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Efficiency Evaluation of Football Teams in English Premier League: Application of Data Envelopment Analysis

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Abstract

In this paper, the financial efficiency of football clubs in English Premier League during 2016-17 season is determined. From a methodological perspective, we use Data Envelopment Analysis (DEA), a deterministic nonparametric frontier method. In particular, variable returns to scale and slack based measure are employed to assess whether teams are spending more resources than they need to achieve efficiency. DEA allows for inclusion of multiple inputs and outputs in assessing the efficiency and provides benchmarks for inefficient clubs. The input parameters selected are total expenses which include the salaries of players, coaches, managers and supporting staff. The output variables being revenue generated, profit gained and points scored at the end of the season.

Keywords: Data Envelopment Analysis, Slack Based Measure, Football, Efficiency.

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1. Introduction

The English Premier League (EPL) constitutes the highest level of professional football in England. It is viewed as the most pursued and best realized football league on the planet. The overall aggregate attendance at the games in 2016/17 season was 13.61 million with an average attendance of around 35.8 thousand. These figures indicate that football is people's favorite activity to spend their leisure time. Apart from this professional football has copied the principles of the business world and resembles with it in various ways like, players, coaches, managers and administrators are constantly paid, football itself has become a branded product, fans have become customers, football clubs have become large companies and affinity with corporate sector has been established.

The average revenue of a premier league club was € 265.7 million and overall revenue generated by the clubs was € 5.31 billion. According to the Annual review of football finance (1) majority of the premier league clubs were ranked in the top 40 revenue generating clubs in the world in 2016/17, with five of the premier league's clubs taking positions in top 10. For clubs to be efficient and to prevent losses, proper utilization of available sources is mandatory. Efficiency of a club depends either if it consumes minimal amounts of input in order to produce outputs or obtain maximum output from their inputs (2).

The main objective of this paper is to determine the efficiency of the football clubs that have participated in the EPL during 2016/17 season by applying input oriented, variable returns to scale and slack based measure (VRS-SBM) which are extensions of Data Envelopment Analysis (DEA) model. DEA methodology analyzes whether clubs are spending more resources than they need to achieve efficiency and also provides insight about the sources of inefficiency. Layout of the paper includes literature review, methodology, data, results and conclusion.

2. Literature Review

Football has been scrutinized much from a long time by operations research and management science in terms of economic and sportive efficiency. The earlier work regarding DEA study on football was carried by (3) who examined technical and scale efficiency of English Premier League teams considering player and coach wages as inputs and points awarded and total revenues as outputs. (4) evaluated the performance of English Premier League football teams from 1998/99 to 2002/03 seasons by the same methodology and noticed that all clubs showed similar managerial skills and all teams were managed with pure technical efficiency. The study of English football clubs carried by (5) also considered points won and revenue as outputs and player coach wages as inputs. They suggested that for the inefficient teams to reach the efficiency frontier must have their inputs (staff cost and other expenses) reduced by approximately 15.5%. (6) calculated the performance of Spanish football teams from 1998 to 2005 using DEA and found that a team's final position in the league depends more on its efficient utilization of resources than potential. The DEA method determined how many points would have the team achieved if it had utilized its resources efficiently. Analyzing 14 French football clubs from 2004 to 2007 (7) evaluated their efficiency. His study revealed that the main distinction between French soccer clubs and other championships lied in competitive balance level. Furthermore, one-third of the DMUs were on efficiency frontier and the cause of inefficiency was associated with the size of clubs and over-investment in players. The economic efficiency of 48 European clubs was measured by (8) utilizing DEA and its extensions – super efficiency and cross efficiency models. The results revealed that the richest clubs were more efficient because they had access to all the competitions and sources of revenue. Also, those clubs that dominated in their national championships were not most efficient clubs because they had utilized surplus inputs. (9) determined the minimum wages that has to be paid to the players in Major League baseball in order to be competitive in each year from 1985 to 2002 by using two-stage DEA. Their study showed that many teams were inefficient due to low player salary. The results also show that teams with large markets spend more on player salaries as compared to teams with small markets. Performance of 40 tennis players for the 2012 season was evaluated by (10) by DEA methodology considering three inputs and eight outputs. As per their results, DEA provided a multidimensional overall assessment of the tennis players which was quite different from the ATP world tour rankings.

3. Methodology

All DEA models can be broadly classified into radial and non-radial models. Radial models provide a proportional score by which all inputs and outputs need to be optimized. Furthermore, radial models neglect the presence of any slacks. The CCR and BCC models with their extensions come under the category of radial models. On the other hand, non-radial models are based on input and output slacks while releasing the condition of proportionality; in other words, in non-radial models, inputs/outputs are allowed to decrease/increase at different proportions. (11) developed additive DEA model which deals with the slacks but fails in providing an overall scalar measure (12) etc., but all were observed with some lacunas. A new non-radial model namely Slack-based Model (SBM) was proposed by (13). This model deals directly with the input excesses and output shortfalls and integrates them in the efficiency measure. In recent times, SBM measure has been widely used to evaluate the efficiencies of various production processes.

Let us consider a set of 'n' DMUs where each $DMU_j\left(j=1\ldots n\right)$ uses 'm' inputs $x_{ij}(i=1,...,m)$ to produce 's' outputs $y_{rj}(r=1,...,s)$. The production possibility set is given as;

$$P=\left\{(x,y)\Big/ x\geq\sum_{j=}^{n}\Lambda_j x_{ij}, y\leq\sum_{j=1}^{n}\Lambda_j y_{rj}, \Lambda\geq 0\right\} \quad (1)$$

A $\mathrm{DMU}(x_o, y_o)$ can be described as follows;

$$\left.\begin{aligned} x_o &= \sum_{j=1}^{n}\Lambda_j x_{ij} + S_i^- \\ y_o &= \sum_{j=1}^{n}\Lambda_j y_{rj} - S_r^+ \end{aligned}\right\} \quad (2)$$

With $\Lambda_j\geq 0$, $s_i^-\geq 0$ and $s_r^+\geq 0$. s_i^- and s_r^+ are respectively the input excesses and output shortfalls, commonly called as slacks. The variable Λ_j is the weight assigned to j[th] DMU. Considering the expression 2, (13) introduced the following Fractional Programming Problem (FPP) to estimate the efficiency of a DMU.

$$\text{Minimize } \tau=\frac{1-\left(\frac{1}{m}\sum_{i=1}^{m}\frac{S_i^-}{x_{io}}\right)}{1+\left(\frac{1}{s}\sum_{r=1}^{s}\frac{S_r^+}{y_{ro}}\right)}$$

with the constraints (3)

$$\sum_{j=1}^{n}\Lambda_j x_{ij} + S_i^- = x_o$$

$$\sum_{j=1}^{n}\Lambda_j y_{rj} - S_r^+ = y_o$$

$$\Lambda_j \geq 0, S_i^- \geq 0, S_r^+ \geq 0, \ \forall\, j, i \text{ and } r$$

As the model 3 is FPP and can be transformed to LPP by applying Charnes and Cooper transformation .Let us multiply a scalar t to numerator and denominator which will not change τ. The scalar t should be adjusted in such a way that the denominator becomes one and can be moved to constraints. Thus, we have the model as;

$$\text{Minimize } \rho = t - \frac{1}{m}\sum_{i=1}^{m}\frac{s_i^-}{x_{io}}$$

with the constraints

$$t + \frac{1}{s}\sum_{r=1}^{s}\frac{s_r^+}{y_{ro}} = 1 \qquad (4)$$

$$\sum_{j=1}^{n}\lambda_j x_{ij} + s_i^- = tx_o$$

$$\sum_{j=1}^{n}\lambda_j y_{rj} - s_r^+ = ty_o$$

$$\lambda_j \geq 0, s_i^- \geq 0, s_r^+ \geq 0, \ \forall\, j, i \text{ and } r, t > 0$$

Let the optimal solution of the above model is as;

$$\left(\rho^*, t^*, \lambda^*, s^{-*}, s^{+*}\right) \qquad (5)$$

Then the solution to the original SBM will be as;

$$\tau^* = \rho^*, \qquad \Lambda^* = \lambda^*/t \qquad (6)$$
$$S^{-*} = s^{-*}, \qquad S^{+*} = s^{+*}/t$$

Based on the optimal solution, one can determine a DMU as efficient or inefficient.

Definition 1: A DMU (x_o, y_o) is said to be efficient if and only if $\rho^* = 1$.

If the condition is true then this is equivalent to $s^{-*} = 0$ and $s^{+*} = 0$ which means that there are no input and no output slacks. For an SBM inefficient DMU (x_o, y_o) we have;

$$x_o = \sum_{j=1}^{n}\lambda_j^* x_{ij} + s_i^{-*} \qquad (7)$$
$$y_o = \sum_{j=1}^{n}\lambda_j^* y_{rj} - s_r^{+*}$$

The DMU (x_o, y_o) can approach one if it tries to minimize the input excesses and output shortfalls. Thus, SBM projection will be as follows;

$$x_o \leftarrow x_o - s^{-*} \qquad (8)$$
$$y_o \leftarrow x_o + s^{+*}$$

The inefficient DMUs need to follow their respective Peer DMUs to become efficient. The peer set or reference set for an inefficient DMU (x_o, y_o) can be obtained based on λ^*.

Definition 2: A set (R_o) of DMUs whose corresponding $\lambda^* > 0$ is a reference set for an inefficient DMU (x_o, y_o). Thus, reference set is;

$$R_o = \left\{ j / \lambda_j^* > 0 \right\}, j = 1, \ldots, n \qquad (9)$$

Using the reference set the DMU (x_o, y_o) can be represented as;

$$x_o = \sum_{j \in R_o}\lambda_j^* x_{ij} + s_i^{-*} \qquad (10)$$
$$y_o = \sum_{j \in R_o}\lambda_j^* y_{rj} - s_r^{+*}$$

Thus, the expression 9 reveals that the efficiency score depends only on the reference set DMUs; it is not affected by the values attributed to non-reference units.

4. Data

The subjects for this investigation are 20 football clubs who have participated in the English Premier League 2016/17 season. The data was compiled from various websites (https:// www. Football benchmark. com, https:// www2. deloitte.com/uk/en/pages/sports-business-group/articles/annual-review-of-football-finance.html and https:// www. premierleague.com). Two inputs and three outputs are taken into consideration for the present study. Our first input is the club total wages including the salaries of players, coaches, managers and supporting staff. (14), (3), (15) and (5) considered this variable for estimating the performance of football teams. Further, (16) and (17) pointed out that there is relationship between the sporting success and the remuneration paid to the players. We use team's total assets as second input in line with previous studies. The facilities available to any football team play an important role in achieving sports success. Total assets of a club includes stadia, practice camp, administrative building etc. (18), (4), (19) and (20) used this input variable for efficiency evaluation of football teams.

The first output taken is total revenue generated by each club during the season and involves the income received from selling tickets, TV broadcasting, sponsorship and other sources of income. Total revenue represents the financial success of a club. (3), (14), (8) and (21) employed this variable for measuring the performance of football teams. The second output being the profit obtained by the football teams. Like club's total revenue, profit also indicates economic success of a team (22). Our third output is points achieved by the teams at the end of the season. The ultimate aim in sports is winning and securing maximum points that indicates on the field sportive success. The number of points allows ranking of clubs to determine whether a team is qualified or is relegated. It is a commonly used output variable in the literature e.g. (23) and (6), (4), (5) and (7). Table 1 displays the raw data of 20 premier league clubs for 2016/17 season.

5. Results

VRS slack based measure of efficiency with input orientation was applied to the data set provided in Table 1. DEA frontier 4.1, software was used and efficiency value of each DMU is shown in Table 2 along with the descriptive statistics of all the teams.

It is observed from Table 2, that 11 clubs were efficient having efficiency score of 1 and for the rest 9 teams the efficiency score ranges from 0 and 1. The proficiency accomplished through input oriented VRS slack based measure of efficiency depends on the presumption that the clubs have capacity to minimize their input quantities at the same dimension of yield. DEA has an advantage as it provides targets for each input used and output produced, which can be shown in the form of slacks. Slack is a noticeable deterioration in performance.

Table 1. Raw Data on Input and Output Variables

Club	Inputs		Outputs		
	Wages (million €)	Total assets (million €)	Revenue (million €)	Profit (million €)	Points
Chelsea	408.3	810	427.7	19.4	93
Tottenham Hotspur	263.6	956	356.2	92.6	86
Manchester City	446.9	1206	555.3	106.4	78
Liver Pool	353	609	423.9	70.9	76
Arsenal	345.1	1006	487.2	142.1	75
Manchester United	456.2	1745	675.9	219.7	69
Everton	170.2	225	199.2	29	61
Southampton	175.6	247	211.9	36.3	46
Bournemouth	118.5	110	158.7	40.2	46
West Bromwich Albion	109.4	144	160.4	51	45
West Ham United	139.6	214	205.6	66	45
Leicester City	172.6	303	271.9	99.3	44
Stoke City	129.2	125	158.1	28.9	44
Crystal Palace	158.2	178	166	7.8	41
Swansea City	147.3	148	148.3	1	41
Burnley	85.4	95	141.6	56.2	40
Watford	128.2	192	142.3	14.1	40
Hull City	87	84	136	49	34
Middlesbrough	113	143	141.2	28.2	28
Sunderland	130	267	147	17	24

Table 2. Summary of Efficiency Scores and Descriptive Sstatistics of Clubs

Club	Efficiency	Club	Efficiency
1	1	11	0.96
2	1	12	1
3	1	13	0.88
4	1	14	0.71
5	1	15	0.67
6	1	16	1
7	1	17	0.66
8	0.82	18	1
9	1	19	0.75
10	0.98	20	0.68
Min: 0.66	**Max: 1**	**Mean: 0.90**	**S.D: 0.13**

Source: own calculation

From Table 3, it can be noticed that for the clubs with unit efficiency, all input and output slacks are 0, while for clubs that were rendered inefficient by DEA analysis input and output slacks are shown. In this regard, for example consider a case of Southampton FC (DMU 8) who's DEA score is 0.82. The club has a slack of 30.16 million € in output 2 which is profit of the team. It indicates that for Southampton FC to reach the efficiency frontier has to make more profit of 30.16 million € at the same level of expenditure and assets available. Similarly, the slack for input 1 and input 2 of Southampton FC is 30.16 and 42.42 which means that the club has potential to become efficient at the same level of outputs by expending 30.16 million € less than the original of 175.6 million €. Total assets for the club should have been 204.58 instead of 247 million €. Same interpretation can be made for other input and output slack figures. Contrary to this, when we analyze clubs having DEA score 1, input and output slacks are 0 pointing that there is no further enhancement conceivable. Since DEA measures relative performance of DMUs and are valid in the group of 20 clubs being analyzed.

In case of efficient clubs the input/output targets and original input/output figures are same and vary in inefficient clubs. The details of input and output targets are provided in Table 4.

Table 3. Input and Output Slacks

Club	Input 1	Input 2	Output 1	Output 2	Output 3
1	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00
8	30.16	42.42	0.00	30.16	0.00
9	0.00	0.00	0.00	0.00	0.00
10	1.85	2.43	0.00	1.85	0.00
11	4.59	7.03	0.00	4.59	0.00
12	0.00	0.00	0.00	0.00	0.00
13	14.50	14.03	0.00	14.50	1.12
14	44.96	50.59	0.00	44.96	2.66
15	47.57	47.79	0.00	47.57	0.91
16	0.00	0.00	0.00	0.00	0.00
17	42.33	95.88	0.00	42.33	0.02
18	0.00	0.00	0.00	0.00	0.00
19	27.60	48.00	0.40	28.00	12.00
20	40.99	163.38	0.00	40.99	16.17

Source: own calculation

Table 4. Input and Output Targets

Club	Input 1	Input 2	Output 1	Output 2	Output 3
1	408.30	810.00	427.70	19.40	93.00
2	263.60	956.00	356.20	92.60	86.00
3	446.90	1206.00	555.30	106.40	78.00
4	353.00	609.00	423.90	70.90	76.00
5	345.10	1006.00	487.20	142.10	75.00
6	456.20	1745.00	675.90	219.70	69.00
7	170.20	225.00	199.20	29.00	61.00
8	145.44	204.58	211.90	66.46	46.00
9	118.50	110.00	158.70	40.20	46.00
10	107.55	141.57	160.40	52.85	45.00
11	135.01	206.97	205.60	70.59	45.00
12	172.60	303.00	271.90	99.30	44.00
13	114.70	110.97	158.10	43.40	45.12
14	113.24	127.41	166.00	52.76	43.66
15	99.73	100.21	148.30	48.57	41.91
15	85.40	95.00	141.60	56.20	40.00
17	85.87	96.12	142.30	56.43	40.02
18	87.00	84.00	136.00	49.00	34.00
19	85.40	95.00	141.60	56.20	40.00
20	89.01	103.62	147.00	57.99	40.17

Source: own calculation

Table 5

Inefficient DMUs	Efficiency	Reference DMUS					
		2	**7**	**9**	**12**	**16**	**18**
8	0.82	NRD	0.07	0.44	0.44	0.03	NRD
10	0.98	0.01	0.19	NRD	0.02	0.75	NRD
11	0.96	NRD	0.14	NRD	0.41	0.43	NRD
13	0.88	NRD	NRD	0.84	0.01	0.14	NRD
14	0.71	NRD	NRD	0.53	0.11	0.35	NRD
15	0.67	NRD	NRD	0.42	NRD	0.46	0.11
17	0.66	NRD	NRD	NRD	NRD	0.99	NRD
19	0.75	NRD	NRD	NRD	NRD	1	NRD
20	0.68	NRD	NRD	NRD	0.04	0.95	NRD

NRD: Non-reference DMU for the corresponding inefficient DMU.

Table 5 shows the target DMUs for inefficient units so as to reach the efficiency frontier. Considering the case of DMU 8, it can follow either DMU 7, 9, 12 or 16 which act as benchmarks for DMU 8 to become efficient. But as per the efficiency values of benchmarks shown in the Table 5, for the DMU8 it is more feasible to follow the DMU 16. Similarly, for DMU10 it more prefers to follow the strategies of DMU 16 as a benchmark.

6. Conclusion

This work has highlighted the efficiency of football clubs in English Premier League by applying DEA Slack Based Measure and BCC model. The DEA methodology has an advantage to set benchmarks for inefficient DMUs and identifies sources of inefficiency. After analyzing the results it can be concluded that apart from on field efficiency off field efficiency is also important so that resources used are managed to achieve good sports results. There is a strong positive correlation between the wages and output variables which means that high wages go with high outputs produced. Chelsea, Manchester City, Manchester United, Liver Pool and Arsenal are dominating the championship both in terms of strong inputs and sports results.

Hull City, Middlesbrough and Sunderland were relegated to EFL Championship because of their poor sports performance by scoring less goals and conceding more goals. Hull City was efficient as per our analysis because it was the only club that had spent less wages and had less assets as compared to other teams in the league.

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