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# IPL 2019: Evaluating the performance of teams by DEA & SEM

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**Abstract**

The analysis of sports data, especially cricket is an interesting field. This paper investigates the efficiency of eight participating teams in the Indian Premier League 2019. We have used Data Envelopment Analysis (DEA), a Linear Programming (LP) based technique and Structural Equation Modeling (SEM) to evaluate the efficiency of the Decision Making Units (DMU) on the basis of DEA Scores. A real dataset of IPL 2019 is used for efficiency estimation.

**Keywords**

DEA, SEM, LP, Efficiency, Cricket, IPL.

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## Contents



## 1. Introduction

IPL is a franchise-oriented T-20 cricket competition. It was launched by BCCI on 13th September, 2007 in New Delhi with a grandiloquent celebration in April, 2008. This master plan, the layout, the reward money, the contract revenue system and team composition rules were a brain child of Lalit Modi, the then BCCI Vice-President who expounded it. The format of IPL is like that of the English Premier League (EPL) of England and the National Basketball League (NBA) in the USA. IPL is considered as the premium T-20 cricket competition in the sports World. IPL is a affluent cricket league and has taken Indian cricket to another level. It is worth billions of rupees. Lots of money, big corporate, celebrities are involved in this tournament.

These eight teams played one another twice in a home & away format. Eventually, the top four teams qualified for the play offs. From the league phase the top two teams played against one another in the first qualifying match, with the winning team went directly to the final and the losing team got another chance to qualify for the final by playing the second qualifying match. From league phase the 3rd and 4th place team played against one another in a match and the winner of that match played the loser of the first qualifying match. Eventually in the IPL final match the two winners from the second qualifier and the first qualifier played the final and the winner wins the IPL trophy.

Cricket is an important component of entertainment in India as well as other cricket playing countries. Over the last few years, the popularity of IPL has been increased phenomenally. Side by side the popularity of unknown talented domestic and International players have also increased. The competition has become cut throat amongst the players. To pick up these players, franchises have to expend high auction price very often. Looking towards it, an urgency of evaluating the performance efficiency of these teams relating to their expenditure of total auction price has become momentous. Analysis of the team's performance is the need of the hour. In order to measure the efficiency, a performance evaluation tool is required for evaluating the performance of these teams.

Various types of methods may be used for measuring the performance of teams. The widespread methods are Stochastic Frontiers Analysis (SFA) and Data Envelopment Analysis

**Table 1.**

| No | NAME OF THE TEAMS | OWNERS |
|---|---|---|
| 01. | Chennai Super Kings (CSK) | India Cements |
| 02. | Delhi Capitals (DC) | GMR Group & JSW Group |
| 03. | Kolkata Knight Riders (KKR) | Red Chilies Entertainment & Mehta Group |
| 04. | Kings XI Punjab (KXIP) | KPH Dream Cricket Pvt. Ltd. |
| 05. | Mumbai Indians (MI) | Reliance Industries |
| 06. | Rajasthan Royals (RR) | Manoj Badale |
| 07. | Royal Challengers Bangalore (RCB) | United Spirits Ltd. |
| 08. | Sunrisers Hyderabad (SH) | Sun TV Network |

(DEA). SFA is good to handle the data with certain level of uncertainty. SFA is not convenient to apply in a multiple inputs and outputs situations. DEA has become an accepted performance measurement tool for organizations such as Universities, Hospitals, Schools etc. It has an ability to handle multiple inputs and outputs. An analysis of the teams in IPL 2019 is conducted here.

## 2. Literature Review

Kimber and Hansford (1993) analysed batting in cricket statistically. This study was expended by Barr and Kantor (2004) by suggesting a method to compare and select batsmen in cricket. Swartz et al. (2006) projected a simulation procedure for optimal batting order in One Day Cricket. This work was expanded by Swartz et al. (2009) by modeling and simulation for one day cricket. Karnik (2009) derived the hedonic price equations to estimate a bid price for all the cricketers in the Indian Premier League (IPL) auction. He proposed a price models using the data from the 2008 season and fruitfully tested next to the data from the 2009 season. The variables in the equations were the regular playing factors such as runs scored, wickets taken and age. Van Staden (2009) proposed a graphical technique for comparison of cricketers' bowling and batting performances. Singh (2011) made an effort for measuring the performance of teams in the IPL using DEA. He took both playing and non-playing factors to analyze the efficiencies of the teams in 2009 season. Lenten et al (2012) used various playing and non-playing factors of the athletes of cricket sport that determine their biding value in the auction of IPL. Sharma (2012) applied Factor Analysis approach in performance measurement of T20 cricket. Gholam et al (2012) applied DEA for cricket team selection. Riju et al (2019) used DEA model to select Cricketers for Indian Cricket team.

In 1918, Sewall Wright used the first application of path analysis, which modeled the bone size of rabbits. Pearl (1998) argues that SEM allows us to test out theories with non-experimental data under the assumption that a causal model is true. According the Ullman (2006), SEM is used to estimate the population covariance matrix and then compare the estimated population covariance matrix with the sample covariance matrix. If these two matrix turns out to be similar, it means that the structural model best fits with the data. De Stobbeleir, K. E., Ashford, S. J., & Buyens, D. (2011) studied the complex relationship among variables.

## 3. Methodology

DEA is a LP technique to measure the relative performance of DMUs. DEA was developed by CCR[3] in 1978, subsequent to the work by George Bernard Dantzig in 1951 and Farrell in 1957. It is an efficient method. It is used to measure the comparative efficiency of set of homogeneous DMUs. A DMU is a decision making unit which converts multiple inputs into multiple outputs. The reputation of DEA is due to its capability for measuring comparative efficiencies without prior weights on the inputs and outputs. Also DEA provides estimates of potential improvement for inefficient DMU. The method also identifies peer DMUs.

Structural Equation Modeling (SEM)[16] has become very important research technique across many disciplines to test the validity of the conceptual model. Partial least squares structural equation modeling (PLS-SEM), is also applied in a variety of fields (Richter et al., 2016, Hair et al., 2012, do Valle & Assaker, 2016),

PLS-SEM widely applies to the same class of models as Covariance Based-SEM (Faizan Ali et al 2017). Partial Least Square based-SEM is a composite-based move to SEM that uses linear combinations of indicator variables as proxies of the conceptual variables under investigation for explaining the variance of the target constructs in the structural model (Rigdon et al., 2017).

The input-reduction method of efficiency measurement of any DMU under VRS requires the solution of the following LPP due to BCC [2] Min $\theta$ Subject to

$$\sum_{j=1}^{n} w_j x_i^j \leq \theta x_i^t; i = 1,2,3\ldots$$

$$\sum_{j=1}^{n} w_j y_r^j \geq y_r^t; r = 1,2,3\ldots s$$

$$\sum_{j=1}^{n} w_j = 1$$

$$w_j \geq 0 (j = 1,2,3,\ldots,n)$$

$x_i^j$ denotes value of the jth input for the ith *DMU*
$Y_r^j$ denotes value of the jth output for the rth DMU
$w_j$ denotes weigtage of the jth DMU

## 4. DATA

The secondary data has been taken from the official website of Indian Premier League www.iplt20.com. run by BCCI.

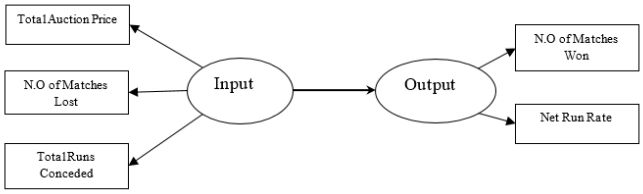
**Table 2: Inputs & Outputs**

| Output | Input Variables |
|---|---|
| Input | Total auction price |
| Input | Number of matches lost |
| Input | Total runs conceded |
| Output | Net run rate |
| Output | Number of matches won |

## 5. Results & Analysis

In our research Data Envelopment Analysis (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).

Our conceptual model was tested using PLS methodology using smart PLS 3.0. In the first stage where the validity of inputs and outputs were checked using the below conceptual model.



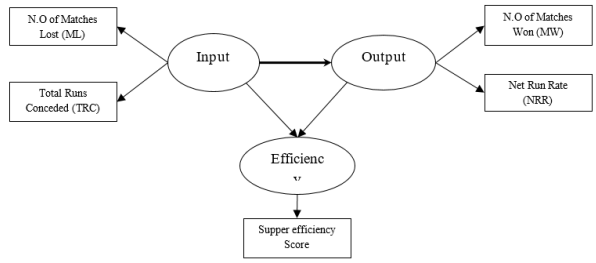

The result indicates that out of the three inputs one input was not significant and the remaining two was significant. Total auction price was hence removed from our analysis since the path (Input ← Total Auction Price ) t-statistics was less than 1.96 (for 5% level of significance). Then the proposed model is converted to two inputs and two outputs which are shown below.

Next step involves calculation of efficiency score and super efficiency score using DEA. Input oriented VRS is used to find out the efficiency score among the eight teams. This is tabulated below.

The result shows that out 8 teams 4 teams are efficient enough or better than their counter part. This is concurrent with the results of the IPL 2019. Hence this four team (CSK, DC, MI & SH) moved further to play the playoff. The next step involves validation of efficiency score with inputs and output using smart PLS 3.0. The path diagram below shows measurement model which was tested using PLS.

**Table 3: Data with efficiency score**

| DMU | TRC {I} | ML {I} | NRR {O} | MW {O} | Efficiency | Rank |
|---|---|---|---|---|---|---|
| CSK | 2012 | 5 | 0.831 | 9 | 1.12 | 1 |
| DC | 2238 | 5 | 0.744 | 9 | 1 | 3 |
| KKR | 2419 | 8 | 0.728 | 6 | 0.83 | 7 |
| KXIP | 2503 | 8 | 0.449 | 6 | 0.8 | 8 |
| MI | 2282 | 5 | 1.121 | 9 | 1 | 2 |
| RR | 2192 | 8 | 0.251 | 5 | 0.92 | 5 |
| RCB | 2266 | 8 | 0.093 | 5 | 0.89 | 6 |
| SH | 2200 | 8 | 1.277 | 6 | 1 | 4 |




Consistency evaluation is checked using Cronbach's Alpha and Composite Reliability which is greater than 0.6.

**Table 4: Consistency evaluation**

| Construct | Cronbach's Alpha | Composite Reliability (CR) | Average Variance Extracted (AVE) |
|---|---|---|---|
| Efficiency | 1.000 0.65 | 1.000 | 1.000 |
| Input | 0.651 0.65 | 0.850 | 0.740 |
| Output | 0.726 0.65 | 0.873 | 0.775 |

The table above shows the construct reliability and validity used in the model. The reliability & validity of the measurement model was examined as suggested by Litwin, 1995. The Cronbach's Alpha are all above 0.65 and CR values are above 0.7 which suggest the model has sufficient reliability. Hence the reliability and validity of the model are supported in our model. The table below shows the collinearity statistics in terms of Variance Inflation Factor (VIF) which measures whether the construct are correlated with each other.

The table above shows the VIF values and are all below the recommended value of 5, it clearly shows that the measurement model doesn't have multicollinearity issue. After reliability and validity, the measurement model is tested to determine the significance of each path which is the tabulated below.

By comparing the two input path (ML → Input & TRC → Input ) ML is contributing more towards the efficiency score rather than TRC. Hence the team should concentrate more on not losing a match rather than conceding more runs. Whereas comparing the two output path (MW → Output & NRR →

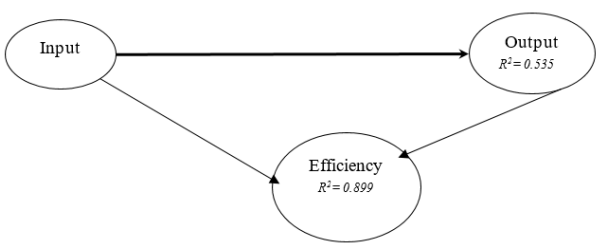
**Table 5: Collinearity statistics**

| Indicators | VIF |
|---|---|
| Efficiency | 1.000 5 |
| ML {I} | 1.303 5 |
| MW {O} | 1.480 5 |
| NRR {O} | 1.480 5 |
| TRC {I} | 1.303 5 |

**Table 6: Significance of paths**

| Relationship | Path | t-value | Significance | Support |
|---|---|---|---|---|
| ML {I} ← Input | 0.888 | 5.770 | 0.000 | Yes |
| TRC I ← Input | 0.832 | 3.724 | 0.000 | Yes |
| MW O ← Output | 0.939 | 6.290 | 0.000 | Yes |
| NRR O ← Output | 0.818 | 3.688 | 0.000 | Yes |

Output ) MW is contributing more towards the efficiency score since its path coefficient score is more. The t-value of all the paths (inputs and outputs) are greater than 1.96 (at 5% level of significance), hence all paths are significant in calculating the efficiency of the IPL team. R2 values along with path coefficient should be considered for measuring model performance which is diagrammatically shown below.




The value of $R^2$ so obtained for efficiency score form both input and output is deterministic with accuracy of 90%.

## 6. Conclusions, Limitations & Future scope

In this research work efficiency measurement based on specified inputs and outputs has been done. Efficiency measures thus obtained reflects the close competition prevailing in IPL. Final team rankings in IPL 2019 and efficiency scores obtained in this analysis are significantly correlated with little more exception. However choice of inputs and outputs affects efficiency scores.

Non availability of reliable data on wages of head coach, different expenditure and staff wages hinders detailed research. Detailed research need to be carried out to assess the impact of different inputs and outputs combinations. Window analysis and historically efficient team identification can be carried out in future. Identifying factors affecting auction price and forecasting can be an area of research.

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