represented using the following equation:

$$e_i = \beta_0 + \beta_1 v_{i1} + \cdots + \beta_m v_{im} + \varepsilon_i$$

where $\{e_i\}_{1 \leq i \leq n}$ are the independent variables, which represent the efficiency scores in our case, the $V_i = (v_{ij})_{1 \leq j \leq m}$ represent the dependent variables, which are the inputs and outputs, β_i's are the regression coefficients, and $\varepsilon_i \sim \mathcal{N}(0, \sigma^2)$ are known by the Gaussian noises or errors. The coefficients $\beta = (\beta_0, \beta_1, \dots, \beta_m)$ maximise what is known by the log-likelihood function, which is given by

$$\mathrm{L_n}(\beta, \sigma) = \frac{1}{\mathrm{n}} \sum_{\mathrm{i}=1}^{\mathrm{n}} \left(1 - \delta_{\mathrm{e_i}=0}\right) \log\left[\frac{1}{\sigma}\phi\left(\frac{\mathrm{e_i} - \mathrm{V_i^T}\beta}{\sigma}\right)\right] + \delta_{\mathrm{e_i}=0} \log\left[\Phi\left(\frac{\mathrm{e_i} - \mathrm{V_i^T}\beta}{\sigma}\right)\right]$$

where ϕ is the standard normal distribution density function, and Φ is the corresponding cumulative function.

5. Results and Discussion

4.1 Results DEA models

The obtained efficiency scores showed that the clubs could be divided into five categories: Efficient: having efficiency scores 100%; Nearly Efficient: having efficiency scores more than or equal to 90% and less than 100%; Moderately Efficient: having efficiency scores more than or equal to 80% and less than 90%; Inefficient: having efficiency scores more than or equal to 70% and less than 80%; Severely Inefficient: having efficiency scores less than 70%).

Table 2 reveals the relative efficiency scores obtained from the first Malmquist DEA model through the study period. These scores are obtained by solving the problem (2) for $\mathrm{s} = \mathrm{t} = 1$ for the first period and $\mathrm{s} = \mathrm{t} = 2$ for the second one, under the condition that $\sum_{\mathrm{n}=1}^{\mathrm{N}} \lambda_{\mathrm{n}} = 1$, which guarantee that the change in inputs does not necessarily produce a proportional change in outputs. Indeed, this is typically the variable return to scale (VRS) DEA model solved over the two separate periods.

For Bundesliga League, post-COVID-19, five teams were efficient: Bayern Munich, Schalke 04, VfB Stuttgart, Werder Bremen, and Hertha Berlin. Eintracht Frankfurt was nearly efficient, while Borussia Dortmund and VfL Wolfsburg were moderately efficient. With two inefficient teams Borussia Monchengladbach and 1.FC Koln.

Table 2: DEA Efficiency Scores before and during the COVID-19 crisis (Model 1)

DMUs (teams)	Division	Efficiency Scores before (during)	DMUs (teams)	Division	Efficiency Scores before (during)
Bayern Munich	**Bundesliga**	1.000(1.000)	**Chelsea**		0.943(1.000)
Borussia Dortmund		1.000(0.880)	**Newcastle United**		0.841(0.812)
Schalke 04		0.760(1.000)	**Wolverhampton Wanderers**		1.000(1.000)
VfB Stuttgart		1.000(1.000)	**Tottenham Hotspur**		0.681(1.000)
Borussia Monchengladbach		1.000(0.770)	**Juventus**	**Serie A**	1.000(0.990)
Werder Bremen		0.725(1.000)	**Inter Milan**		0.956(1.000)
1. FC Koln		0.676(0.777)	**AC Milan**		1.000(1.000)
Hertha Berlin		0.951(1.000)	**Genoa**		0.967(0.810)
Eintracht Frankfurt		1.000(0.944)	**Torino**		1.000(0.721)
VfL Wolfsburg		1.000(0.891)	**Bologna**		1.000(0.745)
Real Madrid	**La Liga**	1.000(1.000)	**AS Roma**		1.000(1.000)
FC Barcelona		1.000(0.910)	**Lazio**		1.000(0.894)
Atletico Madrid		1.000(1.000)	**SSC Napoli**		1.000(1.000)
Athletic Bilbao		1.000(1.000)	**Fiorentina**		0.594(0.839)
Valencia		1.000(0.927)	**Marseille**	**Ligue 1**	1.000(1.000)
Real Sociedad		1.000(0.876)	**Saint Etienne**		1.000(1.000)
Sevilla		1.000(1.000)	**Paris Saint-German**		1.000(1.000)
Real Betis		0.930(1.000)	**AS Monaco**		0.942(1.000)
Manchester United	**Premier League**	1.000(0.942)	**Nantes**		1.000(0.556)
Liverpool		1.000(1.000)	**Olympique Lyonnais**		1.000(1.000)
Arsenal		1.000(1.000)	**Bordeaux**		0.769(1.000)
Everton		0.855(1.000)	**Stade de Reims**		1.000(1.000)
Aston Villa		1.000(0.943)	**Lille OSC**		1.000(1.000)

Manchester City		1.000(1.000)	**OGC Nice**		0.823(0.933)
Mean					**0.946(0.941)**

Bundesliga holders Bayern Munich unsurprisingly maintained its position of being relatively efficient as the team dominated Europe during the 2019/2020 season. Moreover, the team used to live stream training sessions between the trainers and the players through Zoom when imposed the lockdown. Furthermore, they even managed to increase their Matches Won percentage from 76% to 83%. On the other hand, Borussia Monchengladbach, a team that pre-COVID-19 demonstrated noticeable performances and even managed to qualify for European competitions, dropped from being relatively efficient pre-COVID-19 to being inefficient post-COVID-19. They struggle to find consistency in the league post-COVID-19, which could affect their chances of qualifying for European competition next season. Moreover, their Matches Won percentage dropped from 51% to just 40%. Actually, in 35 games played in Domestic League pre- and post-COVID-19, Borussia Monchengladbach scored 61 goals in 35 games but have won fewer games after COVID-19. That means that they did not sustain the outputs with the same inputs.

For La Liga League, post COVID-19, five teams were efficient Real Madrid, Atletico Madrid, Athletic Bilbao, Sevilla, and Real Betis. Two teams were nearly efficient FC Barcelona and Valencia. Lastly, Real Sociedad was the only moderately efficient team in this league. Atletico Madrid is well known to be an offensive team that mainly focuses on defence as their coach (Diego Simeone) favours defensive tactics over attacking ones. Moreover, when watching Atletico Madrid, it is noticed that all 11 players participate in the team's defending situations, even the attackers, which makes it extremely difficult to score against such a team. Therefore, Atletico Madrid maintained their rank of being a relatively efficient team after COVID-19 due to these tactics. Moreover, this team increased its match won percentage from being 47% to 60%.

On the other hand, FC Barcelona had a relatively efficient team before COVID-19 but dropped to a nearly efficient team. Possible reasons for this could include that the club appointed a new head coach (Ronald Koeman) during the summer, which recently started opting for a formation that includes three central defenders with more midfielders and attackers. Therefore, more emphasis is made on attacking in such formations. Moreover, in the case of FC Barcelona, not all players participate in defending situations. For example, Lionel Messi did not return to defend his team due to his age and to utilise his attacking effect as much as possible without losing fitness, but this could eventually affect the team.

As concerning Premier League, post-COVID-19, seven teams were efficient Liverpool, Arsenal, Everton, Manchester City, Chelsea, Wolverhampton Wanderers and Tottenham Hotspurs. Furthermore, Manchester United and Aston Villa were nearly efficient. Lastly, Newcastle United was moderately efficient. In the Premier League, the most compelling case was Tottenham Hotspurs; as before, COVID-19 was severely inefficient, but after COVID-19 jumped up to being relatively efficient. That can be because Tottenham purchased defensive players to acquire good fitness levels in the summer transfer window to improve the team defensively. Players included a defensive midfielder (Pierre-Emile Hojbjerg), two defensive fullbacks (Matt Doherty & Sergio Rodriguez), a centre-back (Joe Rodon), and an attacking player that has defensive attributes (Gareth Bale). Almost all these players start weekly in the team's matches and produce high-level performances for the team, which led to

the increase in Tottenham's rank and winning more matches as matches won percentage increased from 37% to 60%. As a result, Inputs were slightly changed, but outputs had a significant change. Another interesting case within this league is Liverpool which sustained their rank of being relatively efficient but with lower inputs. Pre COVID-19, Liverpool scored 135 goals in 61 games, while post-COVID-19 scored just 95 goals in 51 games but stayed relatively efficient compared to other teams in the group.

As toward Serie A-League, post-COVID-19, four teams were efficient Inter Milan, AC Milan, AS Roma and SSC Napoli. Juventus was nearly efficient. Genoa, Lazio, and Fiorentina were moderately efficient. Two teams in this league were inefficient, Torino and Bologna. Serie A included more than one team that slipped to the lower category after COVID-19; lower-level teams do not acquire many players that can perform as good as the starting 11 in their teams. For example, higher-level teams such as Inter Milan can play players on the bench to produce the same results as the starting ones. However, teams like Lazio, Bologna, Torino, and Genoa cannot afford to buy as many players to perform such squad rotation and maintain the same results due to their financial situations. Post COVID-19, teams will be focusing more on their budgets and money spent on players. As a result, the chance for young players in the academy levels of each team to get the chance to feature in the first team should increase. Therefore, clubs that are considered lower-level teams should utilise their young talents in the current times. A noticeable team is Fiorentina; before COVID-19, it struggled and was in the severely inefficient category, but after COVID-19, they turned the situation and climbed up to be moderately efficient. That is because goals and matches won have increased with the same number of matches after COVID-19. Slight changes in the inputs affected the outputs significantly, and thus the efficiency level.

Lastly, for Ligue 1 League, post COVID-19, eight teams were efficient Marseille, Saint Etienne, Paris Saint-German, AS Monaco, Olympique Lyonnais, Bordeaux, Stade de Reims, and Lille OSC. OGC Nice was nearly efficient. However, Nantes was the only severely inefficient team among all the other DMUs. Before the COVID-19 pandemic, Nantes used to be in the efficient category. Still, after COVID-19, they dropped all the way to severely inefficient, which shows that the team was heavily affected during that period. Moreover, the matches won percentage decreased from 38% to just 16%. During the 2020/2021 season, which posted COVID-19, Nantes had four different head coaches for the first team, which shows instability in the team as they struggle to achieve good results. Currently (21/4/2021), they stay in the 19th position in league with 28 points, and they are facing the danger of relegation. Presently, Ligue 1 has five-game weeks to go; Nantes could escape relegation by a slight difference if they stay consistent and attempt to win the coming matches. Both teams above them (Lorient and Nimes) acquire points that are not withholding much difference from Nantes, respectively (32 and 31 points). However, focusing on defensive tactics while finishing the game in winning situations is highly important to prevent relegation. In addition, pre-COVID-19 Nantes had scored 32 goals and managed to win 13 matches, but post COVID-19, it scored 33 goals and won just five matches. Even though inputs have slightly increased but without efficiency, as pre-COVID-19, they had fewer inputs while achieving a higher output.

It is commonly known that one of the drawbacks of the DEA method is that the number of efficient DMUs on the frontier increases with the increase in the number of inputs and outputs considered. For this reason, following the nature of the variables in this study, one can reduce the number of inputs and outputs to get a better overview of the efficiency scores. Accordingly, the number of

matches won are added together, similarly for the number of scored goals and matches played, and thus, only three variables are included in the second model.

Table 3 reveals the relative efficiency scores obtained from the second Malmquist DEA model during the study period. For Bundesliga League, post-COVID-19, three teams were efficient: Bayern Munich, Schalke 04 and VfB Stuttgart. Borussia Dortmund and VfL Wolfsburg were moderately efficient. On the other hand, Werder Bremen appeared inefficient, and each of Borussia Monchengladbach, 1. FC Koln, Hertha Berlin and Eintracht Frankfurt appeared severely inefficient DMUs.

Table 3: DEA Efficiency Scores before and during the COVID-19 crisis (Model 2)

DMUs (teams)	Division	Efficiency Scores before (during)	DMUs (teams)	Division	Efficiency Scores before (during)
Bayern Munich	**Bundesliga**	0.910(1.000)	**Chelsea**	**Premier League**	0.714(0.865)
Borussia Dortmund		0.794(0.822)	**Newcastle United**		0.741(0.602)
Schalke 04		0.619(1.000)	**Wolverhampton Wanderers**		0.754(1.000)
VfB Stuttgart		1.000(1.000)	**Tottenham Hotspur**		0.604(0.817)
Borussia Monchengladbach		0.811(0.590)	**Juventus**	**Serie A**	0.959(0.861)
Werder Bremen		0.549(0.726)	**Inter Milan**		0.799(0.842)
1. FC Koln		0.512(0.418)	**AC Milan**		0.884(0.887)
Hertha Berlin		0.513(0.567)	**Genoa**		0.470(0.631)
Eintracht Frankfurt		0.745(0.681)	**Torino**		0.719(0.384)
VfL Wolfsburg		0.663(0.843)	**Bologna**		0.668(0.603)
Real Madrid	**La Liga**	0.788(1.000)	**AS Roma**		0.705(0.861)
FC Barcelona		0.814(0.867)	**Lazio**		0.827(0.748)
Atletico Madrid		0.945(0.943)	**SSC Napoli**		0.756(0.839)
Athletic Bilbao		0.887(0.767)	**Fiorentina**		0.456(0.631)
Valencia		0.793(0.691)	**Marseille**	**Ligue 1**	1.000(0.853)
Real Sociedad		0.784(0.645)	**Saint Etienne**		0.695(1.000)
Sevilla		0.831(1.000)	**Paris Saint-German**		1.000(0.956)
Real Betis		0.575(0.875)	**AS Monaco**		0.734(1.000)
Manchester United	**Premier**	0.777(0.839)	**Nantes**		0.797(0.487)

Liverpool	**League**	1.000(0.750)	**Olympique Lyonnais**		0.728(0.950)
Arsenal		0.688(0.847)	**Bordeaux**		0.677(1.000)
Everton		0.750(0.874)	**Stade de Reims**		1.000(0.759)
Aston Villa		0.553(0.789)	**Lille OSC**		0.858(0.911)
Manchester City		1.000(1.000)	**OGC Nice**		0.753(0.722)
Mean					**0.762(0.807)**

As concerning La Liga League, post-COVID-19, two teams were efficient: Real Madrid and Sevilla. Atletico Madrid was nearly efficient. FC Barcelona and Real Betis were moderately efficient. On the other hand, Athletic Bilbao appeared inefficient. Moreover, Valencia and Real Sociedad appeared severely inefficient DMUs. As concerning Premier League, post-COVID-19, two teams were efficient: Manchester City and Wolverhampton Wanderers. Manchester United, Arsenal, Everton, Chelsea, and Tottenham Hotspur were moderately efficient. In contrast, Liverpool and Aston Villa were inefficient. Moreover, Newcastle United appeared severely inefficient DMUs. As toward Serie A-League, post-COVID-19, five teams were moderately efficient: Juventus, Inter Milan, AC Milan, AS Roma and SSC Napoli. Besides, Lazio was inefficient, and each of Genoa, Torino, Bologna and Fiorentina seemed severely inefficient DMUs. Lastly, for Ligue 1 League, post-COVID-19, three teams were efficient: Saint Etienne, AS Monaco and Bordeaux. Paris Saint-German, Olympique Lyonnais and Lille OSC were nearly efficient. Marseille seemed moderately efficient. At the same time, Stade de Reims and OGC Nice appeared inefficient DMUs, and Nantes was severely inefficient DMUs.

It is worth noting that teams need to focus mainly on defensive tactics. When focusing on attacking tactics, teams leave defences exposed with huge spaces for the opposition to take advantage of. However, when the players participate in defending, the output results can be maintained or even increased while input will stay. For example, scoring the same number of goals but having a more stable defence that concedes less will lead to winning more matches and achieving more points. Not to mention having a healthy position in terms of goal differences.

Nevertheless, defending is a task that requires exerting more fitness than when in an attacking position. COVID-19 affected the fitness of all teams, so defending as an entire team of 11 players for 90 minutes would be a task that many teams cannot accomplish. Therefore, more drills that focus on increasing fitness and defending should be incorporated in the teams' training to maximise the outputs while maintaining the same inputs.

4.2 Results of the Malmquist Index models

The Malmquist index (MI) could appraise the relative efficiency change (progress or regress) over time. In the non-parametric framework, MI is measured due to the catch-up (or recovery) term and the frontier-shift (or innovation) term. Both terms arose from the DEA methodology.

Table 4, panel A reveals the first model summary of the Malmquist index for the relative efficiency changes regarding the top ten teams' performance during the study period. The results show, on average, a decline in the technical or managerial efficiency (effch) score of teams' performances by 1%.

Table 4: Malmquist DEA Index Summary

Panel A: Malmquist index summary-model 1 (Top 10 DMUs)											
DMUs (teams)	**Malmquist Index Summary**					**DMUs (teams)**	**Malmquist Index Summary**				
	effch	**techch**	**pech**	**sech**	**Tfpch**		**effch**	**Techch**	**pech**	**sech**	**tfpch**
AC Milan	1.035	2.124	1.000	1.035	2.199	**Hertha Berlin**	1.333	1.070	1.052	1.268	1.426
Tottenham Hotspur	1.488	1.081	1.469	1.013	1.608	**AS Monaco**	1.134	1.214	1.061	1.069	1.376
Real Madrid	1.000	1.579	1.000	1.000	1.579	**Real Betis**	1.227	1.044	1.075	1.142	1.282
Fiorentina	1.435	1.070	1.413	1.015	1.535	**Stade de Reims**	1.000	1.279	1.000	1.000	1.279
Werder Bremen	1.411	1.032	1.379	1.023	1.456	**Inter Milan**	1.050	1.146	1.046	1.005	1.203
Panel B: Malmquist index summary-model 2 (Top 10 DMUs)											
DMUs (teams)	**Malmquist Index Summary**					**DMUs (teams)**	**Malmquist Index Summary**				
	effch	**techch**	**pech**	**sech**	**tfpch**		**effch**	**techch**	**pech**	**sech**	**tfpch**
Real Betis	1.403	1.044	1.523	0.921	1.464	**Genoa**	1.281	0.996	1.344	0.953	1.276
Aston Villa	1.363	1.020	1.427	0.955	1.390	**Arsenal**	1.251	1.010	1.231	1.016	1.263
Tottenham Hotspur	1.380	0.985	1.353	1.021	1.360	**Sevilla**	1.218	1.035	1.204	1.011	1.260
Wolverhampton	1.346	0.992	1.326	1.015	1.335	**AS Monaco**	1.228	1.005	1.362	0.901	1.233
Fiorentina	1.300	1.019	1.383	0.940	1.325	**Real Madrid**	1.241	0.984	1.268	0.978	1.221

Notes: all Malmquist index averages are geometric means; effch = Technical efficiency change; techch = Technological change; pech = Pure technical efficiency change; sech = Scale efficiency change; and tfpch =Total factor productivity (TFP) change**.**

The Malmquist Index results of the total factor productivity show that 24 out of 48 teams improved their (tfpch) during the post-COVID-19 term. As the top five teams for relative efficiency with (tfpch>1) over the study period, AC Milan achieved the best relative performance during the post-COVID-19 term by increases 119.9% compared with the pre-

period, followed by Tottenham Hotspur, Real Madrid, Fiorentina, and Werder Bremen with an advance 60.8%, 57.9%, 53.5%, and 45.6% respectively. Furthermore, the improvements in the total factor productivity of these prime teams are connected to the technical or managerial efficiency changes of transforming inputs to outputs side by side technological efficiency changes.

Table 4, panel B reveals the second model summary of the Malmquist index for the relative efficiency changes regarding the top ten teams' performance during the study period. The results show, on average, a decline in the technical or managerial efficiency (effch) score of teams' performances by 3.5% with a decay in the technological efficiency (techch) score by 1%, which caused a reduction in the total factor productivity by 3.6%. Moreover, the Malmquist Index results of the total factor productivity show that 26 out of 48 teams improved their (tfpch) during the post-COVID-19 term. As the top five teams for relative efficiency with (tfpch>1) over the study period, Real Betis achieved the best relative performance during the post-COVID-19 term by increases 46.4% compared with the pre-period, followed by Aston Villa, Tottenham Hotspur, Wolverhampton Wanderers and Fiorentina with an advance 39%, 36%, 33.5%, and 32.5% respectively. Furthermore, the improvements in the total factor productivity of these prime teams are connected to the technical or managerial efficiency changes of transforming inputs to outputs.

4.3 Results of Statistical Tests

The adopted Malmquist Index showed that the teams' total factor productivity declined post-COVID-19 compared to the previous period (pre-COVID-19). Plus, complimentary tests were applied to check the extent of statistically significant variations among teams' scores pre and post the COVID-19 pandemic period.

Table 5: The results of Wilcoxon and Sign Tests

Efficiency Scores	Wilcoxon Signed Ranks Test		Sign Test	
	Z-statistic	P-value	Z-statistic	P-value
Model 1 (before vs during)	-0.270	0.787	-0.371	0.710
Model 2 (before vs during)	-1.743	0.081	-1.327	0.185
Notes: *p < 0.05; **p < 0.01				

Table 5 reveals some statistical tests via the Wilcoxon-test and Sign-test (through IBM SPSS Version 26). In addition, Wilcoxon-test and Sign-test were adopted considering the test of normality results through Kolmogorov-Smirnov and Shapiro-Wilk tests. Generally, the complementary tests for the current study models showed no significant proof of a change in the teams' efficiencies during the study period at the 5% significance level. Accordingly, H1 is not supported.

4.4 Results of the Tobit Regression Analysis

The Tobit regression analysis was utilised via robust standard errors technique to obtain unbiased regression analysis coefficients and avoid the main problems that hinder regression analysis, such as heteroscedasticity. Furthermore, the analysis was appropriated to recognise the effect of the variables regarding the inputs of the Malmquist DEA models on the relative efficiency scores for teams under investigation.

Table 6, panel A summarises the teams' relative efficiency drivers through the first study model by the Tobit regression analysis. The results of

panel C refer that the overall efficiency scores over the current study period were positively linked with the matches won in all competitions at a 0.05 significance level. Plus, there were negatively associated with the goals scored in all competitions at a 0.05 significance level. Commonly, the overall Tobit model results over the study period were significant at a 0.05 significance level.

Table 6, panel B summarises the relative efficiency drivers by the second study model. The results of all panels refer that the overall efficiency scores were positively associated with the total matches won at a 0.05 significance level. In contrast, the association was negatively significant with total goals scored and matches played. Thus, commonly, the results of the overall model were significant at a 0.05 significance level. Plus, it should be noted that the topic is not by the number of goals scored to obtain the best relative efficiency, but by the number of matches won (as an output) compared to the number of goals scored and matches played (as inputs). According to previous results, H2.1 and H2.2 are supported, while H2.3 is partially supported over the study period. It is worth noting that recognising the determinants of teams' relative efficiency is essential for decision-makers to promote policies and strategies involving continuous improvement and realise best practices.

Table 6: The results of Tobit regression

Panel A: Model 1 results over the study period				
Eff. Scores	**Coef.**	**Robust Std. Err.**	**t**	**P>|t|**
MWDL	.033526	.0066123	5.07	0.000**
MWDC	.0710377	.0304169	2.34	0.022**
MWEC	.0681483	.0208711	3.27	0.002**
GSDL	-.0094586	.0021829	-4.33	0.000**
GSDC	-.0126287	.005684	-2.22	0.029**
GSEC	-.0152275	.0070661	-2.16	0.034**
MPDL	-.0085973	.0054031	-1.59	0.115
MPDC	-.0176211	.0255773	-0.69	0.493
MPEC	-.0001714	.0093683	-0.02	0.985
_cons	1.327229	.1938782	6.85	0.000**
F(9, 87)	6.51			
Prob > F	0.0000**			
Pseudo R2	0.7567			
Log pseudolikelihood	-7.6756242			
Number of obs	96			

Panel B: Model 2 results over the study period				
TMW	.0391566	.0031194	12.55	0.000**
TGS	-.0075395	.0009783	-7.71	0.000**
TMP	-.013194	.0023753	-5.55	0.000**
_cons	1.117612	.0850083	13.15	0.000**
F(3, 93)	53.68			
Prob > F	0.0000**			
Pseudo R2	-10.6430			
Log pseudolikelihood	62.655534			
Number of obs	96			

Notes: *p < 0.1; **p < 0.05; MWDL=Matches Won in Domestic League; MWDC=Matches Won in Domestic Competitions; MWEC=Matches Won in European Competitions; GSDL=Goals Scored in Domestic League; GSDC= Goals Scored in Domestic Competitions; GSEC= Goals Scored in European Competitions; MPDL=Matches Played in Domestic League; MPDC= Matches Played in Domestic Competitions; MPEC= Matches Played in European Competitions; TMW= Total Matches Won; TGS=Total Goals Scored; TMP=Total Matches Played.

6. Economic Impact:

The interrelationship between economic, finance and football are strong and positive. As financial business, the football economy has also been affected by global economic conditions especially during the pandemic period. Football teams were forced to sell assets, implement internal depreciations and focus on exportations. It is known that the main revenue depends on Spectators, then comes from tickets sales, sponsorships, television rights and fans' donation. In general, economists assume that countries with higher per capita GDP should have better athletes since they can offer better equipment, infrastructure, healthcare systems and well stablished school systems which provides the required base to produce good athletes. In the other hand theses conditions well support the football teams to produce high revenue.

Based on the literature and recent studies, football has the potential to become the 17th largest economy in the world. The best leagues in the world are the perfect scenario for some of the best players, resulting in a number of successes achieved by both the national teams and the European clubs. These considerations are reflected in the economic impact of the meat industry, which accounts for about 2% of GDP in terms of its contribution to GDP. That said, we believe it is more important to emphasize how football has a positive impact on all other industries. [List of European countries by GDP: https://statisticstimes.com/economy/european-countries-by-gdp.php

Fig 1 shows he Gross Domestic Product (GDP) in European Union was worth 17088.62 billion US dollars in 2021, according to official data from the World Bank. The GDP value of European Union represents 12.78 percent of the world economy. source: World Bank

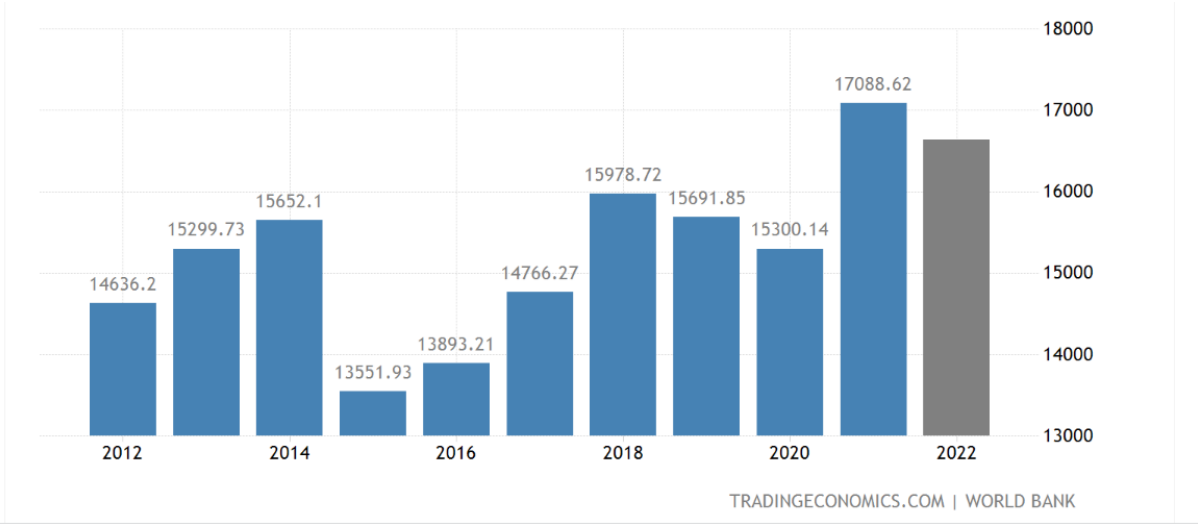

Fig 1: GDP in European Union - https://tradingeconomics.com/european-union/gdp

7. Conclusion

In this research paper, data envelopment analysis is applied on 48 different teams (DMUs) across Europe's top 5 football leagues to assess and compare relative efficiency in terms of performance pre and post COVID-19. The adopted first model's outputs comprised the number of Matches Won in all competitions, whether in the Domestic League and Cup; or in the European Competitions (Champions League and the Europa League), while the inputs comprised the number of matches played and goals scored in these competitions. However, the outputs for the second model include the number of Matches Won in all competitions, while the inputs included the number of total matches played in these competitions. Furthermore, the collected secondary data was before and after COVID-19 to compare and rank teams based on their relative efficiency scores. Following the results, the teams were classified according to five categories: relatively efficient, nearly efficient, moderate, inefficient, and severely inefficient.

The main findings of the first Malmquist DEA model included that out of the 48 teams analysed pre-COVID-19, about 68.75% of teams are relatively efficient (33 teams), 12.5% are nearly efficient (6 teams), 6.25% are moderate efficient (3 teams), 6.25% are inefficient (3 teams), and 6.25% are severely inefficient (3 teams). Nevertheless, post-COVID-19, about 60.42% of teams are relatively efficient (29 teams), 14.58% are nearly efficient (7 teams), 14.58% are moderate efficient (7 teams), 8.3% are inefficient (4 teams), and 2.1% are severely inefficient (one team).

At the same time, the findings of the second Malmquist DEA model involved that out of the 48 teams analysed pre-COVID-19, about 12.5% of teams are relatively efficient (6 teams), 6.25% are nearly efficient (3 teams), 14.58% are moderate efficient (7 teams), 37.5% are inefficient (18 teams), and 29.17% are severely inefficient (14 teams). Nonetheless, post-COVID-19, about 20.8% of teams are relatively efficient (10 teams), 8.3% are nearly efficient (4 teams), 31.25% are moderate efficient (15 teams), 14.58% are inefficient (7 teams), and 25% are severely inefficient (12 teams).

Moreover, the models' findings through the Malmquist DEA index revealed that about 50% to 54.17% of teams regarding both adopted models boost their total factor productivity scores. Plus, the annual means findings reveal that the technical efficiency changes and technological efficiency changes were the primary references for enhancing the total factor productivity index. Furthermore, the complementary tests through the Wilcoxon-test and the Sign-test confirmed that there were no

significant differences in teams' efficiencies among the pre and post COVID-19.

Furthermore, the Tobit regression analysis findings showed that the overall efficiency scores are positively associated with the overall matches won in all competitions. Besides, the overall efficiency scores are negatively associated with the overall goals scored and matches played in these competitions. That confirms that the matter is not to obtain the best relative efficiency by the number of goals scored, but by the number of matches won compared to the number of goals scored and matches played. Naturally, these findings may be helpful for managers and decision-makers to promote strategies and policies related to the continuous improvement process.

Economically, it is recommended that all the inefficient teams to implement the suggestions to improve the efficiency by wining matches regardless the number of goals as much they can through promote strategies and policies related to the continuous improvement process to increase their revenue which will affect directly the per capita GDP percentage related to the football industry.

The future work could include considering more seasons after COVID-19 and comparing it to the same number of seasons pre-COVID-19. Moreover, the future work can also incorporate several titles won during more seasons as an output in the DEA and uncertain variables, which needs integration of stochastic DEA models (Mourad et al., 2019). Besides, the limitation of the current study is that the data do not include titles won since the first season post-COVID-19. In addition, more economical analysis should be conducted as per of the collected data.

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