Mathematical Statistician and Engineering Applications
ISSN: 2094-0343
2326-9865

Measuring the Performance of the Indian Premier League Teams through an Integrated Optimality Analytics by Data Envelopment Analysis Approach

Ashok R.[1], Raju Nellutla[2] , Rajagopalan V. [3]

[1]Department of Statistics, Annamalai University, Annamalai Nagar– 608 002, India.(E-mail: ashokpts@gmail.com)
ORCID: 0000-0001-7024-2564

[2] Department of Mathematics &Statistics,Guru Nanak Institutions Technical Campus (A),Hyderabad,India(E-mail: rajunellutla@gmail.com)
ORCID: 0000-0000-0000-0000

[3] Department of Statistics, Annamalai University, Annamalai Nagar - 608 002, India
(E-mail: rajagopalan.ve@gmail.com)
ORCID: 0000-0003-3363-2533

Article Info
Page Number: 8918 - 8940
Publication Issue:
Vol 71 No. 4 (2022)

Article History
Article Received*: 25 March 2022*
Revised*: 30 April 2022*
Accepted*: 15 June 2022*
Publication*: 19 August 2022*

Abstract

In this present research paper, we evaluate the Indian Premier League Teams Optimality Analytics by CCR, BCC models through Data Envelopment Analysis (DEA) approach and see the optimal empirical Performance of teams with respect to all the IPL teams India.

The team wise Performances is evaluated by considering the Efficiency of one team over rest of the teams under various permutations of inputs and outputs by computing the Technical Efficiency (T.E), Pure Technical Efficiency(P.T.E), Scale Efficiency, constant returns to scale (CRS), variable returns to scale (VRS), along with Reference set , Peers and rank of the decision-making units. Based on the reference set and peerweight in this analysis,we can express the input and output values needed to bring every DMUs into an efficient frontier. Also, by CCR and BCR theoretical models we evaluate the Technical Efficiency (TE) and Pure Technical Efficiency (PTE) of the teams for the data are presented.

Keywords and phrases: BCC Model, CCR Model, CRS, DEA, Peers, Pure Technical Efficiency, Technical efficiency, VRS.

1 Introduction

The IPL Indian Premier League has been started in the year 2008 as a cricket league organized by BCCI. IPL has successfully completed 14 seasons till 2021 and 15th season would take place in this year 2022. IPL is considered to be the finest Twenty20 competition in the world of cricket based on the line of English Premier League (EPL). This has encouraged the best fit players who could not reach the National teams and given an opportunity to explore and raise the new talent. Its impact has spread globally. IPL is professional men's Twenty20 cricket league, which falls in the months of March and April every year. There is an interchange nation players included in all the teams to have a unity in diversity. During the time of COVID the royal country UAE has opened an invitation to have it with no audience. It is the first of its kind to have broadcasted live in YouTube. According to Duff & Phelps, the brand value of IPL in 2019 was $ 6.3 billion. According to BCCI in the season 2015 IPL contributed $150 million to the Indian economy. In the season 2020 IPL has record viewership and an overall increase was 23% compared to 2019.

Each team can select the players through auction and the contract is for one year with a franchise having the option to exchange the contract by one or two years. Teams get the profit through advertisements by increasing the team's brand value. Most of the investment will be on training the teams, Players, Trainers salaries, brand promotion. And also, whenever the teams win the tournaments they generate more revenue. The prize money is distributed among the owner and the players of the winning team.

In this paper we use DEA model to measure the technical efficiency and pure efficiency of the IPL teams by taking the data of the seasons 2018, 19 and 20. As an input lost matches in the season, spent money which includes players Auction Amount, promotions, Staff Salaries and other expenditures, runs given to the opposite team. As an output points scored, runs scored and brand value. The team has to have the proportionate ratio of the investment (input) and the profit (Output), whoever has the best ratio is the profitable team.

The Author [1] assessed efficiency of Korean Professional Baseball Teams using Data Envelopment Analysis and Author [2]analyzed that (DEA) was carried out to find out most efficient IPL team of 2019 using three inputs and two output variables. The validity of DEA was carried out using SEM in two stages, first the validity of inputs and outputs was checked whether the research can be carried out with the chosen inputs and output, and secondly, validity of efficiency, which was found out from DEA, was checked with the chosen sets of inputs and output of the production using Structural equation modeling (SEM), Input as a Total auction price, Number of matches lost, Total runs conceded, and Output as a Net run rate, Number of matches won. The researchers [3] applied DEA techniques in school initiative studies. The researchers like Rhodes, Cooper and Thanassoulis was applied appropriate methods for evaluating the efficiencies, which directed their efforts extending towards ‘‘best practice’’ to the field of science technology. Which led to the lot of improvements in the field of productionAuthor [4] used Data Envelopment Analysis Techniques to set of universities in U.K and performed subject wise analysis and Authors [5] evaluated performance of universities in Telangana state and also Authors [6] applied different models in DEA for their evaluation process. Authors [7] evaluate the hospital efficiency in India by using DEA. Authors [8] Assessing Professional Tennis Players Using Data Envelopment Analysis (DEA)) evaluated the performance of professional tennis players from the perspective of the efficiency of their game using data envelopment analysis (DEA).

2 Data Envelopment Analysis

Data Envelopment Analysis (DEA) is relatively “data oriented” and mathematical approach for evaluating the performance of a set of peer entities called decision making entities, which convert multiple inputs in to multiple outputs .In the recent years, the DEA has emerged into a greater variety of application for using evaluating the performance of many different kinds of entities engaged in many different activities in many different contexts in many different countries world over.DEA represents a great progression of continuous advancing for the data analysis , which find extensive use in industry , society , education even in sports sector. Author [9] Measuring the Technical Efficiency of Decision Making Units by CCR Model in Data Envelopment Analysis.[10] Assessed Selection and Analysis of Input-Output Variables using Data EnvelopmentAnalysis ofDecisionMakingUnits-IndianPrivateSectorBanks.[11] Assessed the performance of Agriculture forming in Telangana State for the financial years 2018-19 and 2019-20 using CCR Model by Data Envelopment Analysis.

3 CCR and BCC models in Data Envelopment Analysis

3.1 Efficiency Analysis is always computed to assess the performance of an organization. The Efficiency is an important factor in economic analysis, where the process has a single input and single output, and then the efficiency is defined as:

$$\text{Efficency} = \frac{\text{Output}}{\text{Input}} \qquad (1)$$

The theory of production from the economic point of view then can be considered as a formal model to link inputs and outputs, this theory has several strengths. First, some formal relationship between inputs and outputs exists and a ‘‘best performance’’ can be identified by comparing different units transforming in to inputs to output.

Figure 1: Transformation of Input/ Output Process

Suppose there are n number of Decision Making Units, i.e., DMU_1, DMU_2,…,DMU_n Few common input and output for each of this DMU’s j= 1,2,3,…,n **.**

DMUs are selected as follows:

1. For each input and output of the DMU’s are Numerical data, with the data assumed to be positive for all Decision Making Units (DMUs).
2. The inputs and outputs should reflect in the components that will enter in to the relative efficiency evaluations of the Decision Making Units (DMUs).
3. In principle, smaller input amounts are preferable and larger output amounts are preferable, so the efficiency scores should reflect these principles.
4. The measurement units of the different inputs and outputs need not to be congruent.

Suppose n input and s output are selected with properties noted 1 and 2. Let the input and output data for DMU_j be (x_{1j}, x_{2j}, x_{3j},…,x_{nj}) and (y_{1j},y_{2j},y_{3j},…,y_{sj}) respectively. The input data matrix A and the output data matrix B can be arranged as follows:

$$X = Inputs = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nn} \end{bmatrix} \qquad (2)$$

$$Y = \text{Outputs} = \begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ y_{s1} & y_{s2} & \cdots & y_{sn} \end{bmatrix} \quad (3)$$

Where X is an (n x n) matrix and Y is an (s x n) matrix.

3.2 The CCR Model: In Data Envelopment Analysis (DEA) the most widely used model is CCR Model [12] and [13]. A Constant Return to Scale relationship is assumed between Inputs and Outputs. It was the first Data Envelopment Analysis model to be developed CCR after Charnes, Cooper and Rhodes who introduced this. This model is calculates the Overall Efficiency (O.E) for each unit, where both the, Technical Efficiency(T.E) and Scale Efficiency (S.E) are aggregated into one value. The Primal CCR model is explained as follows:

Decision Making Units DMU_j: The j[th]Decision Making Unit $j = 1,2,3, \ldots, n$.

$\boldsymbol{x_{ij}}$: The amount of the i[th] input of the j[th] Decision Making Units $\boldsymbol{x_{1j}, x_{2j}, xy_{3j}, \ldots, x_{nj}}$.

$\boldsymbol{y_{ij}}$: The amount of the j[th] output of the j[th] Decision Making Units $\boldsymbol{y_{1j}, y_{2j}, y_{3j}, \ldots, y_{sj}}$

$\boldsymbol{v_i}$: The weight assigned to the i[th]input ,$i = 1,2,3, \ldots, n$.

$\boldsymbol{u_r}$: The weight assigned to the r[th]output ,$r = 1,2,3, \ldots, s$.

The Fractional Programming Problem (FPP) is :

$$\textbf{Max}\boldsymbol{R} = \frac{u_1 y_{1k} + u_2 y_{2k} + u_3 y_{3k} \cdots + u_s y_{sk}}{v_1 x_{1k} + v_2 x_{2k} + v_3 x_{3k} \cdots + v_m x_{mk}}, \qquad \boldsymbol{k = 1, 2, 3, \ldots, n} \quad (4)$$

$$\textbf{Subjecttoconstraints}: \frac{u_1 y_{1j} + u_2 y_{2j} + \cdots + u_s y_{sj}}{v_1 x_{1j} + v_2 x_{2j} + \cdots + v_m x_{mj}} \le \boldsymbol{1}, \qquad \mathbf{j = 1, 2, 3, \ldots, n}. (5)$$

$$\textbf{Nonnegativity}\boldsymbol{u_1, u_2, u_3, \ldots, u_s \ge 0} \,\&\, \boldsymbol{v_1, v_2, v_3, \ldots v_m \ge 0} \qquad (6)$$

The ratio of input and output should not exceed 1 for every decision making unit. The objective is to maximize the decision making units. The optimal value of R^* is at most one. Mathematically, non negativity constraints (6) is not sufficient for the fractional terms in (5) to have a positive value . Assuming that all outputs have some non zero and this leads to be the reflected in the weights $\boldsymbol{u_r}$and $\boldsymbol{v_i}$ being assigned positive values. Now we replace the Factional Program (FP) by the following Linear Programming Problem (LPP),

$$\textbf{Max}\boldsymbol{R(u,v) = u_1 y_{1k} + u_2 y_{2k} + u_3 y_{3k} + --- + u_s y_{sk}} (7)$$

$$\textbf{Subjectto}\boldsymbol{v_1 x_{1j} + v_2 x_{2j} + v_3 x_{3j} + --- + v_m x_{mj} = 1} (8)$$

$\boldsymbol{u_1 y_{1j} + u_2 y_{2j} + u_3 y_{3k} + --- + u_s y_{sj} \leq v_1 x_{1j} + v_2 x_{2j} + v_3 x_{3j} + --- + v_m x_{mj}}$ (9)

$\boldsymbol{u_1, u_2, u_3, \dots, u_s \geq 0, v_1, v_2, v_3, \dots v_m \geq 0}$(10)

$$\therefore \text{ Optimal Solution } (\boldsymbol{v}^*, \boldsymbol{u}^*, \boldsymbol{R}^*)$$

The ratio scale is evaluated by using the Primal Problem. The primal becomes

$$\boldsymbol{MaxR}^*(\boldsymbol{v}^*, \mathbf{u}^*) = \frac{\sum_{r=1}^{s} \boldsymbol{u_r^* y_{rk}}}{\sum_{i=1}^{m} \boldsymbol{v_i^* x_{ij}}} \quad (\mathbf{11})$$

$$\boldsymbol{R}^*(\boldsymbol{v}^*, \mathbf{u}^*) = \sum_{r=1}^{s} \boldsymbol{u_r^* y_{rj}} \qquad from \quad (4) \quad (\mathbf{12})$$

$$\textbf{Subjecttoconstraints}: \sum_{r=1}^{s} \boldsymbol{u_r^* y_{rj}} - \sum_{i=1}^{m} \boldsymbol{v_i^* x_{ij}} \leq \mathbf{0} \boldsymbol{j} = \mathbf{1, 2, 3}, \dots, \boldsymbol{n} \, (\mathbf{13})$$

$$\sum_{i=1}^{m} \boldsymbol{v_i x_{ik}} = \mathbf{1} \quad (\mathbf{14})$$

$$\textbf{Nonnegativity} \boldsymbol{u_r} \geq \mathbf{0}, \boldsymbol{v_i} \geq \mathbf{0}$$

The ratio of input and output should not exceed 1 for every decision making unit. The objective is to maximize the decision making units. The optimal value of R^* is at most one. Mathematically, non negativity constraints (6) are not sufficient for the fractional terms in (5) to have a positive value. Assuming that all outputs have some non zero and this leads to be the reflected in the weights $\boldsymbol{u_r}$and $\boldsymbol{v_i}$ being assigned positive values. Now we replace the Factional Program (FP) by the following Linear Programming Problem (LPP),

$\textbf{Max}\boldsymbol{R}(\boldsymbol{u}, \boldsymbol{v}) = \boldsymbol{u_1 y_{1k} + u_2 y_{2k} + u_3 y_{3k} + --- + u_s y_{sk}}$ (7)

$\textbf{Subjectto}\boldsymbol{v_1 x_{1j} + v_2 x_{2j} + v_3 x_{3j} + --- + v_m x_{mj}} = \mathbf{1}$ (8)

$\boldsymbol{u_1 y_{1j} + u_2 y_{2j} + u_3 y_{3k} + --- + u_s y_{sj} \leq v_1 x_{1j} + v_2 x_{2j} + v_3 x_{3j} + --- + v_m x_{mj}}$
(9)

$\boldsymbol{u_1, u_2, u_3, \dots, u_s \geq 0, v_1, v_2, v_3, \dots v_m \geq 0}$ (10)

$$\therefore \text{ Optimal Solution } (\boldsymbol{v}^*, \boldsymbol{u}^*, \boldsymbol{R}^*)$$

The ratio scale is evaluated by using the Primal Problem. The primal becomes

$$\boldsymbol{MaxR}^*(\boldsymbol{v}^*, \mathbf{u}^*) = \frac{\sum_{r=1}^{s} \boldsymbol{u}_r^* \boldsymbol{y}_{rk}}{\sum_{i=1}^{m} \boldsymbol{v}_i^* \boldsymbol{x}_{ij}} \quad (\mathbf{11})$$

$$\boldsymbol{R}^*(\boldsymbol{v}^*, \mathbf{u}^*) = \sum_{r=1}^{s} \boldsymbol{u}_r^* \boldsymbol{y}_{rj} \qquad from \quad (4) \quad (\mathbf{12})$$

$$\textbf{Subjecttoconstraints}: \sum_{r=1}^{s} \boldsymbol{u}_r^* \boldsymbol{y}_{rj} - \sum_{i=1}^{m} \boldsymbol{v}_i^* \boldsymbol{x}_{ij} \le \mathbf{0} \boldsymbol{j} = \mathbf{1}, \mathbf{2}, \mathbf{3}, \dots, \boldsymbol{n} \, (\mathbf{13})$$

$$\sum_{i=1}^{m} \boldsymbol{v}_i \boldsymbol{x}_{ik} = \mathbf{1} \quad (\mathbf{14})$$

$$\textbf{Nonnegativity} \boldsymbol{u}_r \ge \mathbf{0}, \boldsymbol{v}_i \ge \mathbf{0}$$

The above linear programming problem yield the Optimal Solution R^*, where efficiency score is called Technical Efficiency or CCR Efficiency for the particular DMU_j and efficiency scores for all DMUs are obtained by repeating them for each DMU_j , $j = 1,2,3, \dots, n$ .The value of R^* is always less than or equal to 1 . DMUs for which $R^* < 1$ are relatively inefficient and those for which$R^* = 1$ are relatively efficient, having their virtual input-output combination points on the frontier. The frontier itself consists of linear facts spanned by efficient units of the data, and the resulting frontier production function has no unknown parameters.

3.3 The BCC Model: To the existing model approach CCR extended by Banker, R.D., Charnes R.F and Cooper W.W. This B.C.C Model is next model in DEA.Which is used in efficiency analysis and a variable return to scale (VRS) relationship assumed between input variables and output variables. Banker, Charnes and Cooper (BCC) who first introduced this model. If the total constraints equal to one is adjoined, which is known as Banker, Charnes R.F and Cooper BCC model. Added a constraint as an additional variable into multiplier problem. This extra variable is makes it possible to affect returns to scale VRS evaluation. This scale is constant or decreasing or increasing. This BCC model is also referred to Variable Returns to Scale (VRS) model. The convexity constraints in this model formulation make sure that composite units of similar scale size units being calculated.

The Production Possibility Set (P.P.S) of the BCC Model is defined below:

$$P(BCC) = \{(x, y)/x \geq X\lambda, y \leq Y\lambda, e\lambda = 1, \lambda \geq 0\} \quad (15)$$

The input-oriented BCC Model calculates the pure technical efficiency of DMUs by solving envelopment form of linear programming problem:

Objective function $Min(\theta_B, \lambda): \theta_B$ (16)

Subject to Constraints: $\theta_B x_0 - X\lambda \geq 0$ (17)

$Y\lambda \geq y_o$ (18)

$e\lambda = 1$ (19)

$\lambda \geq 0$ (20)

Here θ_B is a known as scalar.

Dual multiplier form of the linear programming problem (BCC_R) is expressed as:

Objective function: $Maximize\ (v, u, x_0)\ R = uy_0 - u_0$ (21)

Subject to Constraints: $vx_0 = 1$ (22)

$-vX + uY - u_0\, e \leq 0$ (23)

$u \geq 0, \quad v \geq 0$

Here u_0 is free in sign.

Here v & u $are\ Vectors$ and θ &u_0 $are\ Scalars$.

The equivalent BCC Fractional Programming is found from the dual problem as

Objective function : Maximize $\frac{uy_0 - u_0}{vx_0}$(24)

Sub to constraints: $\frac{uy_j - u_0}{vx_j} \leq 1$, $j = 1,2,3, \ldots, n$ (25)

$v \geq 0, u \geq 0, u_0$is free in sign.

The difference between CCR and BCC model is present in the free variable u_0, which dual variable associated with the constraint $e\lambda = 1$ in the Envelopment model. This evaluation is obtained from the CCR model and BCC model.

The BCC model optimal solution is presented by $(R_B^*, \lambda^*, s^{-*}, s^{+*})$. Where $R_B^*\ \lambda^* s^{-*}$ and s^{+*} represents maximal Pure Technical Efficiency (PTE), peer weight, input excesses and output short fall respectively.

3.4 The Reference Set (R.S): When we observe the DMU has CCR inefficient $R^* < 1$ then there must be one constraint produce equality between the left hand side and right hand side of the equation(7) other wise , R^* could be enlarged. Let $j \in \{1,2,3, \dots, n)$ be

$$\boldsymbol{E_k^{'}} = \left\{ \boldsymbol{j}: \sum_{r=1}^{s} \boldsymbol{u_r^* y_{rj}} = \sum_{i=1}^{m} \boldsymbol{v_i^* x_{ij} j} = \boldsymbol{1, 2, 3, \dots, n} \right\} \tag{26}$$

The subset of E_k and $E_k^{'}$, composed of CCR efficient DMUs, is called the Reference Set (RS) or the peer group to the DMU1, DMU2, DMU3,…, DMUk.

3.5 Potential Improvement (PI): An efficient study not only provides an efficiency score per each unit but also indicates by how much and in which areas an inefficient unit needs to improve in order to improve the efficiency. This information can enable the targets to be set which could help inefficient units to be improved in their performance.

3.6 Reference Comparison(RC): If the assessment of units was found to be inefficient then it is felt to be justified that the information provided can be used as a basis for setting targets for the units .As a first step in setting targets, the inefficient unit should be compared with the units in its reference set.

3.7 Peer Group (PG): Data Envelopment Analysis identifies for each inefficient unit a set of excellent units, called Peer Group, which includes those units that are efficient if evaluated with the optimal weights of inefficient unit. The Peer Group, made up of Decision Making Units which are characterized by operating methods similar to the inefficient unit being examined, which is a realistic term of comparison which unit aim to imitate in order to improve its performance. Another name for the peer group is reference set.

3.8 Returns to Scales: The performance evaluation depends on Returns to Scale (RTS). There are two types of returns to scale techniques used in DEA. Those are Constant Returns to Scale(CRS) and Variable returns to scale(VRS).

3.8. 1 Constant Returns to Scale (CRS): Every unit is increases in input that goes into the process, the output produced increases by a constant proportional quantity; hence it is represented by Constant Returns to Scale (CRS).

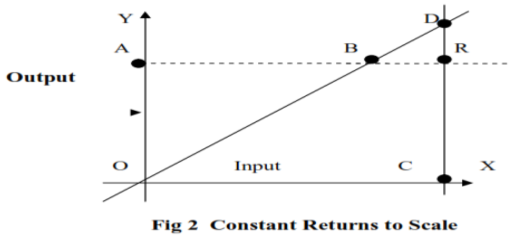

Figure 2: Constant Return to Scale

From the figure 2 it is clear that the production of a single output is examine graphically. From figure 2 we observe that f***(x)*** is a straight line and has a single slope. In figure 2 we observe that R is projected onto the frontier either under an input- reducing or an output – increasing consideration. By comparison B and D points are projected on the frontier.

3.8.2 Variable returns to scale (VRS) :The variable returns to scale (VRS) result in a non-proportionate change (increase or decrease) in the outputs.

3.8.2.1 Increasing Returns to Scale (IRS): For every unit increases in the input, the output increases by a more than proportionate quantity displaying is increasing returns to scale(IRS).

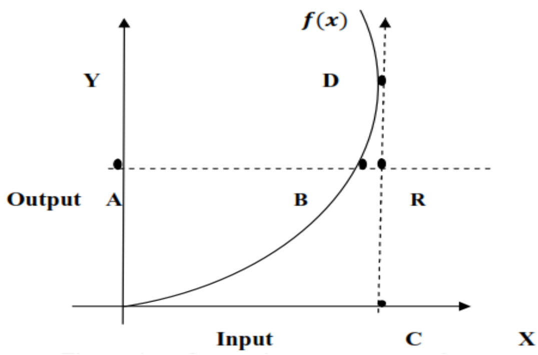

Figure 3: Increasing returns to scale

Figure 3, represents a function f*(x)* with an increasing slope. R is lies above the efficient frontier.

3.8.2.2 Decreasing Returns to Scale (DRS): For every unit decreases in input and the output decreases by a less than proportionate quantity displays decreasing returns to scale (DRS).

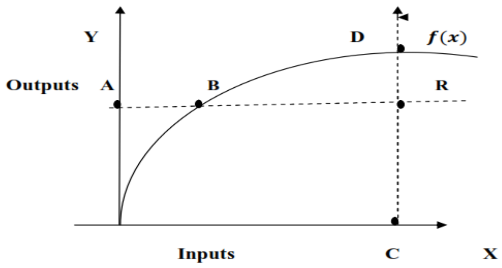

Figure 4: Decreasing returns to scale

A. In figure 4, the function **f(x)** has a decreasing slope. It is clear that R is lies below the efficient status. For this, R could be projected onto the frontier either under an input-reducing or an output–increasing consideration. Where B and D points are projected on the frontier. The input reducing efficiency is obtained by$\frac{CR}{CD}$.

B. **Rank of DMUS:** In Data Envelopment Analysis (DEA) identify the reference sets and assign a ranks of a DMUS based on the reference sets.

3.9 Most Productive Scale Size (MPSS): The CCR and BCC models are used to find which DMU is under Most Productive Scale Size. A Decision-Making Units found to be efficient in a CCR Model will also found an efficient DMU in BCC model and constant returns to scale (CRS) prevails.

3.10 Decomposition of Technical Efficiency (T.E): The CCR Model assumes the constant returns to scale Production Possible Set (PPS) .It is postulated that the radial expansion and reduction of all observed Farming input and output resources and their non negative combinations are possible. Hence the CCR score is called Global Technical Efficiency (GTE). The BBC Model assumes that convex combinations of observed Engineering Colleges form the production possible set (PPS) and BCC scores is called Local Pure Technical Efficiency (LPTE). If a DMUs is fully efficient in both CCR and BCC scores, it is operating in the Most Productive Scale Size(MPSS). If a DMU has fully efficient in BCC but low in score in CCR Model , then it operating locally efficient but no t global due to the scale size of the Decision Making Unit.Due to the reason to characterized the Scale Efficiency (S.E).

Let the CCR and BCC model optimal scores of a decision making units is θ^*_{CCR} and θ^*_{BCC} respectively. Then the Scale Efficiency (S.E) is defined as $\text{Scale Efficiency (S.E)} = \frac{\theta^*_{CCR}}{\theta^*_{BCC}}$ (27)

For BCC efficient Decision Making Units with Constant to scale (CRTS), in the Most Productive Scale Size , it is Scale Efficiency (S.E) is one. The CCR Model score is called the Technical Efficiency (Global). The BCC express the Pure Technical Efficiency (Local) under variable returns to scale (VRTS).

4. Data Consideration and Analysis

The following are the Inputs and Outputs of the problem

S.No.	Inputs	Outputs
1	Lost Matches	Points
2	Spent Money	Runs Scored
3	Runs given	Brand Value (BV)

The IPL teams full name as follows for further reference:

IPL Team	Team full Name
RCB	Royal Challengers Bangalore
KKR	Kolkata Knight Riders
CSK	Chennai Super Kings
SRH	Sunrisers Hyderabad
DC	Delhi Capitals
PBKS	Kings XI Punjab
MI	Mumbai Indians
RR	Rajasthan Royals

The IPL data and the results of Data Envelopment Analysis (DEA) for IPL teams of CCR Model Technical Efficiency (T.E) and Pure Technical Efficiency for the seasons 2018, 2019 & 2020 is presented below:

Table 1: IPL Team Data for the Season 2018

Rank	Team	Won	Lost	Runs_Scored	Runs_Given	Points	Spent	BV
1	SRH	9	5	2230	2193	18	58.35	462
2	CSK	9	5	2488	2433	18	40.05	647
3	KKR	8	6	2363	2425	16	59	686
4	RR	7	7	2130	2141	14	68.85	284
5	MI	6	8	2380	2282	12	46.35	746
6	RCB	6	8	2322	2383	12	48.85	647
7	PBKS	6	8	2210	2259	12	67.4	343
8	DC	5	9	2297	2304	10	45.4	343

From the Table 1 shows the IPL teams data for the season 2018 includes Ranks , won matches , Lost matches, Total Runs Scored in the season, Total Runs given in the season, Points, Spent money and Band Value.

Table 2: The CCR Model Technical Efficiency of IPL Team for The Season 2018

S.No.	DMU(IPL TEAM)	CCR T.E	References	Rank	Peers	Name of the Peer teams
1	SRH	1	3	1	0	SRH
2	CSK	1	4	2	0	CSK
3	KKR	0.99	0	3	2	CSK,MI
4	RR	0.96	0	4	2	MI,SRH
5	MI	1	6	5	0	MI
6	RCB	0.93	0	6	2	CSK,MI
7	PBKS	0.94	0	7	2	MI,SRH
8	DC	0.95	0	8	2	CSK,MI

From the Table 2, It is clear that the CCR model technical efficiency (T.E) of the eight IPL teams in the season 2018 has the following limits: $0.93 \leq R^{*} \leq 1.00$, According to CCR model three teams have been performed well and has efficient status namely Sunrise Hyderabad (SRH), Chennai Super Kings (CSK), Mumbai Indians (MI) and other five teams inputs lose as per CCR Model. Potential Improvement is essential for reaming teams in order to progress his performance.

From Table 2, we observe that Sunrise Hyderabad (SRH), Chennai Supper Kings (CSK), Mumbai Indians (MI) were performed well as per CCR Model when compared to the eight teams from the season 2018. We observed that, CSK, MI, SRH are peers to the remaining teams. MI has six references, which is highest one in this model. The peer contributions of this team are more comparing to remaining teams. According to Data Envelopment Analysis (DEA) properties every efficient DMU by itself-role model. CSK,SRH are efficient DMU's. These two DMUs by itself is a role model DMU's. The T.E of KKR is 0.99, Hence KKR performance is technically inefficient frontier. If return to scale is constant it could have produced its current outputs 0.99 or 99% of inputs. Thus, removal of all inefficiencies is achieved by reducing all inputs by .01% of their observed values. Infarct, based on the reference ser and peer weight, we can express the input and output values needed to bring KKR into efficient frontier. In this way we analyze the inefficient IPL Teams in order to improving their performance towards improve the performance in their next season.

The CCR Model Distribution Score Graph in presented for the Season 2018 as below:

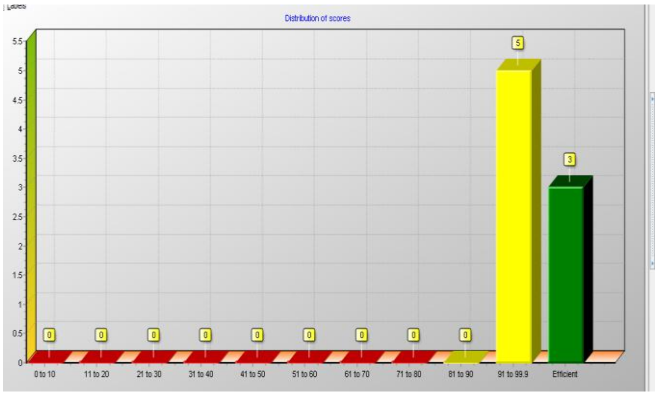

Figure 5: The CCR Model Distribution Score Graph for the Season 2018

From the Figure 5, we can find the CCR Model distribution of score graph 91 to 99.9 have five DMU's, These DMU's performance is technically inefficient frontier and remaining three DMU's are in efficient frontier.

The BCC Model results are shown in the following table:

Table 3: The BCC Model Pure Technical Efficiency of the IPL Teams for the Season 2018

S.No.	DMU	BCC P.T.E	References	Rank	Peers	Name of the Peer teams

1	SRH	1	2	1	0	SRH
2	CSK	1	2	2	0	CSK
3	KKR	1	1	3	0	KKR
4	RR	1	1	4	0	RR
5	MI	1	3	5	0	MI
6	RCB	0.94	0	6	2	CSK,MI
7	PBKS	0.94	0	7	2	MI,SRH
8	DC	1	1	8	0	DC

From the Table 3, the Pure Technical Efficiency variation for the eight IPL teams is in the following bounds i.e.: 0.94 ≤ R*≤1.00. As per BCC Model six IPL teams have been performed well and efficient DMU's namely SRH, CSK, KKR, RR, MI and DC inputs loses as per BCC model pure Technical Efficiency (PTE), Potential improvement is required for RCB, PBKS in order to progress his performance with regards to results. We observed that the peers to the inefficient Teams seem to be CSK, SRH, MI. MI has highest references i.e. 3. The peer contribution of Mumbai Indian is more compare to remaining IPL teams (DMU's).

The BCC Model distribution score Graph is presented for the Season 2018 as below.

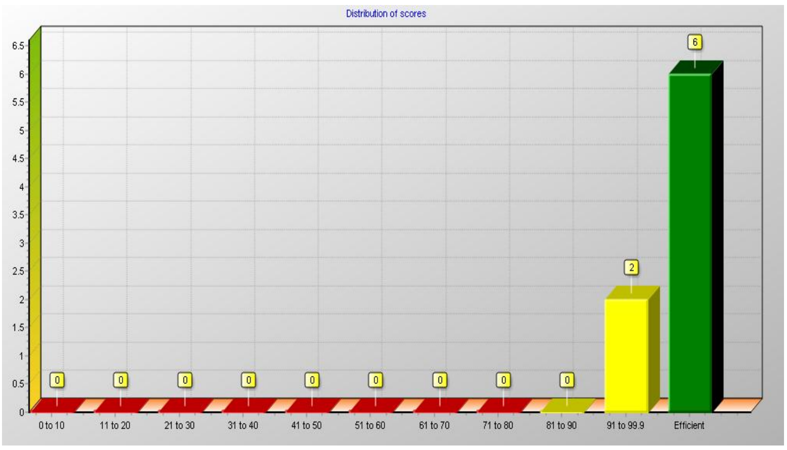

Figure 6: The BCC Model Distribution Score Graph in Presented for the Season 2018

From the above Figure 6, it is clear that 91 to 99.99, 2 IPL teams performance is technically inefficient frontier and 6 IPL teams (DMU's) are performing well.

Table 4: IPL Team Data for the Season 2019

Rank	Team	Won	Lost	Runs_Scored	Runs_Given	Points	Spent	BV
1	MI	9	5	2390	2282	18	70.86	809
2	CSK	9	5	2043	2012	18	73.6	732
3	DC	9	5	2207	2238	18	56.83	374
4	SRH	6	8	2288	2200	12	72.3	483
5	KKR	6	8	2466	2419	12	66.8	629
6	PBKS	6	8	2429	2503	12	48.8	358
7	RR	5	8	2153	2192	11	61.05	271
8	RCB	5	8	2146	2266	11	63.85	595

From the Table 4: shows the IPL teams data for the season 2019 includes Ranks, won matches, Lost matches, Total Runs Scored in the season, Total Runs given in the season, Points, Spent money and Band Value.

Table 5: The CCR Technical Efficiency of IPL Team for the Season 2019

S.No.	DMU(IPL TEAM)	CCR T.E	References	Rank	Peers	Name of the Peer teams
1	MI	1	4	1	0	MI
2	CSK	1	1	2	0	CSK
3	DC	1	1	3	0	DC
4	SRH	1	1	4	0	SRH
5	KKR	0.99	0	5	2	MI,PBKS
6	PBKS	1	4	6	0	PBKS
7	RR	0.96	0	7	2	MI,PBKS
8	RCB	0.92	0	8	2	MI,PBKS

From the Table 5, it is clear that the CCR model technical efficiency (T.E) of the eight IPL teams in the season 2019 has the following limits: $\mathbf{0.92 \leq R^{*} \leq 1.00}$, According to CCR model three teams have been performed well and has efficient status namely Sunrise Hyderabad (SRH), Chennai Super Kings (CSK), Mumbai Indians (MI), Delhi Capitals (DC), Punjab Kings (PBKS) and other

ISSN: 2094-0343
2326-9865

three teams inputs lose as per CCR Model. Potential Improvement is essential for reaming teams in order to progress his performance with regards to results.

From Table 5, we observe that Sunrise Hyderabad (SRH), Chennai Super Kings (CSK), Mumbai Indians (MI), Delhi Capitals (DC), Punjab Kings (PBKS) were performed well as per CCR Model when compared to the eight teams from the season 2019. We observed that, MI, PBKS are peers to the remaining teams. MI & PBKS has four references, which is highest one in this model. The peer contributions of these teams are more comparing to remaining teams.

According to Data Envelopment Analysis (DEA) properties every efficient DMU by itself-role model. CSK, Dc, SRH are efficient DMU's. These two DMUs by itself is a role model DMU's. The T.E of KKR is 0.99, Hence KKR performance is technically inefficient frontier. If return to scale is constant it could have produced its current outputs 0.99 or 99% of inputs. Thus, removal of all inefficiencies is achieved by reducing all inputs by .01% of their observed values. Infarct, based on the reference ser and peer weight, we can express the input and output values needed to bring KKR into efficient frontier. In this way we analyze the inefficient IPL Teams in order to improving their performance towards improve the performance in their next season.

The CCR Model Distribution Score Graph in presented for the Season 2019 as below:

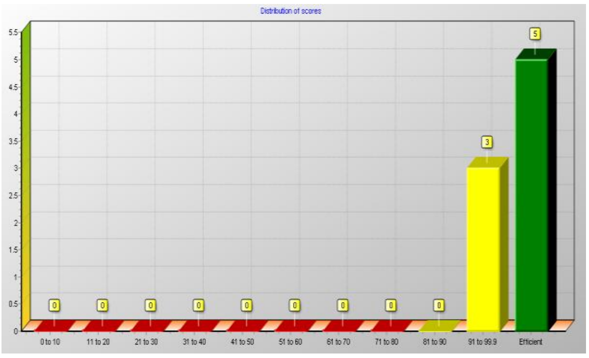

Figure 7: The CCR Model Distribution Score Graph for the Season 2019

Table 6: The BCC Pure Technical Efficiency of IPL Team for the Season 2019

S.No.	DMU(IPL TEAM)	CCR T.E	References	Rank	Peers	Name of the Peer teams
1	MI	1	2	1	0	MI
2	CSK	1	3	2	0	CSK

3	DC	1	2	3	0	DC
4	SRH	1	2	4	0	SRH
5	KKR	1	1	5	0	KKR
6	PBKS	1	2	6	0	PBKS
7	RR	0.98	0	7	3	CSK,DC,SRH
8	RCB	0.96	0	8	3	CSK,MI,PBKS

The Pure Technical Efficiency variation for the eight IPL teams is in the following bounds 0 .96 ≤ R ≤ 1.00. As per the BCC model six IPL teams (DMU's) were technical efficient i.e.: have been well and efficient DMU's Namely MI, CSK, DC, SRH, KKR and PBKS. RR, RCB inputs loses as per BCC model. Pure Technical Efficiency (PTE), Potential improvement is required for RR, PBKS in order to progress his performance with regards to results.

From the above table, we observed that the peers to the inefficient IPL teams seem to be MI, DC, CSK, SRH, PBKS by highest efficiency. CSK has highest reference i.e. 3. The Peer contribution of CSK is more compare to remaining Teams (DMU's)

The BCC Model Distribution Score graph is presented for the Season 2019 as below:

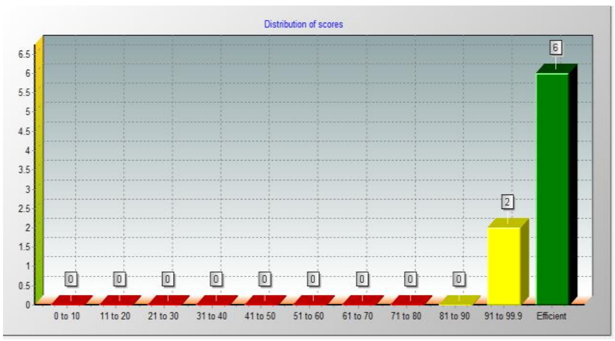

Figure 8: The BCC Model Distribution Score Graph for the Season 2019

Table 7: IPL Team Data for the Season 2020

Rank	Team	Won	Lost	Runs_Scored	Runs_Given	Points	Spent	BV
1	MI	9	5	2378	2187	18	83.05	761
2	DC	8	6	2289	2271	16	76	370
3	SRH	7	7	2225	2125	14	74.9	442
4	RCB	7	7	2147	2183	14	78.6	536

5	KKR	7	7	2219	2206	14	76.5	543
6	PBKS	6	8	2335	2343	12	68.5	318
7	CSK	6	8	2191	2275	12	84.85	611
8	RR	6	8	2288	2482	12	70.25	249

From the Table 7, shows the IPL teams data for the season 2020 includes Ranks , won matches , Lost matches, Total Runs Scored in the season, Total Runs given in the season, Points, Spent money and Band Value.

Table 8: The CCR Model Technical Efficiency of IPL Team for the Season 2020

S.No.	DMU(IPL TEAM)	CCR T.E	References	Rank	Peers	Name of the Peer teams
1	MI	1	6	1	0	MI
2	DC	0.95	0	2	2	CSK,MI
3	SRH	1	3	3	0	SRH
4	RCB	0.93	0	4	2	CSK,MI
5	KKR	0.99	0	5	2	CSK,MI
6	PBKS	0.94	0	6	2	MI,SRH
7	CSK	1	4	7	0	CSK
8	RR	0.96	0	8	2	MI,SRH

From Table 8, it is clear that the CCR model Technical Efficiency (T.E) of the eight teams as the following bounds i.e.: $0.93 \leq \theta \leq 1.00$. According to CCR model three Teams have been performed well and efficient status namely MI, SRH and CSK and other five teams inputs lose as per CCR Model Potential improvement is essential for remaining Teams in order to progress his performance with regards to results.

From Table 8, we observed that MI,SRH and CSK are performed well as per CCR Model when compared to five IPL Teams. We observed that MI,SRH and CSK are peers to the remaining teams. MI has six references, which is highest one in this model. The peer contribution of this team is more compare to remaining Teams. According to Data Envelopment Analysis (DEA) properties every efficient DMU by it self-role model. The technical efficiency of RCB is 0.93. Hence, RCB performance is technically inefficient frontier. If return to scale is constant it could have produced its current outputs 0.93 or 93% of Inputs. Thus, removal of all inefficiencies is achieved by reducing all inputs by 0.07 or 7% of their observed values.

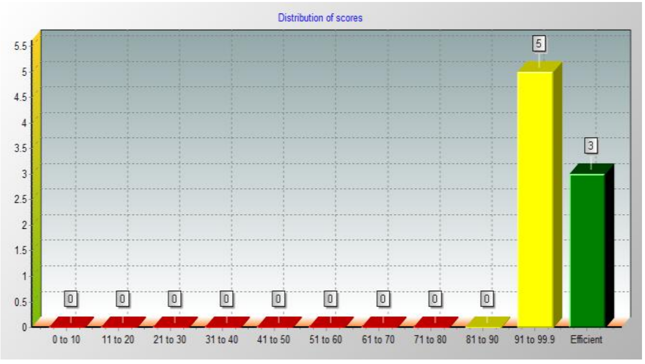

Figure 9: The CCR Model Distribution Score Graph for the Season 2020

Table 9: The BCC Pure Technical Efficiency of IPL Team for The Season 2020

S.No.	DMU(IPL TEAM)	CCR T.E	References	Rank	Peers	Name of the Peer teams
1	MI	1	3	1	0	MI
2	DC	1	1	2	9	DC
3	SRH	1	2	3	9	SRH
4	RCB	0.94	0	4	2	CSK,MI
5	KKR	1	1	5	0	KKR
6	PBKS	0.94	0	6	2	MI,SRH
7	CSK	1	2	7	0	CSK
8	RR	1	1	8	0	RR

The Pure Technical Efficiency variation for the eight IPL teams is in the following bounds 0 .94 ≤ R ≤ 1.00. As per the BCC model six IPL teams (DMU's) were technical efficient i.e.: have been well and efficient DMU's Namely MI, DC, SRH, KKR, CSK, RR. And PBKS, RCB inputs loses as per BCC model. Pure Technical Efficiency (PTE), Potential improvement is required for RR, PBKS in order to progress his performance with regards to results.

From the Table 9, we observed that the peers to the inefficient IPL teams seem to be MI, DC, SRH, KKR, CSK, RR by highest efficiency. MI has highest reference i.e. 3. The Peer contribution of MI is more compare to remaining Teams (DMU's)

The BCC Model Distribution Score graph is presented for the Season 2020 as below:

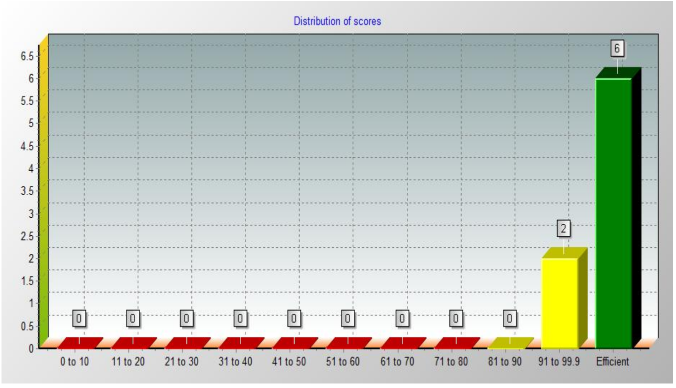

Figure 10: The BCC Model Distribution Score Graph for the Season 2020

Table 10: The CCR & BCC Technical Efficiency of IPL Team for the Seasons 2018, 2019 & 2020

S. No.	IPL TEAM	CCR T.E			BCC T.E.		
		2018	2019	2020	2018	2019	2020
1	SRH	1	1	1	1	1	1
2	CSK	1	1	1	1	1	1
3	KKR	0.99	0.99	0.99	1	1	1
4	RR	0.96	0.96	0.96	1	1	0.94
5	MI	1	1	1	1	1	1
6	RCB	0.93	0.92	0.93	0.94	1	0.94
7	PBKS	0.94	1	0.94	0.94	0.98	1
8	DC	0.95	1	0.95	1	0.96	1

Table 10: shows the CCR, BCC technical efficiency of IPL teams for the seasons 2018, 2019 & 2020. The overall performance of the each team shown in the Table 10. Teams SRH, CSK, MI are technically efficient of all the seasons. KKR, RR was inefficient with CCR model and Pure Technically efficient. RCB, PBKS & DC are Inefficient all the seasons.

5 Conclusions

From this data analysis we found that for the season 2018 SRH, CSK, MI performs well as per CCR Technical Efficiency. SRH, CSK, KKR, RR, MI & DC perform well as per BCC Pure Technically Efficiency when compared to the 8 IPL teams. For the Season 2019 SRH, CSK, MI, PBKS & DC performs well as per CCR Technical Efficiency. SRH, CSK, KKR, RR, MI & RCB perform well as per BCC Pure Technically Efficiency when compared to the 8 IPL teams. For the Season 2020 SRH, CSK & MI perform well as per CCR Technical Efficiency. SRH, CSK, KKR, MI, PBKS & DC perform well as per BCC Pure Technically Efficiency when compared to the 8 IPL teams.

Acknowledgement

No research grants.

References

[1] Joon Ho Kang, Young Han Lee and Kwon Sihyeong, Evaluating Management efficiency of Korean Pofessional Baseball Teams using Data Envelopment Analysis, International Journal of Sport and Health Science Vol.5, (2007), 125 – 134.

[2] SubrataJana1 ,ArijitGhosh and BanhiGuha , IPL 2019: Evaluating the performance of teams by DEA & SEM, Malaya Journal of Matematik, Vol. 1, (2011), 41-45.

[3] Rutter , M. and MaughanB.,School effectiveness findings 1970-2002,Journal of School Psychology ,Vol.40, No.6, (2002), 451-475.

[4] Kwimbere, F.J., Measuring efficiency in not-for-profit organizations: an attempt to evaluate efficiency in selected UK university departments, School of Management,University of Bath,1987.

[5] Nellutla, R., Ashok, R., Ramesh, M., and Haragopal, V. V.Technical Efficiency of Universities in Telangana State through Data Envelopment Analysis (DEA) Approach. European Journal of Mathematics and Statistics, Vol. 2.No, 6, 30-39. https://doi.org/10.24018/ejmath.2021.2.6.62

[6] RajuNellutla, and V. V Haragopal ,Performance of Management Schools in Secondary School Examinations of Andhra Pradesh State by Data Envelopment Analysis, International Journal of Scientific Research, Vol-4, Issue. 9, (2015), 179-182.

[7] M. Goverdhan, RajuNellutla, and V. V Haragopal, A Critical Data Envelopment Analysis of Hospital efficiency in India , International Journal of Scientific Research, Vol-5,issue2, (2016), 471- 475.

[8] Ruiz, Pastor, and Pastor, Assessing Professional Tennis Players Using Data Envelopment Analysis (DEA), Journal of Sports Economics, Vol. 14, (2013).

[9] RajuNellutla, M. Goverdhan and V.V. Haragopal, Measuring the Technical Efficiency of Decision Making Units by CCR Model in Data Envelopment Analysis, International Journal

of Scientific Research in Mathematical and Statistical Sciences, Vol.5, Issue.4, (2018), 54-60.

[10] B.Vittal, RajuNellutla and M. Krishna Reddy ,Selection and Analysis of Input-Output Variables using Data Envelopment Analysis of Decision Making Units - Indian Private Sector Banks, International Journal of Engineering and Advanced Technology (IJEAT) Volume-10 Issue-5,(2021), 119-126.

[11] Pavan Kumar Donthula, RajuNellutla and V.V Haragopal,Measuring the Technicalefficiency in Agriculture Farming through CCR Model by Data Envelopment Analysis,IOSRJournalofMathematics, Vol-17, Issue 4, (2021), 1-8.

[12] Banker, R.D., R.F. Charnes and W.W. Cooper , Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis, Management Science, Vol. 30, 1078–1092.

[13] Charnes, A, W. Cooper, and E., Rhodes, Measuring the Efficiency of decision making units, European Journal of Operational Research, Vol. 2, (1978), 429 – 444.