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# Performance Assessment of European Football Teams: Using Stochastic Data Envelopment Analysis Model

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**Abstract:** Data Envelopment Analysis (DEA) is a powerful mathematical optimization method widely used for measuring, evaluating and improving the performance of Decision Making Units (DMUs). These used in the various forms, such as hospitals, government agencies, educational institutions, air force, bank branches, business firms, sport teams and even people including the performance of countries, regions, etc. Recently DEA has been extended to examine the performance through the different sport types. In this paper, a Stochastic Input Oriented Data Envelopment Analysis (SIODEA) Model is conducted for measuring and evaluating the relative efficiency scores of football teams selected from different European countries during 2014/2015 season each with some of inputs are stochastic with normally distributed and recent inputs are deterministic and outputs, to shed light on the professional football teams performance.

**Keywords:** Data Envelopment Analysis; Stochastic Variables; Efficiency Measurement; Football Efficiency; Performance Assessment.

## 1. Introduction

Assessment of performance is a crucial component of the management process in any type of organization (i.e. educational institutions, banks, business firms, hospitals, sport teams, etc.…). Today's Sports life takes a very important place as a mean to stay fit and healthy along with the entertainment. Sports are considered one of the types of competitive activity via casual or organized involvement, aiming to use, maintain or enhance skills while providing entertainment to players and spectators. Usually any game is between two sides either individuals or teams, each trying to win the opponent. Some sports allow a draw game; others provide tie-breaking method, to ensure that there is a winner and a loser at the end of the game. A number of such two sided games may be arranged in a game producing a champion. Many sports leagues make an annual champion by arranging games in a regular sports season, followed in some cases by playoffs. It has several various kinds such as football, basketball, tennis, handball, volleyball, cricket, etc…

Football is considered the most popular sport in most countries around the world, especially in Europe for many reasons:

(1) In England 1863 was introduced, also in England the first football association was formed.

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(2) The famous top leagues in the world are the European leagues such as Spain, England, Italy, and Germany.

(3) The most prestigious club competition in European football and one of the most prestigious tournaments in the world is considered the Champions League.

In addition to, football sports is considered the most widely followed sport. Since in over 200 countries around the world, it is played by approximately 250 million players and over 1.3 billion are interested people in football sports; a combined television audience of more than 26 billion watched football tournaments in 2010 [1, 2]. In European football there are many various forms of competitions which are national (domestic) competitions including league and cup for each country and after finishing in a domestic league at top position, teams qualify for playing in the international competitions such as the Europa (UEFA) League and Champions League. Given the behavioral objectives set by the football clubs, it makes evaluating the efficiency of football teams is not an easy task.

DEA as originally proposed by Charnes et al. [3], is a non-parametric frontier estimation methodology based on mathematical programming for evaluating the relative efficiencies and performance of a collection of related comparable entities (called Decision Making Units or DMUs) in transforming multiple inputs into multiple outputs. The objective of DEA approach is to assess the relative efficiency of each DMU in relation to its peers with the result as a classification of all DMUs as either "efficient" or "inefficient". Not only classifying the DMUs, but also determining the level of inefficiency and the corresponding amount to enhance the performance [4]. In addition to, the main DEA advantage is that it does not require any prior assumptions on the relationships between the input variables and output variables [5].

There are many publications that address the applications of DEA in different sectors of sports and especially in football. Haas [6] used the traditional DEA model to assess the relative efficiency of 20 English football teams in the 2000/01 season to investigate how close to their potential English Premier League Clubs play. Haas et al. [7] applied the deterministic CRS (Constant Return to Scale) and deterministic VRS (Variable Return to Scale) DEA models for studied the relative efficiency of the German football teams in the 1999/2000 season. Barros and Santos [8] used deterministic DEA model to measure and analyze the relative efficiency of the Portuguese football clubs in their football league. Barros and Leach [9] used DEA to assess the performance of English Premier League football clubs from 1998/99 season to 2002/03 season.

García-Sánchez [10] applied the DEA deterministic model to measure the offensive and defensive efficiency during the 2004/05 season for Spanish football teams. Boscá et al. [11] used DEA model to evaluate and analyze the relative efficiency during seasons from 2001/02 to 2002/03 for Italian and Spanish football teams in order to detect differences between their performance when they play at home and away. González-Gómez and Picazo-Tadeo [1] applied DEA technique to assess the sporting performance of Spanish football teams during seasons from 2001/02 to 2006/07 at League, King's Cup and European competitions. Picazo-Tadeo and González-Gómez [12] evaluated the relative efficiency of Spanish football teams using traditional DEA model from seasons 2001/02 to 2007/08 in the League controlling, and for the extra games played in the King's Cup, Champions League and UEFA Cup. Hamidi et al. [13] utilized DEA technique for evaluating the relative efficiency of the Iranian teams that played in their premier football league. Kounetas [14] applied DEA deterministic model to examine the relative efficiency of Greek football clubs, taking into account an 8-year-period which has been divided into two intervals before the Euro 2004 victory from 2000 to 2004 and after the Euro 2004 victory from 2005 to 2008.

Zambom-Ferraresi et al. [15] evaluated the sports performance during seasons from 2004/05 to 2013/14 via DEA approach for the teams that have participated in the Union of European Football Associations, Champions League.

From all the previous applications, and Kounetas [14], we have reached to:

(1) Most of the DEA applications that were related to determining the efficiency of football teams, it was obvious that those applications focused on comparing teams within the same country, such as England, Spain, Portugal, Brazil and Germany.

(2) Little (if not none), was oriented on comparing the efficiency of football teams from different countries with each other. A team's efficiency measure could not necessarily depend only on the domestic league competition, but could also depend on its performance in the domestic cup competition and/or the international league competitions based on the team's level, e.g. Europa League and Champions League.

(3) In all the previous applications, and to our knowledge, in most of the DEA applications related to football sector, the DEA applied in measuring the efficiency was deterministic, i.e. the input and output variables are deterministic in nature. This is not necessarily true for all variables, some of these variables could be stochastic.

Therefore, in this research we are looking forward to applying the stochastic DEA model in the football sector to evaluate the performance of the 64 European football teams based on the domestic competitions (league and cup) and the European international competitions (Europa League and Champions League).

The rest of the paper is organized as follows. The coming section addresses the methodology of the stochastic DEA model. The third section discusses the data identification and period of study. In the fourth section, we present the analyses and findings. The paper will end with the conclusions and implications for the future.

## 2. Methodology

The basic DEA model is developed by Charnes et al. [3] working under the concept of CRS, which means regardless of the size of the DMU, the outputs change in direct proportion to the change in inputs, assuming that the scale of operations does not influence efficiency. Then extended by Banker et al. [16] under the concept of VRS, which means changing inputs may not result in proportional changes in outputs, a preferred DEA assumption. El-Demerdash et al. [4] modified the standard DEA model to measure the relative efficiency in the presence of random variation in some of inputs from given outputs. In the Chance Constrained Input Oriented DEA Model, the outputs are assumed to be deterministic while some of inputs are stochastic variables and remaining inputs are deterministic variables, each stochastic input $x_j, j \in J_S$ is normally distributed with mean $\mu_p$ and variance $\sigma_p^2$ and the relation between the same stochastic input variable through different DMUs is dependent, this means $cov(x_i, x_p) \neq 0$ .. The chance-constrained DEA model builds on the method of CCP and is as showed below:

$$\text{Min } Z_p = \theta$$

$$s.t.$$

$$\sum_{i=1}^{n} \lambda_i \mu_{ij} - \theta \mu_{pj}$$

$$\leq e \sqrt{\sum_{\substack{i=1 \\ i \neq p}}^{n} \lambda_i^2 \sigma_{ij}^2 + (\lambda_p - \theta)^2 \sigma_{pj}^2 + 2cov(x_{ij}, x_{pj})},$$

$$\forall m = 1, \dots J_S$$

$$\sum_{i=1}^{n} \lambda_i x_{ij} \leq \theta x_p \ , \qquad \forall j = 1, \dots \dots . J_D$$

$$\sum_{i=1}^{n} \lambda_i y_{ik} \geq y_p \ , \qquad \forall k = 1, \dots \dots . K$$

$$\sum_{i=1}^{n} \lambda_i = 1, \qquad \forall i = 1, \dots \dots . n$$

$$\lambda_i \geq 0, (i = 1,2, \ldots., n)$$

Where $\theta$ = efficiency score of DMU$p$; $k = 1$ *to* $K$ (no. of outputs); $m = 1$ *to* $J_D$ (no. of deterministic inputs); $j = 1$ *to* $J_S$ (no. of stochastic inputs); $i = 1$ *to* $n$ ( no. of DMUs); $y_{ik}$ = amount of output k produced by DMU $i$; $x_{ij}$ = amount of input j utilized by DMU $i$; $\lambda_i$ = weight given to DMU $i$.

## 3. Data Collection and Period of Study

The determination and selection of study variables is considered an important issue in any performance study analysis. Based on our study of the factors that affect the performance of football teams, the survey by [14] on data for football events, and the data availability issues, we came up with a set of variables consisting of 4 stochastic input variables, 4 deterministic input variables and 4 output variables to be considered in this study. This research contains the data of 64 European football teams in order to measure and compare their performance. These teams were all teams have played in one of the European international competitions, either the Champions League or the Europa League or both in the 2014/15 season. Our dataset is collected from kooora.com website, which is considered the top Arabic website for football, providing statistics for the Arab and international competitions with analysis of all football events.

The main input variables consist of eight variables divided into four deterministic input variables, which are the number of overall matches played in domestic competitions, the number of overall against goals in domestic competitions, the number of overall matches played in international leagues competitions, and the number of overall against goals in international competitions. Four stochastic input variables, which are the average number of overall for goals in domestic competitions, the average spectators attendance in domestic competitions, the average number of overall for goals in international competitions, and the average spectators attendance in international competitions.

On the other hand, the main selected output variables are for which are: the number of overall matches won in domestic competitions, the number of overall matches won in international leagues competitions at home, the number of overall matches won in international leagues competitions away, and the number of competitions won throughout the season in domestic competitions (league, cup and super cup) and in international competitions (Europa League, Champions League and European super cup).

## 4. Results and Discussion

As mentioned earlier in section 1, this research aimed to measure and analyze the relative efficiency of 64 European football teams taking into consideration their contributions in the domestic competitions in the 2014/15 season and took part in the Europa League or Champions League by utilizing an input oriented stochastic DEA model. In general the DEA technique, teams are identified as fully efficient and assigned an efficiency score of unity. Inefficient teams are assigned scores of less than unity. Given the selected variables, we formulated the stochastic DEA problem for each DMU (team). The results are presented in Table 1. The results show that 34 teams (i.e. 53%) are efficient teams this means achieved the maximum efficiency score of 1 and the remaining 30 teams (i.e. 47%) are inefficient with efficiency scores are between 0 and 1. Also, it can be noted that the minimum efficiency is AS Roma team with a score of 0.762. On the other hand, the results for inefficient teams show that 2 teams with efficiency scores are less than 0.8, 10 teams with efficiency scores are between 0.8 and less than 0.9, and 18 teams with efficiency scores are between 0.9 and less than 1.

The most advantage of DEA model in general is the ability to give the improvement recommendations for each inefficient team through either decreasing the input used or increasing the output produced or both. In this context, for example consider a case of:

- Team 25 (AS Roma) whose relative efficiency score is 0.762. It is recommended to increase the number of matches played in international leagues by 2.5 (i.e. 3) and increase the number of international goals for by 5.6 (i.e. 6) in addition to reduce the number of international goals against by 3.2 (i.e. 4).
- Team 8 (Manchester City) whose relative efficiency score is 0.864. It is not real to improve the relative efficiency recommended to reduce the number of matches played in domestic leagues, Therefore it is recommended to increase the number of won matches played in domestic leagues 1.4 (i.e. 2). On the same basis, the total competitions won needs to improve by 1.3 or 2 competition either domestic or international.
- Team 19 (Paris Saint-Germain) whose relative efficiency score is 0.931. It is not real to improve the relative efficiency recommended to reduce the number of matches played in international leagues, therefore it is recommended to increase the number of won matches played at home in international leagues 0.12 (i.e. 1) and also, for Away matches increase by 0.89 (i.e. 1). On the same basis, it needs to increase the number of international goals for by 1.1 (i.e. 2) and reduce the number of international goals against by 0.91 (i.e. 1).

## 5. Conclusion

This research applied the input oriented stochastic DEA model to evaluate and measure the relative efficiency of 64 European football teams from which are ranked amongst the top five sporting clubs in their domestic leagues in addition to have played in one of the European international competitions, either the Champions League or the Europa League or both in the 2014/15 season. The analysis was built based on 12 input and output variables divided to 4 stochastic input, 4 deterministic input and 4 output variables. The result shows that 34 teams (i.e. 53%) are efficient teams and the remaining 30 teams (i.e. 47%) are inefficient teams.

**Table 1 Efficiency Scores.**

| Team | Team Name | Efficiency | Team | Team Name | Efficiency | Team | Team Name | Efficiency |
|---|---|---|---|---|---|---|---|---|
| 1 | Real Madrid CF | 1 | 23 | Saint Etienne | 0.974 | 45 | Besiktas | 1 |
| 2 | FC Barcelona | 1 | 24 | Juventus FC | 1 | 46 | Galatasaray Spor | 1 |
| 3 | Atletico de Madrid | 1 | 25 | AS Roma | 0.762 | 47 | Bursaspor | 1 |
| 4 | Villarreal CF | 0.799 | 26 | SSC Napoli | 1 | 48 | TrabzonSpur | 0.989 |
| 5 | Sevilla CF | 1 | 27 | ACF Fiorentina | 0.877 | 49 | Olympiacos CFP | 1 |
| 6 | Athletic De Bilbao | 0.850 | 28 | Internazion-ale | 0.876 | 50 | Asteras Tripolis FC | 0.909 |
| 7 | Chelsea FC | 1 | 29 | Torino | 1 | 51 | PAOK FC | 0.979 |
| 8 | Manchester city | 0.864 | 30 | PSV Eindhoven | 1 | 52 | Panathinaikos | 0.889 |
| 9 | Arsenal FC | 1 | 31 | Ajax Amsterdam | 0.911 | 53 | Ludogorets Razgrad | 1 |
| 10 | Tottenham Hotspur | 1 | 32 | FC Twente Enschede | 1 | 54 | RSC Anderlechet | 0.869 |
| 11 | Liverpool | 0.858 | 33 | Feyenord Rotterdam | 0.932 | 55 | Club Brugge KV | 1 |
| 12 | Everton | 0.955 | 34 | FC Groningen | 1 | 56 | FC Basel | 0.902 |
| 13 | Bayern Muinch | 1 | 35 | FC Dynamo Kyiv | 1 | 57 | FC Zurich | 0.929 |
| 14 | BV Borussia Dortmund | 0.881 | 36 | FC Shakhtar Donetsk | 0.963 | 58 | BSC Young Boys | 1 |
| 15 | Bayer 04 Leverkusen | 1 | 37 | FC Dinpro DinproPetrovsk | 1 | 59 | FC Bate Borisov | 1 |
| 16 | VfL Wolfsburg | 0.867 | 38 | Zenit St.Petersburg | 1 | 60 | NK Maribor | 0.987 |
| 17 | Schalke 04 | 1 | 39 | CSKA MoKova | 0.994 | 61 | Malmo FF | 0.945 |
| 18 | Borussia Monchengladbach | 0.899 | 40 | SL Benfica | 1 | 62 | Steaua Bucurest | 1 |
| 19 | Paris Saint-Germain | 0.931 | 41 | FC Porto | 1 | 63 | Red Bull Salzburg | 0.991 |
| 20 | AS Monaco FC | 1 | 42 | Sporting CP | 0.897 | 64 | AC Sparta Prague | 1 |
| 21 | Lille OSC | 0.830 | 43 | GD Estoril | 0.935 | | | |
| 22 | Olympique Lyonnais | 1 | 44 | CD Nacional Funchal | 1 | | | |

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