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# Two Stage Approach for the Performances of Teams in Football Using Data Envelopment Analysis

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**Abstract**

Football is a very popular subdivision of sports for our country, as all around the world and the money spent for football is on a large scale. In spite of this, scientific studies interested in the statistical, economical dimensions and performance evaluation for the football are scarce in our country even in the world. One of the reasons of this is not to record football statistics in our country. FIFA statistics can be hold as a sample in this field. FIFA, holds about fifty numbers of different football statistics at player basis or team level during the World Cup matches. It is obvious that the performance of players one by one and as an entire and the team's performance is so important. The goal of this study is to pioneer for how the performance analysis is applied and how its results can be benefited in football if the statistics are recorded. Displaying the numerical size of defectiveness mathematically also helps trainers and players. On the other hand, the output oriented CCR model of data envelopment analysis and super efficiency model AP were used.

## 1. INTRODUCTION

In the last quarter of the century, compared to the other sport branches such as baseball, rugby, volleyball, handball, basketball, athletics, boxing, football has come into a more popular position all around the world. Football has more advantages in terms of competition among all sport branches, since, it is a simple game and also it is not necessary to have expensive equipment to play football.

Football has become the indispensable component of civil society and culture in the countries where football is number one in all of the sport branches. The decisions of referees, the tactics and strategies of coaches and teams, the faults of players are components of unending debates. The debates are spread from television channels and newspapers to streets, workplaces, schools and homes, in other words, all of the people in the country participate in debates related with football. Behind these, the success of the national football team is celebrated in all cities of the country. Traffic stops and squares are converted into festival situation with cars, people and waved flags. All diversities and dissimilarities between people disappear. The greater the win is, the higher the festival show is. Football plays a big role in acquiring national identification with this aspect. Football trains and educates people in the character and meaning of living together and also it provides people to adapt themselves into the social life.

Parallel to its rising process, football also have become a commercial resource with an increasing acceleration. It is observed that some of the football teams reach the budgets stated with hundreds of million dollars when TV broadcasting rights income and the income achieved from their supporters and sponsors are summed up. For example, it is stated that the income of Manchester United from England Premier League for 13/14 season is £433m, and the income of Bayern München including an operating income for 14/15 season is $106 million (Jones, 2015). When all of the teams in any of the country are taken into consideration, it is realized that the football sector forms an important commercial area.
In spite of its significant economic and social functions, there is not so many scientific studies related with football in terms of performance evaluations and statistical and economical dimensions. On the other hand, there exist studies about performance evaluations in the other sport branches. Especially,

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there are several scientific studies in topics of professional baseball, basketball and American football. (Anderson, 1997; Carmicheal, 1995; Fizel, 1996; Hofler, 1997).

Performance evaluation in football can be done according to the points of view stated below:

- The efficiency of football director and coach: The input and outputs which are based on the experience of coach and directors are taken into consideration. These studies can be counted as examples for this point of view. (Scully, 1994; John, L. and D'itri, M., 1996; Dawson and Dobson, 2002; Tiedemann et al., 2011; Santín, D., 2014)

- The efficiency of the team in the match: It is measured with inputs as ball possession of players, corner kicks, shots, penalty kicks and with outputs as the number of goals and match results. The study of Carmichael and et al., 2000; Alp, İ., 2006; Boscá, J. E., Liern, V., Martínez, A., & Sala, R., 2009; González-Gómez, F., & Picazo-Tadeo, A. J., 2010 can be given as an example.

- The efficiency of team or teams during the season: The season is thought of as a process. Cumulative efficiency is calculated thanks to the data which are held every week. According to the different aims and expectations, different ways can be thought of in this point of view. Some of the studies which take place at this point of view are Carmicheal and Thomas, 1995, Hofler and Payne 1997; Villa, G., & Lozano, S., 2016. The studies which have been done at this point of view until now are income and management oriented. This study can be also included into this group. However, it is different in terms of its point of view and the modeling method. In this study, performance evaluation was tried to be measured in terms of game side of the football. The proposed team performance evaluation model is composed of three different pieces: The Goalkeeper efficiency, the team attack efficiency and the team defense efficiency. This will be the first team evaluation oriented study done in football literature.

In this study, the validity of ordering (ranking) of teams will be tested according to the performance results of teams obtained thanks to the proposed team performance evaluation model. The teams have qualified to attend into the FIFA World Cup at the end of a two-year long period of time. On the other hand, FIFA World Cup process is a short season. The evaluations done in this study reflect only this short period.

For the team performance evaluation, multi-input and multi-output must be taken into consideration simultaneously. Simultaneous evaluation can be done either by determining the distribution function of the process or by assigning weights to the inputs and outputs. Determining the distribution function is a time-consuming process and the probability of making mistake in this process is very high. The weights which will be assigned into the inputs and outputs can be found either in a subjective manner by determining before or with the help of a model in an objective manner. The weights determined subjectively are open to the discussions. These weights may cause the right criticisms of the researchers. The weights can be found with the help of model by Data Envelopment Analysis (DEA) in an objective manner in performance evaluation. (Charnes and et al. 1978). This method selects the weights so as to maximize the performance value of the evaluated Decision Making Unit (DMU), each of the teams in this study.

## 2. METHOD

### 2.1. Data Envelopment Analysis

DEA is a new methodology which calculates the relative performance scores of various decision making units by the operation research methods. Performance calculation is in a multi-variable and complicated structure. The other methods used for this aim has drawbacks (for instance, the predetermined weights method).
Initially, DEA was thought of especially for the performance calculation of non-profit DMUs. However, it became widespread, and it was applied to the various areas as the efficiency of military operations,

commercial banks, universities, hospitals and agricultural cooperatives. (Banker, R.D., et al., 2004, Grosskopf, S., et al., 2004, Gattoufi, S., et al., 2004).

In DEA, efficient production frontier is determined without a defined function via input and outputs. DEA constitutes reference points by taking the data into consideration. The DMUs which constitute the reference points take the entire performance Score (1 or 100), whereas the performance values of less efficient DMUs are bigger than 1 or 100 (in output oriented model).

In DEA, different mathematical models are used. (Charnes, A., 2013). The output oriented model CCR (1) which will be used in this study is defined as below. Behind the efficiency scores, the model provides the lacks in outputs and excesses in the input.

$$\begin{aligned} &\min_{\theta,\lambda,S^+,S^-} h_0 = \phi_0 + \varepsilon \sum_{r=1}^{s} S_r^+ + \varepsilon \sum_{i=1}^{m} S_i^- \\ &\phi_0 y_0 - \sum_{j=1}^{n} y_{rj}\lambda_j + S_r^+ = 0 \\ &\sum_{j=1}^{n} x_{ij}\lambda_j + S_i^- = x_{i0} \\ &\lambda_j, S_r^+, S_i^- \geq 0 \\ &j = 1,2,\dots,n \; i = 1,2,\dots,m \quad r = 1,2,\dots,s \end{aligned} \tag{1}$$

Where $x$ is the vector of the inputs, $y$ is the vector of outputs of teams; $\varepsilon$ is the infinitesimal non-Archimedian constant, which ensures that no input or output is allocated zero weight; $S^+$ and $S^-$ are the slack vectors of the outputs and inputs; $\phi$ is the scalar variable that represents the possible radial augmentation and $\lambda$ is the vector whose optimal values form a combination of units that make up the performance of the team under analysis and establishes a direction in which to identify the source of in efficiency of the team.

If the performance score of $h_0 = 1$ (or 100) and the all of the residual variables of $S^+$ and $S^-$ are equal to zero, then $DMU_o$ is fully efficient. If the performance score of $h_0 > 1$ (or 100), then $DMU_o$ is an inefficient DMU.

## 3. APPLICATION

### 3.1. FIFA World Cup and Data

FIFA was founded in 1904 by seven European countries under the leadership of France. In the following years, participations from Africa and America occurred. First world cup with a wide participation was done in 1930. This organization was the beginning of a new and successful century for football. Today, FIFA is the top promoter of more than 200 Sport Associations.

Teams can participate in the FIFA World Cup by passing eliminations arranged in different regions. It is composed of Europe (UEFA), Asia (AFC), Africa (CAF), North-Central America and Caribbean (CONCCAF), Oceania (OFC) and South America (CONMEBOL) regions. For each of the region, teams achieve participation ability with a different method and different number of teams achieve from each of the regions. Totally, 32 countries (15 of them from UEFA, 4 from AFC, 5 from CAF, 3 from CONCACAF, 0 from OFC and 5 from CONMEBOL) qualified to participate in the 2002 FIFA World Cup.

The abbreviations of the 32 countries are as follows: Argentina (ARG), Belgium (BEL), Brazil (BRA), Cameroon (CMR), China (CHN), Costa Rica (CRC), Croatia (CRO), Denmark (DEN), Ecuador (ECU), England (ENG), France (FRA), Germany (GER), Italy (ITA), Japan (JPN), Kingdom of Saudi Arabia (KSA), Korea Republic (KOR), Mexico (MEX), Nigeria (NGA), Paraguay (PAR), Poland (POL), Portugal (POR), Republic of Ireland (IRL), Republic of South Africa (RSA), Russia (RUS), Sénégal (SEN), Slovenia (SVN), Spain (ESP), Sweden (SWE), Tunisia (TUN), Turkey (TUR), United States (USA) and Uruguay (URU).

The world cup which began with the France and Senegal match played on 31th May 2002 in the capital city of South Korea, Seoul ended with Germany and Brazil match played in 30th June 2002 in the city of Yokohama, Japan. The statistics of players and teams which were held during the world cup are in the official web site of FIFA.

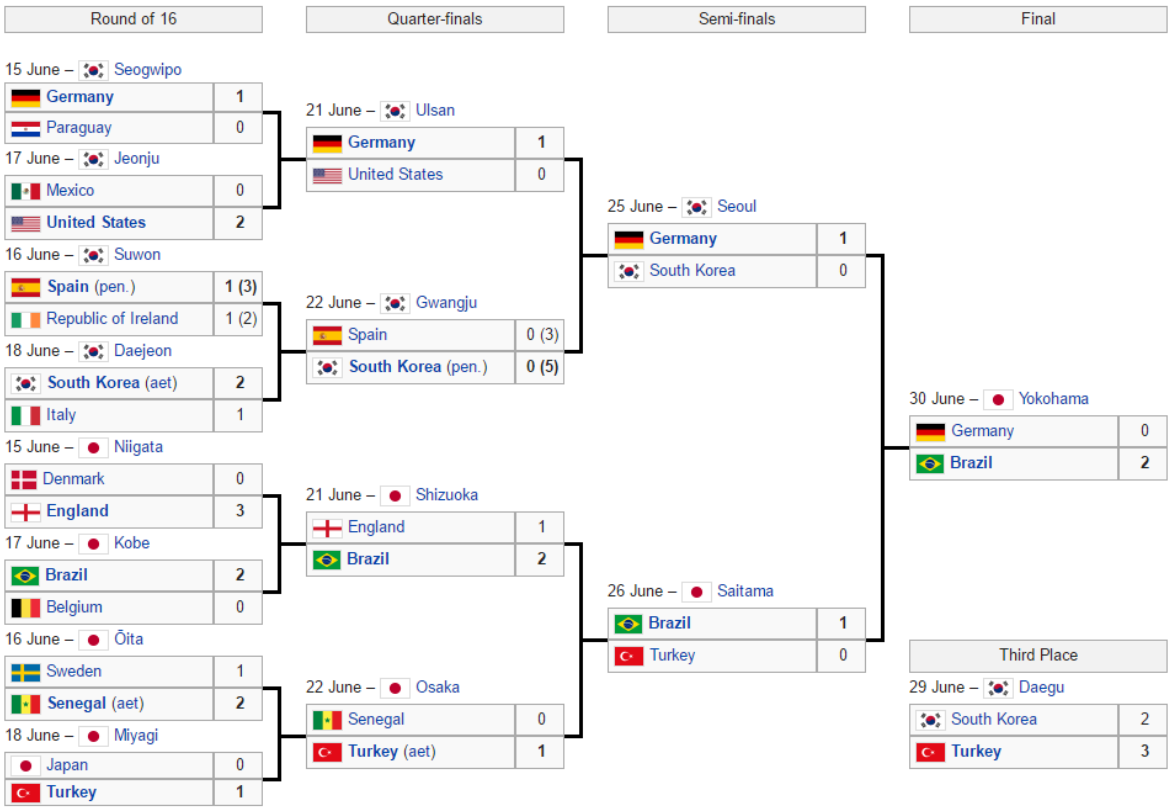


***Figure 1.*** *World Cup Final*

Ref: available at: https://goo.gl/GG6eGm (accessed 15 February 2017).

In football, team performance can be thought of as the resultant of the successes of goalkeeper, attack and defense players. For that reason, the team performance will be calculated in two steps. Firstly, the goalkeeper, defense and attack performances of the teams will be calculated, then by taking the average of the values of these three pieces, the performances of the teams will be obtained.

### 3.1.1. Data and Performance of the Goalkeepers of the Teams

The summary statistics of raw data of Goalkeepers of 2002 FIFA World CUP were stated in Table 1 below. In the official web site of FIFA, there exist statistics belonging to the 36 Goalkeepers of 2002 FIFA World Cup. 4 of these Goalkeepers (Dabanovic M. (SVN), Enyeama V. (NGA), Tavarelli R. (PAR), Catkic O. (TUR), Majdan R. (POL)) were excluded from the analyses since they took place in matches in short periods and they were the second goalkeeper of their teams.

In Table 1, there are seven variables, which can be qualified as output variables. In order to provide the right mechanism of the method, some of these variables will have meaningful transformations; on the other hand, some of them will be represented with the new variables. Since the World Cup is elimination oriented, each of the Goalkeepers cannot play in equal number of matches. For that reason, the all variables will be divided by the number of MP. For all of the Goalkeepers, the input value will be assumed as 1.
The output variables, which will be used in the application, are:

GAa (GA / MP): Goal Againts Average. This variable affects the performance of the goalkeeper negatively. According to this variable, Al Deayea M. (KSA) has the highest GAa value in Table 3. This variable was adjusted again to provide Al Deayea to have the lowest value 0.

***Table 1.*** *The Summary Statistics of Goalkeepers of 2002 FIFA World Cup*

| | MP Matches Played | GA Goals Againts | PKS Penalty Kicks Saved | FKS Free Kicks Saved | CKS Corner Kicks Saved | FBS Fast Breaks Saved | IS Individual Saves |
|---|---|---|---|---|---|---|---|
| Mean | 3,88 | 4,84 | ,16 | 1,25 | ,53 | ,88 | 13,09 |
| Median | 3,00 | 5,00 | ,00 | 1,00 | ,00 | ,50 | 11,50 |
| Mode | 3 | 3[a] | 0 | 1 | 0 | 0 | 8 |
| Variance | 2,113 | 4,007 | ,201 | ,903 | ,386 | 1,597 | 44,668 |
| Range | 5 | 10 | 2 | 3 | 2 | 6 | 33 |

a. Multiple modes exist. The smallest value is shown

The other variables affect the performance of goalkeepers positively. These are:
PKSa (PKS / MP): Average of Penalty kicks saved.
FKSa (FKS / MP): Average of Free Kicks Saved.
CKSa (CKS / MP): Average of Corner Kicks Saved
FBSa (FBS / MP): Average of Fast Break Saved.
ISa (IS / MP): Average of Individual Saves.

12 of 32 national Goalkeepers were efficient, in other words, their performance scores were found entire (1 or in other words 100%). In Table 2, the efficient goalkeepers, the weights of the variables in efficient goalkeepers and their number of references (Benchmarks) to the inefficient goalkeepers were stated.

Kahn O. achieved the whole performance score by weight of 99% with Goal Againts Average (GAa) variable and by weight of 1% with Average of Fast Break Saved (FBSa) variable. Recber R. achieved the whole performance score by weight of 63% with Goal Againts Average (GAa) variable and by weight of 37% with Average of Individual Saves (ISa). Barthez F. Achieved the whole performance score by weight of 100% with only Average of Fast Break Saved (FBSa) variable. In the whole performance score of Chilavert J. L., Average of Individual Saves (ISa) variable had an important role with the weight of 95 %. In the whole performance score of Shorunmu I., Average of Free Kicks Saved (FKSa) variable played a role with a weight of 90 %.

***Table 2.*** *Efficient Goalkeepers*

| | Goalkeepers (DMU) | Score | GAa | PKSa | FKSa | CKSa | FBSa | ISa | Benchmarks |
|---|---|---|---|---|---|---|---|---|---|
| 2 | KAHN Oliver (GER) | **100** | 0.99 | 0 | 0 | 0 | 0.01 | 0 | 14 |
| 4 | RECBER Rustu (TUR) | **100** | 0.63 | 0 | 0 | 0 | 0 | 0.37 | 7 |
| 7 | FRIEDEL Brad (USA) | **100** | 0 | 0.74 | 0.11 | 0 | 0 | 0.14 | 1 |
| 3 | IKER CASILLAS (ESP) | **100** | 0.82 | 0.13 | 0 | 0.05 | 0 | 0 | 0 |
| 18 | BUFFON Gianluigi (ITA) | **100** | 0.28 | 0.22 | 0 | 0.13 | 0 | 0.36 | 0 |
| 26 | PLETIKOSA S (CRO) | **100** | 0.58 | 0 | 0 | 0.35 | 0 | 0.08 | 7 |
| 9 | CHILAVERT J L (PAR) | **100** | 0 | 0 | 0 | 0.05 | 0 | 0.95 | 3 |
| 32 | BARTHEZ Fabien (FRA) | **100** | 0 | 0 | 0 | 0 | 1 | 0 | 7 |
| 29 | BOUMNIJEL Ali (TUN) | **100** | 0.45 | 0 | 0.34 | 0.21 | 0 | 0 | 2 |
| 27 | ALIOUM Boukar (CMR) | **100** | 0.79 | 0 | 0.21 | 0 | 0 | 0 | 7 |
| 28 | SHORUNMU Ike (NGA) | **100** | 0 | 0 | 0.9 | 0 | 0.1 | 0 | 8 |
| 22 | DUDEK Jerzy (POL) | **100** | 0 | 0 | 0.14 | 0.76 | 0.1 | 0 | 2 |

In DEA, the efficient goalkeepers were shown as references (models, peers, Benchmarks) to the non-efficient goalkeepers in terms of their deficient points (variables). A large number of reference times is

a positive indicator for the referenced goalkeeper's career. Kahn O. was chosen 14 times as sample for the 20 non-efficient goalkeepers. This frequency is equal to the two times of the referenced times of the other efficient goalkeepers. Iker C. and Buffon G. could not be a reference to any of the non-efficient goalkeepers.

The goalkeepers who do not have a whole performance score of (1, 100%), in other words non-efficient goalkeepers and their performance scores were stated in Table 3. In addition to this, the referenced efficient goalkeepers for the non-efficient goalkeepers and the weights (ratios) of these referenced efficient goalkeepers, the shortage (deficiency) amount in output variables of non-efficient goalkeepers were listed and denoted in Table 3.

Output oriented model (CCR) was used in calculating the performance scores of goalkeepers, team attack and team defense. In output oriented models, the whole performance score of 100 (or 1) is assigned to the efficient Decision Making Unit (DMU), on the other hand, a score bigger than 100 (or bigger than 1) is assigned to the non-efficient DMU. The performance score, which is bigger than 100 shows that the related DMU is non-efficient and it can become an efficient DMU if it increases the DMU's outputs according the ratio of amount in excess. For instance; Lee Woon J. will be efficient in the case of incrementing (increasing) his outputs in the ratio of 104.18 %. The goalkeepers that have inefficiencies must eliminate these deficiencies.

The values of output increasing ratio, scores were adjusted again in efficiency score column as an expression of (1/score). According to the result of this transformation, the adjusted performance score of Narazaki S. is 97.00%.

The performance scores of Marcos and Seaman D. are approximately 100%, especially Markos can be considered as an efficient goalkeeper. The performance score of Jiang J.is the lowest and this value is equal to the 51.85 percentages of the whole efficient goalkeepers.

The transfer (moving) of the non-efficient DMU to the efficient frontier, in other words becoming efficient, is made possible by taking the input and output values of efficient DMU in definite ratios as reference and by achieving these ratios in its performance. These calculations can also be made in DEA.

For instance, Given S. will be efficient if he simulates his outputs in the ratio of 68% to Kahn O.'s outputs and in the ratio of 32% to Recber R.'s outputs. The only efficient goalkeeper reference for Nigmatullin R. is Kahn O.

***Table 3.*** *Nonefficient Goalkeepers*

| Goalkeepers (DMU) | Score (%) | Adjusted Score (%) | Benchmarks* | GAa {s} |
|---|---|---|---|---|
| MARCOS (BRA) | 100.01 | 99.99 | 2 (0.75) 18 (0.21) 29 (0.04) | 0 |
| SEAMAN David (ENG) | 100.90 | 99.10 | 2 (0.69) 4 (0.26) 26 (0.05) | 0 |
| CAVALLERO Pablo (ARG) | 102.38 | 97.67 | 2 (0.72) 26 (0.12) 29 (0.16) | 0 |
| NARAZAKI Seigo (JPN) | 103.09 | 97.00 | 2 (0.61) 18 (0.39) | 0 |
| LEE WOON JEE (KOR) | 104.18 | 95.98 | 2 (0.45) 4 (0.21) 18 (0.18) 29 (0.13) 30 (0.03) | 0.004 |
| GIVEN Shay (IRL) | 105.63 | 94.67 | 2 (0.68) 4 (0.32) | 0 |
| SORENSEN T. (DEN) | 106.28 | 94.09 | 4 (0.61) 18 (0.14) 22 (0.25) | 0 |
| HEDMAN Magnus (SWE) | 106.38 | 94.00 | 2 (0.34) 7 (0.66) | 0 |
| VITOR BAIA (POR) | 111.80 | 89.44 | 18 (0.56) 26 (0.26) 29 (0.14) 30 (0.04) | 0 |
| ARENDSE Andre (RSA) | 112.50 | 88.89 | 18 (0.37) 27 (0.38) 30 (0.25) | 0 |
| SYLVA Tony (SEN) | 112.70 | 88.73 | 2 (0.58) 26 (0.01) 29 (0.07) 30 (0.35) | 0.006 |
| PEREZ Oscar (MEX) | 112.80 | 88.65 | 2 (0.67) 4 (0.21) 26 (0.07) 30 (0.05) | 0 |
| CEVALLOS Jose (ECU) | 116.08 | 86.15 | 2 (0.46) 29 (0.21) 30 (0.33) | 0 |
| AL DEAYEA M. (KSA) | 128.57 | 77.78 | 22 (0.86) 32 (0.14) | 2.14 |
| SIMEUNOVIC M. (SVN) | 129.96 | 76.95 | 4 (0.33) 22 (0.67) | 0 |
| NIGMATULLIN R. (RUS) | 133.93 | 74.66 | 2 (1.00) | 0 |
| CARINI Fabian (URU) | 137.48 | 72.73 | 2 (0.44) 4 (0.36) 30 (0.19) | 0 |
| CE VLIEGER Geert (BEL) | 150.40 | 66.49 | 2 (0.67) 26 (0.33) | 0 |
| LONNIS Erick (CRC) | 162.61 | 61.50 | 2 (0.44) 26 (0.24) 29 (0.32) | 0 |
| JIANG Jin (CHN) | 192.86 | 51.85 | 18 (0.21) 27 (0.21) 30 (0.14) 32 (0.43) | 0 |

* 2: KAHN Oliver (GER), 4: RECBER Rustu (TUR), 7: FRIEDEL Brad (USA),3: IKER CASILLAS (ESP), 18: BUFF
S (CRO), 9: CHILAVERT J L (PAR), 32: BARTHEZ Fabien (FRA), 29: BOUMNIJEL Ali (TUN), 27: ALIOUM
(NGA), 22: DUDEK Jerzy (POL)

### 3.1.2. Data, Variables and Performance of Teams in terms of Attacks

The summary statistics of teams' attack of 2002 FIFA World Cup were stated in Table 4 below. All these variables affect the attack capability positively.

***Table 4.*** *The Summary Statistics of Teams Attack of 2002 FIFA World Cup*

| | TMP Team Matches Played | TP Team Penalties | TA Team Attacs | TCK Team Corner Kicks | TFK Team Free Kicks | TSP Team Short Passes | TLP Team Long Passes | TSOG Team Shots on Goal | TGF Team Goals |
|---|---|---|---|---|---|---|---|---|---|
| Mean | 4,00 | ,41 | 2,94 | 21,56 | 7,38 | 1160,22 | 535,09 | 21,53 | 5,03 |
| Median | 3,50 | ,00 | 2,00 | 19,50 | 6,50 | 961,00 | 485,50 | 18,00 | 5,00 |
| Mode | 3 | 0 | 2 | 12[a] | 3 | 874[a] | 461[a] | 17 | 5 |
| Variance | 1,806 | ,378 | 6,899 | 112,51 | 22,69 | 219385 | 29603 | 109,096 | 15,515 |
| Range | 4 | 2 | 12 | 49 | 19 | 1739 | 629 | 48 | 18 |

a. Multiple modes exist. The smallest value is shown

By summing up Team Corner Kicks and Team Free Kicks, TCFK variable and by summing up Team Short Passes and Team Long Passes variables, TSLP variable were obtained as two new variables as in the form of related abbreviations. All of the variables were used in the solution model when they were divided by Team Matches Played variable.

As a result of the solution, 7 teams (BRA, GER, ESP, TUR, KOR, ARG, and FRA) were found efficient in terms of attack. (Table 5.) Brazilian national team achieved efficiency score (100.00%) by weight of 44% with Team Penalties variable and by weight of 56% with Team Assist variable. Spanish National Team was the team, which was shown as a sample reference team to the other teams in the World Cup most. (22 times). Although Turkish National Team is efficient, Turkish National Team was never shown as a sample reference in terms of attack.

***Table 5****. Efficient Teams in Attack*

| | DMU | Score | TMP | TPa | TAa | TCKa + TFKa | TSPa + TLPa | TSOGa | TSFa | Benchmarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BRA | **100** | 0 | 0.44 | 0.56 | 0 | 0 | 0 | 0 | 13 |
| 2 | GER | **100** | 0 | 0 | 0.51 | 0.49 | 0 | 0 | 0 | 5 |
| 3 | ESP | **100** | 0 | 0.34 | 0 | 0 | 0.66 | 0 | 0 | 22 |
| 4 | TUR | **100** | 0.41 | 0 | 0.07 | 0 | 0.53 | 0 | 0 | 0 |
| 5 | KOR | **100** | 0.43 | 0 | 0 | 0.09 | 0.41 | 0.07 | 0 | 6 |
| 23 | ARG | **100** | 0 | 0 | 0 | 0.8 | 0 | 0.2 | 0 | 12 |
| 32 | FRA | **100** | 0 | 0 | 0 | 0.16 | 0.15 | 0.69 | 0 | 9 |

The non-efficient teams in terms of attack were stated in Table 6 with their other results. The non-efficient teams with the lowest score were the national teams of Poland and Tunisia. (65.87%, 66.56%, respectively). The teams that are the nearest to the efficient teams are the national teams of Mexico and Italy (98.82%, 94.18%, respectively). Some of the following results that are inferred from this table: The teams of DEN, MEX, RUS, ECU, and KSA achieved their efficiency score only from the variable, which was obtained by summing up the Team Short Passes and Team Long Passes variables. Only Spain National Team was shown as a reference to these 5 teams to be efficient. In the right side of the table, the deficiency amount of each output variable for the related team so as to be efficient was denoted in Table 6. Non-efficient teams must eliminate these deficiencies to be efficient.

***Table 6.*** *Nonefficient Teams in Attack*

| | DMU | SCORE (%) | ADJUSTED SCORE (%) | TMP | TPa | TAa | TCKa + TFKa | TSPa +TLPa | TSOGa | TSFa | BENCHMARKS* | TMP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | SEN | 128.37 | 77.90 | 0.48 | 0.04 | 0 | 0 | 0.48 | 0 | 0 | 1 (0.35) 3 (0.29) 5 (0.36) | 0 |
| 7 | USA | 121.10 | 82.58 | 0.32 | 0 | 0 | 0 | 0.41 | 0.28 | 0 | 1 (0.38) 3 (0.47) 5 (0.14) | 0 |
| 8 | BEL | 107.50 | 93.02 | 0 | 0 | 0 | 0.6 | 0 | 0.12 | 0.28 | 1 (0.05) 2 (0.63) 23 (0.31) | 1.44 |
| 9 | PAR | 121.87 | 82.05 | 0 | 0 | 0 | 0.24 | 0.22 | 0.41 | 0.13 | 1 (0.34) 3 (0.42) 23 (0.15) 32 (0.08) | 0.34 |
| 10 | POR | 114.04 | 87.69 | 0 | 0 | 0 | 0 | 0.45 | 0 | 0.55 | 1 (0.49) 3 (0.51) | 2.56 |
| 11 | IRL | 109.94 | 90.96 | 0 | 0 | 0.03 | 0.16 | 0.81 | 0 | 0 | 3 (0.87) 23 (0.07) 32 (0.07) | 0.33 |
| 12 | ENG | 124.18 | 80.52 | 0.46 | 0.04 | 0 | 0 | 0.49 | 0 | 0 | 1 (0.23) 3 (0.40) 5 (0.38) | 0 |
| 13 | CRC | 115.27 | 86.75 | 0 | 0 | 0 | 0.34 | 0.32 | 0.02 | 0.32 | 1 (0.11) 2 (0.14) 3 (0.63) 23 (0.11) | 1.84 |
| 14 | DEN | 117.39 | 85.19 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 (1) | 0.3 |
| 15 | JPN | 121.33 | 82.42 | 0.17 | 0 | 0 | 0.19 | 0.64 | 0 | 0 | 3 (0.77) 5 (0.08) 23 (0.15) | 0 |
| 16 | SWE | 134.62 | 74.28 | 0.23 | 0 | 0 | 0.09 | 0.36 | 0.32 | 0 | 1 (0.22) 3 (0.56) 5 (0.10) 32 (0.12) | 0 |
| 17 | RSA | 123.23 | 81.15 | 0 | 0 | 0 | 0 | 0.5 | 0 | 0.5 | 1 (0.09) 3 (0.91) | 1.49 |
| 18 | ITA | 106.18 | 94.18 | 0 | 0 | 0.07 | 0.42 | 0 | 0.51 | 0 | 1 (0.35) 2 (0.05) 23 (0.48) 32 (0.12) | 0.36 |
| 19 | MEX | 101.19 | 98.82 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 (1) | 0.95 |
| 20 | URU | 107.89 | 92.69 | 0 | 0.24 | 0 | 0.74 | 0 | 0 | 0.02 | 1 (0.09) 3 (0.45) 23 (0.46) | 1.03 |
| 21 | RUS | 123.82 | 80.76 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 (1) | 1.29 |
| 22 | POL | 151.82 | 65.87 | 0 | 0 | 0 | 0.28 | 0.22 | 0.4 | 0.1 | 1 (0.22) 3 (0.37) 23 (0.31) 32 (0.10) | 0.08 |
| 24 | ECU | 109.39 | 91.42 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 (1) | 1.72 |
| 25 | SVN | 134.63 | 74.28 | 0 | 0 | 0 | 0 | 0.98 | 0.02 | 0 | 3 (0.71) 32 (0.29) | 0.38 |
| 26 | CRO | 123.03 | 81.28 | 0.01 | 0 | 0.04 | 0.47 | 0 | 0.48 | 0 | 1 (0.09) 2 (0.08) 23 (0.67) 32 (0.16) | 0 |
| 27 | CMR | 111.24 | 89.90 | 0 | 0 | 0.04 | 0.33 | 0.63 | 0 | 0 | 2 (0.07) 3 (0.11) 23 (0.82) | 0.17 |
| 28 | NGA | 139.83 | 71.52 | 0 | 0 | 0 | 0.01 | 0.99 | 0 | 0 | 3 (0.73) 32 (0.27) | 0.26 |
| 29 | TUN | 150.24 | 66.56 | 0.15 | 0 | 0 | 0.23 | 0.62 | 0 | 0 | 3 (0.50) 5 (0.13) 23 (0.37) | 0 |
| 30 | CHN | 133.13 | 75.11 | 0.07 | 0 | 0 | 0.17 | 0.76 | 0 | 0 | 3 (0.50) 23 (0.01) 32 (0.49) | 0 |
| 31 | KSA | 116.74 | 85.66 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 (1) | 1.5 |

* 1:BRA, 2:GER, 3:ESP, 4:TUR, 5:KOR, 23:ARG, 32:FRA

### 3.1.3. Data, Variables and Performance of the Teams in terms of Defense

The summary statistics of the Defense of the Teams in 2002 FIFA World Cup were stated in Table 7 below. The variable of Team Goals Against affects team defense capability negatively; on the other hand, all of the other variables affect the team defense positively. A new TGAr variable was derived from Team Goals Against by $\left(\frac{\max(TGA)-TGA}{TMP}\right)$ transformation.

***Table 7.*** *The Summary Statistics of Teams Defense of 2002 FIFA World Cup*

| | TMP Team Matches Played | TGA Team Goals Againts | TFC Team Fauls Committed | TTC Team Tackles Committed |
|---|---|---|---|---|
| Mean | 4,00 | 5,03 | 71,88 | 178,41 |
| Median | 3,50 | 5,00 | 64,00 | 146,50 |
| Mode | 3 | 3 | 57 | 123[a] |
| Variance | 1,806 | 4,354 | 629,210 | 4567,668 |
| Range | 4 | 10 | 94 | 253 |

a. Multiple modes exist. The smallest value is shown

Both of the CRS and VRS models gave the same solution. As a result of the solution, 6 teams (ARG, CRO, NGA, GER, ENG, BRA) were found efficient in defense (Table 8). Nigeria, an efficient team in defense, was the most (14 times) referenced team to the non-efficient teams in terms of defense.

***Table 8****. Efficient Teams in Defense*

| | DMU | Score | TMPa | TGAa | TFCa | TTCa | Benchmarks |
|---|---|---|---|---|---|---|---|
| 1 | ARG | **100** | 0 | 0.3 | 0 | 0 | 5 |
| 3 | CRO | **100** | 0 | 0.16 | 0 | 0.01 | 8 |
| 6 | NGA | **100** | 0 | 0.1 | 0.07 | 0 | 14 |
| 8 | GER | **100** | 0.08 | 0.15 | 0 | 0.01 | 11 |
| 9 | ENG | **100** | 0.03 | 0.06 | 0.08 | 0 | 2 |
| 10 | BRA | **100** | 0.06 | 0 | 0.06 | 0 | 5 |

The non-efficient teams in defense were denoted in Table 9. The non-efficient teams achieved higher score than attack efficiency. There were 6 teams (FRA, MEX, ESP, SWE, CRC and KOR) that achieved a score of 97% and over this percentage. There is only technical inefficiency for the non-efficient national teams of FRA, MEX, ESP, URU, TUN, SWE, CRC, BEL, PAR and USA. Increasing the defense outputs according to the ratio of their score are enough for these teams to be efficient. They do not have combined inefficiency. Paraguay national team had the lowest inefficiency ratio (71.85 %).

***Table 9**. Nonefficient Teams in Defense*

| | DMU | SCORE (%) | ADJUSTED SCORE (%) | TMPR | TGAR | TFCR | TTCR | BENCHMARKS* | TMP |
|---|---|---|---|---|---|---|---|---|---|
| 2 | CMR | 106.73 | 93.72 | 0.07 | 0.16 | 0 | 0.01 | 1 (0.87) 3 (0.08) 8 (0.05) | 0 |
| 4 | FRA | 102.66 | 97.40 | 0.06 | 0.14 | 0.01 | 0.01 | 1 (0.34) 3 (0.01) 6 (0.63) 8 (0.02) | 0 |
| 5 | JPN | 105.38 | 94.89 | 0.06 | 0.13 | 0 | 0.01 | 3 (0.60) 8 (0.27) 16 (0.13) | 0 |
| 7 | IRL | 109.79 | 91.08 | 0.08 | 0.18 | 0.03 | 0 | 1 (0.35) 6 (0.30) 10 (0.35) | 0 |
| 11 | RUS | 109.46 | 91.35 | 0.07 | 0.17 | 0 | 0.01 | 1 (0.12) 3 (0.81) 8 (0.07) | 0 |
| 12 | POR | 115.07 | 86.94 | 0.09 | 0.19 | 0.03 | 0 | 1 (0.84) 6 (0.05) 10 (0.11) | 0 |
| 13 | MEX | 102.29 | 97.76 | 0.01 | 0.02 | 0.03 | 0.01 | 6 (0.54) 23 (0.27) 27 (0.01) 31 (0.18) | 0 |
| 15 | DEN | 117.56 | 85.06 | 0.03 | 0.07 | 0.08 | 0 | 6 (0.37) 9 (0.35) 10 (0.25) 31 (0.03) | 0 |
| 17 | RSA | 114.78 | 87.12 | 0.06 | 0.15 | 0 | 0.01 | 3 (0.77) 8 (0.07) 16 (0.16) | 0 |
| 18 | ESP | 101.11 | 98.91 | 0.03 | 0.06 | 0.07 | 0 | 6 (0.13) 9 (0.10) 10 (0.46) 31 (0.30) | 0 |
| 19 | URU | 117.65 | 85 | 0.06 | 0.12 | 0.01 | 0.01 | 3 (0.67) 6 (0.18) 8 (0.12) 16 (0.03) | 0 |
| 20 | TUN | 111.12 | 89.99 | 0.05 | 0.12 | 0.01 | 0.01 | 3 (0.37) 6 (0.30) 8 (0) 16 (0.32) | 0 |
| 21 | SWE | 102.38 | 97.67 | 0.01 | 0.02 | 0.03 | 0.01 | 6 (0.27) 23 (0.27) 27 (0.43) 31 (0.02) | 0 |
| 22 | CRC | 100.72 | 99.28 | 0.01 | 0.02 | 0.03 | 0.01 | 6 (0.41) 23 (0.01) 27 (0.29) 31 (0.29) | 0 |
| 24 | KOR | **100** | **100** | 0.14 | 0 | 0 | 0 | 8 (0.29) 10 (0.28) 23 (0.43) | 0 |
| 25 | SEN | 114.01 | 87.12 | 0.06 | 0.07 | 0 | 0.01 | 8 (0.29) 16 (0.43) 23 (0.28) | 0 |
| 26 | BEL | 126.66 | 78.95 | 0.06 | 0.13 | 0.01 | 0.01 | 6 (0.04) 8 (0.27) 16 (0.59) 23 (0.10) | 0 |
| 28 | PAR | 139.18 | 71.85 | 0.06 | 0.14 | 0.01 | 0.01 | 6 (0.26) 8 (0.49) 16 (0.14) 23 (0.11) | 0 |
| 29 | POL | 116.95 | 85.50 | 0 | 0.11 | 0.01 | 0.02 | 3 (0.15) 6 (0.01) 16 (0.84) | 0.33 |
| 30 | USA | 116.38 | 85.93 | 0.01 | 0.02 | 0.03 | 0.02 | 6 (0.09) 23 (0.70) 27 (0.14) 31 (0.07) | 0 |

* 1: ARG, 3: CRO, 6: NGA, 8: GER, 9: ENG, 10: BRA

### 3.2. Evaluation of Total Outcomes

All of the teams' attack, defense and goalkeeper efficiency evaluation results and their averages were denoted in Table 10. The teams were ranked according to the average value.

World Cup is played according to the elimination system, whereas super league matches are played according to the scoring system. Team evaluation system proposed in this study is more suitable to the leagues that apply scoring system and its acceptability can be tested statistically. Because points are given to the teams in the league system and all of the teams in the league are ranked according to their scores. On the other hand, World Cup is played according to the elimination system and defeated teams are eliminated. There is not score oriented ranking in this system. After the final and third place match, the ranking is determined for 4 teams. However, by comparing score oriented league results with analysis results using nonparametric tests, the conformity or unconformity of these two rankings could be tested and observed in a scientific manner.

***Table 10.*** *The Total Efficiency Scores of Teams of 2002 FIFA World Cup*

| TEAM | | | GOALKEEPER | | ATTACK | | DEFENSE | | AVERAGE |
|---|---|---|---|---|---|---|---|---|---|
| No | DMU | Name | Score | 1/Score | Score | 1/Score | Score | 1/Score | |
| 1 | BRA | MARCOS | **100** | **100** | **100** | **100** | **100** | **100** | **100** |
| 2 | GER | KAHN O. | **100** | **100** | **100** | **100** | **100** | **100** | **100** |
| 4 | TUR | RECBER R. | **100** | **100** | **100** | **100** | **100** | **100** | **100** |
| 3 | ESP | IKER C. | **100** | **100** | **100** | **100** | 101.11 | 98.90 | 99.63 |
| 23 | ARG | CAVALLERO P | 102.38 | 97.68 | **100** | **100** | **100** | **100** | 99.23 |
| 32 | FRA | BARTHEZ F. | **100** | **100** | **100** | **100** | 102.66 | 97.41 | 99.14 |
| 5 | KOR | LEE W. J. | 104.18 | 95.99 | **100** | **100** | **100** | **100** | 98.66 |
| 18 | ITA | BUFFON G.i | **100** | **100** | 106.18 | 94.18 | **100** | **100** | 98.06 |
| 19 | MEX | PEREZ O. | 112.80 | 88.65 | 101.19 | 98.82 | 102.29 | 97.76 | 95.08 |
| 27 | CMR | ALIOUM B. | **100** | **100** | 111.24 | 89.90 | 106.73 | 93.69 | 94.53 |
| 26 | CRO | PLETIKOSA S. | **100** | **100** | 123.03 | 81.28 | **100** | **100** | 93.76 |
| 12 | ENG | SEAMAN D. | 100.90 | 99.11 | 124.18 | 80.53 | **100** | **100** | 93.21 |
| 24 | ECU | CEVALLOS J. | 116.08 | 86.15 | 109.39 | 91.42 | **100** | **100** | 92.52 |
| 11 | IRL | GIVEN S. | 105.63 | 94.67 | 109.94 | 90.96 | 109.79 | 91.08 | 92.24 |
| 15 | JPN | NARAZAKI S. | 103.09 | 97 | 121.33 | 82.42 | 105.38 | 94.89 | 91.44 |
| 28 | NGA | SHORUNMU I. | **100** | **100** | 139.83 | 71.52 | **100** | **100** | 90.51 |
| 7 | USA | FRIEDEL B. | **100** | **100** | 121.10 | 82.58 | 116.38 | 85.93 | 89.50 |
| 16 | SWE | HEDMAN M. | 106.38 | 94 | 134.62 | 74.28 | 102.38 | 97.68 | 88.65 |
| 14 | DEN | SORENSEN T. | 106.28 | 94.09 | 117.39 | 85.19 | 117.56 | 85.06 | 88.11 |
| 10 | POR | VITOR B. | 111.80 | 89.45 | 114.04 | 87.69 | 115.07 | 86.90 | 88.01 |
| 31 | KSA | AL D. M. | 128.57 | 77.78 | 116.74 | 85.66 | **100** | **100** | 87.81 |
| 17 | RSA | ARENDSE A. | 112.50 | 88.89 | 123.23 | 81.15 | 114.78 | 87.12 | 85.72 |
| 29 | TUN | BOUMNIJEL A. | 100 | 100 | 150.24 | 66.56 | 111.12 | 89.99 | 85.52 |
| 6 | SEN | SYLVA T. | 112.70 | 88.73 | 128.37 | 77.90 | 114.01 | 87.71 | 84.78 |
| 9 | PAR | CHILAVE J. L. | **100** | **100** | 121.87 | 82.05 | 139.18 | 71.85 | 84.63 |
| 22 | POL | DUDEK J. | **100** | **100** | 151.82 | 65.87 | 116.95 | 85.51 | 83.79 |
| 25 | SVN | IMEUNOVIC M. | 129.96 | 76.95 | 134.63 | 74.28 | **100** | **100** | 83.74 |
| 20 | URU | CARINI F. | 137.48 | 72.74 | 107.89 | 92.69 | 117.65 | 85 | 83.47 |
| 13 | CRC | LONNIS E. | 162.61 | 61.50 | 115.27 | 86.75 | 100.72 | 99.29 | 82.51 |
| 21 | RUS | NIGMATULL R. | 133.93 | 74.67 | 123.82 | 80.76 | 109.46 | 91.36 | 82.26 |
| 8 | BEL | DE V. G. | 150.40 | 66.49 | 107.50 | 93.02 | 126.66 | 78.95 | 79.49 |
| 30 | CHN | JIANG J. | 192.86 | 51.85 | 133.13 | 75.11 | **100** | **100** | 75.66 |

Football commentators stress in appropriate situations that football is a game of chance. Although they affect the result of the game, good and bad factors which are not included in the model and are not taken place in statistics change results in a small amount.

According to the results of 2002 FIFA World Cup, the teams that were in the first three ranking BRA, GER, and TUR national teams were found whole efficient in the analysis in terms of attack, defense and goalkeeper efficiencies. Korean National Team which was in the fourth order was in the seventh order according to the results of the analysis and its average efficiency score was 98.66%. Korean national team was whole efficient in defense and attack. The average efficiency score of this team declined due to the score of goalkeeper LEE W.J.

When the matches were played out of 16 investigated teams, 10 teams took place in these matches according to the analysis result: BRA, GER, TUR, ESP, KOR, ENG, MEX, IRL, ITA and JPN national teams. In the quarterfinals played with 8 teams, the five of the teams in the order took place: BRA, GER, TUR, ESP and KOR national teams. In the World Cup, there is not a ranking except the order of first 4 teams. For that reason; the comparisons between the order according to the analysis result and real result (the order at the end of the world cup) were made by taking only these 4 teams into consideration.

## 4. RESULTS AND DISCUSSIONS

CCR output oriented model of DEA with CRS assumptions can be used for football performance evaluations. In this study, teams were evaluated generally. The same analysis can be considered also for team players. The obtained results were compatible with realized results. These kind of evaluations will be scientific analysis that coaches can take advantage of them in different aspects either they are applied inside the team or between teams. In this way, coaches and players will know the strengths and weaknesses of their own team and rival teams in terms of defense, attack and goalkeeper with a numerical way. This will help them in training before matches, in tactics and in the matches as a guide. Nevertheless, player and team statistics which are held throughout the season (as held by FIFA) are required for these all analysis. DEA analysis is the instant picture of the related process. To benefit, it must be repeated throughout the process with cumulative data space. As a result, player, team, league general trend can be observed. Forecasts may be done for the future. In DEA applications, behind the selection of inputs and outputs, the transformations related with variables are also important. The team and the players that are efficient according to the result of the analysis can be ordered inside themselves with the help of super efficiency models if wanted. This will be the concern of other studies because it will increase the work volume.

## CONFLICT OF INTEREST

No conflict of interest was declared by the authors

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