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**CONTRIBUTIONS TO BOOKS**

- Sharma T., Kwatra, G. (2008) Effectiveness of Social Advertising: A Study of Selected Campaigns, Corporate Social Responsibility, Edited by David Crowther & Nicholas Capaldi, Ashgate Research Companion to Corporate Social Responsibility, Chapter 15, pp 287-303.

**JOURNAL AND OTHER ARTICLES**

- Schemenner, R.W., Huber, J.C. and Cook, R.L. (1987), "Geographic Differences and the Location of New Manufacturing Facilities," Journal of Urban Economics, Vol. 21, No. 1, pp. 83-104.

**CONFERENCE PAPERS**

- Garg, Sambhav (2011): "Business Ethics" Paper presented at the Annual International Conference for the All India Management Association, New Delhi, India, 19–23

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- Kumar S. (2011): "Customer Value: A Comparative Study of Rural and Urban Customers," Thesis, Kurukshetra University, Kurukshetra.

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- Garg, Bhavet (2011): Towards a New Gas Policy, Political Weekly, Viewed on January 01, 2012 http://epw.in/user/viewabstract.jsp

# SUPER EFFICIENCY ANALYSIS OF CO-OPERATIVE SUGAR MILLS IN TAMILNADU

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**ABSTRACT**

*Data Envelopment Analysis (DEA) is used to examine the Super efficiencies and relative technical efficiency of 15 Co-operative Sugar mills in Tamilnadu using Charnes, Cooper & Rhodes (CCR) model and Banker, Charnes and Cooper (BCC) model. Based on the analysis, the efficient sugar mills are found. For inefficient sugar mills, the degree to which each inputs needs to be reduced for optimum output is derived using Benchmarking. Super efficiency analysis indicates that Kallakurichi-II sugar mill dominates the sugar mills under study with a super-efficiency score equal to 1.5471. Cheyyar, Dharmapuri, Subramania Siva and Kallakurichi-I sugar mills occupy second, third, fourth and fifth place respectively.*

**KEYWORDS**

Tamilnadu co-operative sugar mills, super efficiency, data envelopment analysis.

## 1. INTRODUCTION

Sugar mills across India face multitude of problems ranging from seasonal raw input, fluctuations in sugar price, old and inefficient machinery, increasing labour cost, huge borrowings with heavy interest and underutilisation of capacity. These problems are especially more notable in co-operative sugar mills in Tamilnadu. This research was carried out to understand the efficiency of 15 co-operative sugar mills, and to ferret out the Super-Efficient co-operative Sugar Mills. These super-efficient sugar mills will form the benchmark for less efficient Sugar Mills and help the co-operative sugar mills as a group to become more efficient and profitable.

## 2. LITERATURE REVIEW

Many researchers have contributed to the technical analysis of Sugar Mills though none have carried out Super Efficiency analysis of co-operative sugar mills in Tamilnadu. Singh S. P. (2006) applied data envelopment analysis in his paper to estimate the relative efficiencies of sugar mills of Uttar Pradesh. Benni Basavaraj (2007) conducted a study on "Interstate sugar factory efficiency: A Comparative analysis". The study compared the average efficiency ranks of the various sugar producing states on the basis of their respective average technical efficiency scores. Mishra and Tripathi (2013) evaluated the operational efficiency of selected sugar mills in Maharashtra using data envelopment analysis. The results revealed that generally there was inefficiency in the operation of the mills. Kumar Krishna (2002) in his research took the issues about comparative behavior of the public sector enterprises and the private sector enterprises into consideration. His study revealed that overall performance of the state corporation mills is better than that of cooperative sugar mills and the private mills. Khanna Gauri (2006) employed the stochastic production frontier to estimate technical efficiency at the farm level. The study results indicate the presence of technical inefficiency. It captures 51% to 55% of the differential between observed and best practice output. Singh N.P. et al. (2007) assessed the performance of sugar mills in India in terms of technical efficiency. The stochastic frontier production function was applied by them to assess sector wise efficiency scores of the Uttar Pradesh sugar mills. The study revealed that there were a majority of mills working in the efficiency range of 60-80 %.

## 3. METHODOLOGY

***Sample and Sampling Method***

No sampling was done. All co-operative sugar mills in Tamilnadu was taken on record. Data on all fifteen co-operative sugar mills in Tamilnadu was collated from annual reports and from Tamil Nadu Co-operative Sugar Federation. The mills studied are Ambur, Amaravathi, Salem, Kallakurichi-I, National, Dharmapuri, Tirupattur, Vellore, Chengalrayan, Tiruttani, N.P.K.R.R., M.R.K., Cheyyar, Subramania Siva and Kallakurichi-II sugar mills. The input and output data for efficiencies and super efficiency analysis are given below:

- The inputs are Cane Purchase cost, Transport Cost, Material Cost, Conversion Cost, Total Interest, Over Heads and Salary &Wage expense. All values are average over the study period of 2005-06 to 2014-15 and are in lakhs of Indian rupees.
- The Output is average Total Sugar Sales in Lakhs of Indian Rupees.

***Period of study***

10 year data from 2005-2006 to 2014-2015 was used for the analysis.

***Procedure***

Data Envelopment Analysis (DEA) was used to calculate the relative efficiencies and Super Efficiencies of the Co-Operative Sugar Mills. DEA is a linear programming methodology for evaluating the relative technical efficiency for each member of a set of peer decision making units (DMUs) with multiple inputs and multiple outputs. It has been widely used to measure performance in many areas. Technical efficiency refers to the degree of the industry technology level that the production process of a production unit reaches. Technical efficiency can be measured from two aspects - input and output. In the case of the given input, the technical efficiency is measured by the degree of output maximization. Under the condition of the given output, the technical efficiency is measured by the degree of input minimization. When there are more than one inputs or outputs, the weight coefficient reflecting the relative importance between inputs and outputs has to be calculated. One method is to adopt the fixed weight, for example, determining the weight of each input and output through subjective forms such as expert consultation or discussion. Another approach is to get the weight of input and output by the data itself, which is the method used by data envelopment analysis (DEA).

There are two major methods to calculate the technical efficiency based on inputs.

**Input-oriented CCR Model:** Charnes, Cooper and Rhodes derived this model hence it is named CCR model. In the CCR model, the returns to scale is assumed constant. It is called 'Constant Return to Scale' (CRS). It indicates that there is constant ratio between inputs and outputs. Increasing the inputs leads to an equivalent increase in the output. The technical efficiency derived from CCR Model includes the component of scale efficiency, which therefore is also referred to as the Comprehensive Technical Efficiency or Over All Technical Efficiency (OTE)

**Input-oriented BCC Model:** Banker, Charnes and Cooper jointly developed this model. The BCC model is based on the Variable Returns to Scale (VRS) and the technical efficiency obtained eliminates the effect of scale, so it is called "Pure Technical Efficiency" (PTE). This is the more suitable model for real production as most producing units are not in a state of optimal scale of production.

Based on above two models, Scale efficiency can be derived.

**Scale Efficiency:** This shows if the production unit (Sugar mills) are of right size to use the inputs for optimum output. The CCR model gives the efficiency value which is not a pure technical efficiency, but contains the component of scale efficiency. The BCC model gives just the technical efficiency which is also referred to as "pure technical efficiency". Based on these two, the scale efficiency value can be separated by using the formula SE = OTE/PTE.

Scale Efficiency = $\frac{Over\ All\ Technical\ Efficiency\ (Obtained\ from\ CCR\ Model)}{Pure\ Technical\ Efficiency\ (Obtained\ from\ BCC\ Model)}$

**Over all Technical Inefficiency:** The overall Technical Inefficiency can be calculated from Over all technical efficiency. OTIE= (1-OTE)×100

**Pure Technical Inefficiency:** The overall Pure Technical Inefficiency can be calculated from Pure technical efficiency. PTIE=(1-PTE)×100

**Scale Inefficiency:** The Scale efficiency can be calculated from Scale efficiency score. SIE=(1-SE)×100

**Super Efficiency:** All the efficient DMUs have OTE scores equal to 1 in theCCR model which makes it impossible to rank and differentiate the efficient DMUs with the CCRmodel. However, the ability to rank or differentiate the efficient DMUs is of practical importance. Further discrimination across the efficient DMUs is desirable to identify top performers. For ranking the efficient DMUs, Andersen and Petersen proposed the super-efficiency DEA model. The core idea of super-efficiency. DEA model is to exclude the efficient DMU under evaluation from the reference set. Thesuper-efficiency score for efficient DMU can take any value greater than or equal to1. This procedure makes the ranking of efficient DMUs possible. Higher super-efficiency score implies higher rank.

## 4. DATA ANALYSIS

The result of DAE CCR input oriented analysis is tabulated in Table 1:

**TABLE 1: CCR INPUT ORIENTED OVERALL TECHNICAL EFFICIENCIES OF SUGAR MILLS**

| No. | DMU | OTE Score | Benchmark(Lambda) |
|---|---|---|---|
| 1 | Ambur | 0.855907 | Dharmapuri (0.499565); SubramaniaSiva (0.016834) |
| 2 | Amaravathi | 0.964304 | Dharmapuri (0.504031) |
| 3 | Salem | 0.968718 | Subramania Siva (0.510708); Kallakurichi-II (0.494457) |
| 4 | Kallakurichi-I | 1 | Kallakurichi-I (1.000000) |
| 5 | National | 0.860146 | Dharmapuri (0.516491); Subramania Siva (0.171812) |
| 6 | Dharmapuri | 1 | Dharmapuri (1.000000) |
| 7 | Tirupattur | 0.972328 | Dharmapuri (0.654627) |
| 8 | Vellore | 0.877822 | Dharmapuri(0.591434); Subramania Siva(0.214248) |
| 9 | Chengalrayan | 0.892851 | Kallakurichi-I(0.272929); Dharmapuri(0.510265); Kallakurichi-II(0.262854) |
| 10 | Tiruttani | 0.761316 | Dharmapuri(0.373416); Subramania Siva(0.264323) |
| 11 | N.P.K.R.R. | 0.800853 | Dharmapuri(0.602708) |
| 12 | M.R.K. | 0.876578 | Kallakurichi-I(0.119261); Dharmapuri(0.407629); Kallakurichi-II(0.239349) |
| 13 | Cheyyar | 1 | Cheyyar(1.000000) |
| 14 | Subramania Siva | 1 | Subramania Siva(1.000000) |
| 15 | Kallakurichi-II | 1 | Kallakurichi-II(1.000000) |

From the table it can be deduced that the technical efficiency score of 5 DMUs is 1. It indicates that out of 15 DMUs, these five DMUs viz., Kallakurichi-I, Dharmapuri, Cheyyar, Subramania Siva and Kallakurichi-II Sugar mills don't contain any other DMU or linear combination of other DMUs and they are technically efficient. These efficient sugarmills together define the efficient frontier of all sugar mills under study and thus form the reference set for inefficient sugar mills. Every DMU is Benchmarked against other efficient sugar mills which have OTE score of 1. If the input of inefficient DMU is multiplied by the lambda of Benchmark, then for an inefficient DMU, theamount by whichinput hasto be reduced in order to make the DMU efficient can be obtained.

Taking Ambur sugar mill as an example, the calculation for optimum input and output - also called 'Projected Value for Efficiency' or 'Strong efficiency Projection'- is done as delineated below:

From Table 1 it can be seen that for Ambur sugar mill, the benchmark sugar mills are Dharmapuri (0.499565) and Subramania Siva (0.016834). The figures in the brackets are the lambda value. Each input of the benchmark has to be multiplied by the lambda value to get the optimum input.

*Ambur Projected Value for optimum efficiency = Original input values of Dharmapuri sugar mill X Lambda + Original input values of Subramania Siva X Lambda.*

The calculation is tabulated in Table below. All figures except lambda value are in Lakhs of Rupees:

**TABLE 2: STRONG EFFICIENCY PROJECTION CALCULATION OF AMBUR SUGAR MILL: BENCHMARK METHOD**

| | CanePurchase | TransportCost | MaterialCost | ConversionCost | Total Interest | OverHeads | Salary&Wages |
|---|---|---|---|---|---|---|---|
| Original Value of Dharmapuri | 4208.914 | 213.326 | 4594.388 | 394.629 | 332.803 | 1647.646 | 1127.92 |
| Lambda Value | 0.499565 | | | | | | |
| Original Value of Subramania Siva | 5666.528 | 315.898 | 6220.696 | 350.672 | 554.063 | 1813.555 | 916.15 |
| Lambda Value | 0.016834 | | | | | | |
| Projected value for Efficiency of Ambur | 2198.016 | 111.888 | 2399.915 | 203.046 | 175.584 | 853.636 | 578.892 |
| Reduce Input of Ambur by | 370.044 | 154.225 | 545.782 | 83.782 | 610.496 | 656.954 | 97.458 |

- The perusal of the above table shows that for Ambur Sugar mill to become efficient under Constant Return to Scale model, it has to reduce CanePurchase by Rs.370.044 Lakhs, TransportCost by Rs.154.225 Lakhs, MaterialCost by Rs.545.782 Lakhs, ConversionCost by Rs.83.782 Lakhs, Total Interest by Rs.610.496 Lakhs, OverHeads by Rs.656.954 Lakhsand Salary and Wages by Rs.97.458 Lakhs.

Similar calculations for all the inefficient sugar mills were carried out and the results are tabulated in Table 3.

**TABLE 3: STRONG EFFICIENCY OF ALL INEFFICIENT SUGAR MILLS : BENCHMARK METHOD (in Rs. Lakhs)**

| Sugar Mills | | CanePurchase | TransportCost | MaterialCost | ConversionCost | Total Interest | OverHeads | SalaryWage |
|---|---|---|---|---|---|---|---|---|
| **Amaravathi** | Reduce Input | -78.5301 | -36.439 | -131.966 | -85.3257 | -323.83 | -464.48 | -144.283 |
| | Projected value | 2121.424 | 107.523 | 2315.715 | 198.9053 | 167.7431 | 830.465 | 568.5068 |
| **Salem** | Reduce Input | -209.658 | -260.594 | -546.319 | -83.1046 | -140.26 | -81.4826 | -26.2471 |
| | Projected value | 6492.481 | 347.5211 | 7107.662 | 377.2784 | 427.302 | 1642.929 | 812.7929 |
| **National** | Reduce Input | -511.755 | -210.334 | -733.288 | -197.222 | -1190.84 | -1244.68 | -120.314 |
| | Projected value | 3147.444 | 164.456 | 3441.75 | 264.072 | 267.0844 | 1162.585 | 739.966 |
| **Tirupattur** | Reduce Input | -78.4143 | -89.1709 | -174.876 | -11.841 | -547.08 | -648.628 | -117.743 |
| | Projected value | 2755.271 | 139.6491 | 3007.613 | 258.335 | 217.862 | 1078.594 | 738.3674 |
| **Vellore** | Reduce Input | -515.442 | -69.8854 | -608.503 | -189.159 | -243.212 | -270.734 | -120.167 |
| | Projected value | 3703.334 | 193.8486 | 4050.046 | 308.5276 | 315.5376 | 1363.023 | 863.373 |
| **Chengalrayan** | Reduce Input | -724.779 | -35.9874 | -811.972 | -214.648 | -538.798 | -566.776 | -119.892 |
| | Projected value | 6039.408 | 299.8746 | 6585.406 | 463.0306 | 603.2134 | 1966.122 | 999.0284 |
| **Tiruttani** | Reduce Input | -962.325 | -188.978 | -1169.65 | -197.188 | -846.075 | -970.389 | -207.968 |
| | Projected value | 3069.465 | 163.1582 | 3359.887 | 240.0512 | 270.7252 | 1094.62 | 663.3421 |
| **N.P.K.R.R.** | Reduce Input | -630.811 | -39.0057 | -710.952 | -139.088 | -1416.33 | -1869.73 | -254.773 |
| | Projected value | 2536.747 | 128.5733 | 2769.075 | 237.8461 | 200.5831 | 993.0497 | 679.8066 |
| **M.R.K.** | Reduce Input | -608.57 | -30.5965 | -670.882 | -106.884 | -148.872 | -373.671 | -103.018 |
| | Projected value | 4322.255 | 217.3055 | 4715.649 | 325.0994 | 361.3797 | 1343.838 | 731.6625 |

- The perusal of the above table shows that for Amaravathi Sugar mill to become efficient under Constant Return to Scale model, it has to reduce Cane Purchase by Rs. -78.53 Lakhs, Transport Cost by Rs. -36.439 Lakhs, Material Cost by Rs. -131.966 Lakhs, Conversion Cost by Rs. -85.326 Lakhs, Total Interest by Rs. -323.83 Lakhs, Over Heads by Rs. -464.48 Lakhs and Salary and Wages by Rs. -144.283 Lakhs.
- Similarly, Salem Sugar mill to become efficient under Constant Return to Scale model, it has to reduce Cane Purchase by Rs. -209.658 Lakhs, Transport Cost by Rs. -260.594 Lakhs, Material Cost by Rs. -546.319 Lakhs, Conversion Cost by Rs. -83.105 Lakhs, Total Interest by Rs. -140.26 Lakhs, Over Heads by Rs. -81.483 Lakhs and Salary and Wages by Rs. -26.247 Lakhs.
- The perusal of the above table shows that for National Sugar mill to become efficient under Constant Return to Scale model, it has to reduce Cane Purchase by Rs. -511.755 Lakhs, Transport Cost by Rs. -210.334 Lakhs, Material Cost by Rs. -733.288 Lakhs, Conversion Cost by Rs. -197.222 Lakhs, Total Interest by Rs. -1190.84 Lakhs, Over Heads by Rs. -1244.675 Lakhs and Salary and Wages by Rs. -120.314 Lakhs.
- From above table it can be inferred that for Tirupattur Sugar mill to become efficient under Constant Return to Scale model, it has to reduce Cane Purchase by Rs. -78.414 Lakhs, Transport Cost by Rs. -89.171 Lakhs, Material Cost by Rs. -174.876 Lakhs, Conversion Cost by Rs. -11.841 Lakhs, Total Interest by Rs. -547.08 Lakhs, Over Heads by Rs. -648.628 Lakhs and Salary and Wages by Rs. -117.743 Lakhs.
- The perusal of the above table shows that for Vellore Sugar mill to become efficient under Constant Return to Scale model, it has to reduce Cane Purchase by Rs. -515.442 Lakhs, Transport Cost by Rs. -69.885 Lakhs, Material Cost by Rs. -608.503 Lakhs, Conversion Cost by Rs. -189.159 Lakhs, Total Interest by Rs. -243.212 Lakhs, Over Heads by Rs. -270.734 Lakhs and Salary and Wages by Rs. -120.167 Lakhs.
- Data from tableindicates that for Chengalrayan Sugar mill to become efficient under Constant Return to Scale model, it has to reduce Cane Purchase by Rs. -724.779 Lakhs, Transport Cost by Rs. -35.987 Lakhs, Material Cost by Rs. -811.972 Lakhs, Conversion Cost by Rs. -214.648 Lakhs, Total Interest by Rs. -538.798 Lakhs, Over Heads by Rs. -566.776 Lakhs and Salary and Wages by Rs. -119.892 Lakhs.
- The perusal of the above table shows that for Tiruttani Sugar mill to become efficient under Constant Return to Scale model, it has to reduce Cane Purchase by Rs. -962.325 Lakhs, Transport Cost by Rs. -188.978 Lakhs, Material Cost by Rs. -1169.65 Lakhs, Conversion Cost by Rs. -197.188 Lakhs, Total Interest by Rs. -846.075 Lakhs, Over Heads by Rs. -970.389 Lakhs and Salary and Wages by Rs. -207.968 Lakhs.
- In order to become efficient under Constant Return to Scale model, N.P.K.R.R. Sugar mill has to reduce Cane Purchase by Rs. -630.811 Lakhs, Transport Cost by Rs. -39.006 Lakhs, Material Cost by Rs. -710.952 Lakhs, Conversion Cost by Rs. -139.088 Lakhs, Total Interest by Rs. -1416.335 Lakhs, Over Heads by Rs. -1869.731 Lakhs and Salary and Wages by Rs. -254.773 Lakhs.
- The perusal of the above table shows that for M.R.K. Sugar mill under Constant Return to Scale model can become efficient byreducing Cane Purchase by Rs. -608.57 Lakhs, Transport Cost by Rs. -30.596 Lakhs, Material Cost by Rs. -670.882 Lakhs, Conversion Cost by Rs. -106.884 Lakhs, Total Interest by Rs. -148.872 Lakhs, Over Heads by Rs. -373.671 Lakhs and Salary and Wages by Rs. -103.018 Lakhs.

To analyse the Pure Technical Efficiency, DAE with BCC method, with input orientation andwith Variable Return to Scale was carried out. The results are tabulated in Table 4.

**TABLE 4: BCC INPUT ORIENTED PURE TECHNICAL EFFICIENCIES OF SUGAR MILLS**

| NO | DMU | PTE Score | Benchmark(Lambda) |
|---|---|---|---|
| 1 | Ambur | 1 | Ambur (1.000000) |
| 2 | Amaravathi | 1 | Amaravathi (1.000000) |
| 3 | Salem | 0.971252 | Subramania Siva (0.476842); Kallakurichi-II (0.523158) |
| 4 | Kallakurichi-I | 1 | Kallakurichi-I (1.000000) |
| 5 | National | 0.889526 | Amaravathi (0.709674); Subramania Siva (0.260185); Kallakurichi-II (0.030141) |
| 6 | Dharmapuri | 1 | Dharmapuri (1.000000) |
| 7 | Tirupattur | 1 | Tirupattur (1.000000) |
| 8 | Vellore | 0.90288 | Amaravathi (0.424471); Dharmapuri (0.415061); Subramania Siva (0.024563); Kallakurichi-II (0.135905) |
| 9 | Chengalrayan | 0.906195 | Kallakurichi-I (0.294190); Dharmapuri (0.371458); Kallakurichi-II (0.334352) |
| 10 | Tiruttani | 0.811179 | Ambur (0.078918); Amaravathi (0.715974); Kallakurichi-II (0.205108) |
| 11 | N.P.K.R.R. | 0.941422 | Amaravathi (0.801042); Dharmapuri (0.198958) |
| 12 | M.R.K. | 0.949479 | Amaravathi (0.475417); Kallakurichi-I (0.089522); Dharmapuri (0.165895); Kallakurichi-II (0.269166) |
| 13 | Cheyyar | 1 | Cheyyar (1.000000) |
| 14 | Subramania Siva | 1 | Subramania Siva (1.000000) |
| 15 | Kallakurichi-II | 1 | Kallakurichi-II (1.000000) |

From the table it can be seen that 8 Sugar mills attained PTE score equal to 1 and can be considered as relatively efficient under Variable Return to Scale in BCC Model. Out of these 8 sugar mills, 5 sugar mills were also relatively efficient under Constant Return to Scale assumption in CCR Model with an OTE score equal to 1. **Thus, in only 3sugar mills the Overall Technical Inefficiency (OTIE) is caused entirely by inappropriate choice of the scale size instead of managerial incapability to organize the resources in the production process. These 3sugar mills are Ambur, Amaravathi and Tirupattur sugar mills.**

To find how much input has to be reduced to attain PTE in inefficient DMUs (Sugar mills), the input of inefficient DMU is multiplied by the lambda of Benchmark. This is similar to the calculations made for earlier CCR model.

Taking Salem sugar mill as an example, the calculation for optimum input and output - also called 'Projected Value for Efficiency' or 'Strong efficiency Projection' - is done as delineated below:

From Table 4 it can be seen that for Salem sugar mill, the benchmark sugar mills are Subramania Siva (0.476842) and Kallakurichi-II(0.523158). The figures in the brackets are the lambda value. Each input of the benchmark has to be multiplied by the lambda value to get the optimum input.

$$\textit{Salem sugar mill's Projected Value for optimum Pure Technical efficiency} = \textit{Original input values of Subramania Siva sugar mill} \times \textit{Lambda} + \textit{Original input values of Kallakurichi} - \textit{II} \times \textit{Lambda}.$$

**TABLE 5: STRONG PURE TECHNICAL EFFICIENCY PROJECTION CALCULATION OF SALEM SUGAR MILL : BENCHMARK METHOD**

| | CanePurchase | TransportCost | MaterialCost | ConversionCost | Total Interest | OverHeads | Salary&Wages |
|---|---|---|---|---|---|---|---|
| Original Value of Subramania-Siva | 5666.528 | 315.898 | 6220.696 | 350.672 | 554.063 | 1813.55 | 916.15 |
| Lambda Value | 0.476842 | | | | | | |
| Original Value of Kallakurichi-II | 7277.772 | 376.554 | 7949.547 | 400.819 | 291.912 | 1449.537 | 697.55 |
| Lambda Value | 0.523158 | | | | | | |
| Projected value for Efficiency of Salem | 6509.463 | 347.6307 | 7125.158 | 376.9068 | 416.9166 | 1623.116 | 801.7877 |
| Reduce Input of Salem by | 192.6758 | 260.4843 | 528.8228 | 83.4762 | 150.6454 | 101.2959 | 37.25234 |

- The above table shows that for Salem Sugar mill to become efficient under Variable Return to Scale model, it has to reduce Cane Purchase by Rs. 192.6758 Lakhs, Transport Cost by Rs. 260.4843 Lakhs, Material Cost by Rs. 528.8228 Lakhs, Conversion Cost by Rs. 83.4762 Lakhs, Total Interest by Rs. 150.6454 Lakhs, Over Heads by Rs. 101.2959 Lakhs and Salary and Wages by Rs. 37.25234 Lakhs.

Similar calculations for all the Pure technical inefficient sugar mills were carried out and the results are tabulated in Table 6.

**TABLE 6: STRONG PURE TECHNICAL EFFICIENCY OF ALL INEFFICIENT SUGAR MILLS : BENCHMARK METHOD** (in Rs. Lakhs)

| | | **Cane Purchase** | **Transport Cost** | **Material Cost** | **Conversion Cost** | **Total Interest** | **Over Heads** | **Salary Wage** |
|---|---|---|---|---|---|---|---|---|
| Salem | Reduce Input | -192.67633 | -260.48435 | -528.82333 | -83.476212 | -150.64531 | -101.29581 | -37.252268 |
| | Projected value | 6509.4627 | 347.63065 | 7125.1577 | 376.90679 | 416.91669 | 1623.1162 | 801.78773 |
| National | Reduce Input | -404.24465 | -179.08231 | -579.84413 | -156.26198 | -956.11004 | -972.72101 | -95.038172 |
| | Projected value | 3254.9544 | 195.70769 | 3595.1939 | 305.03202 | 501.81396 | 1434.539 | 765.24183 |
| | Projected value | 2833.685 | 228.82 | 3182.489 | 270.176 | 764.942 | 1727.222 | 856.11 |
| Vellore | Reduce Input | -409.72915 | -55.14796 | -479.44427 | -150.15717 | -158.67632 | -158.67111 | -95.521784 |
| | Projected value | 3809.0468 | 208.58604 | 4179.1047 | 347.52983 | 400.07368 | 1475.0859 | 888.01822 |
| Chengalrayan | Reduce Input | -634.51505 | -31.505559 | -713.72947 | -228.59167 | -536.33848 | -633.85666 | -207.87478 |
| | Projected value | 6129.672 | 304.35644 | 6683.6485 | 449.08733 | 605.67252 | 1899.0413 | 911.04522 |
| Tiruttani | Reduce Input | -761.28663 | -150.82765 | -914.07887 | -128.88997 | -642.93696 | -721.33764 | -164.52163 |
| | Projected value | 3270.5034 | 201.30835 | 3615.4581 | 308.34904 | 473.86304 | 1343.6714 | 706.78837 |
| N.P.K.R.R. | Reduce Input | -567.90527 | -9.816475 | -605.2414 | -70.738431 | -1156.9336 | -1497.6633 | -139.19655 |
| | Projected value | 2599.6527 | 157.76253 | 2874.7856 | 306.19557 | 459.98443 | 1365.1177 | 795.38345 |
| M.R.K. | Reduce Input | -567.90527 | -9.816475 | -605.2414 | -70.738431 | -1156.9336 | -1497.6633 | -139.19655 |
| | Projected value | 2599.6527 | 157.76253 | 2874.7856 | 306.19557 | 459.98443 | 1365.1177 | 795.38345 |
| Cheyyar | Reduce Input | -578.72163 | -12.5242 | -615.23228 | -72.231008 | -25.778324 | -194.21083 | -42.168676 |
| | Projected value | 4352.1034 | 235.3778 | 4771.2987 | 359.75199 | 484.47368 | 1523.2982 | 792.51132 |

- From the above table it can be deduced that for Salem Sugar mill to become efficient under Variable Return to Scale model, it has to reduce Cane Purchase by Rs. -192.676334 Lakhs, Transport Cost by Rs. -260.484348 Lakhs, Material Cost by Rs. -528.823329 Lakhs, Conversion Cost by Rs. -83.476212 Lakhs, Total Interest by Rs. -150.645308 Lakhs, Over Heads by Rs. -101.295811 Lakhs and Salary and Wages by Rs. -37.252268 Lakhs.
- The perusal of the above table shows that for National Sugar mill to become efficient under Variable Return to Scale model, it has to reduce Cane Purchase by Rs. -404.244645 Lakhs, Transport Cost by Rs. -179.082312 Lakhs, Material Cost by Rs. -579.844127 Lakhs, Conversion Cost by Rs. -156.261983 Lakhs, Total Interest by Rs. -956.110037 Lakhs, Over Heads by Rs. -972.721012 Lakhs and Salary and Wages by Rs. -95.038172 Lakhs.
- The above table data shows that for Vellore Sugar mill to become efficient under Variable Return to Scale model, it has to reduce Cane Purchase by Rs. -409.729154 Lakhs, Transport Cost by Rs. -55.14796 Lakhs, Material Cost by Rs. -479.444265 Lakhs, Conversion Cost by Rs. -150.15717 Lakhs, Total Interest by Rs. -158.676319 Lakhs, Over Heads by Rs. -158.67111 Lakhs and Salary and Wages by Rs. -95.521784 Lakhs.
- The scrutiny of the table shows that for Chengalrayan Sugar mill to become efficient under Variable Return to Scale model, it has to reduce Cane Purchase by Rs. -634.51505 Lakhs, Transport Cost by Rs. -31.505559 Lakhs, Material Cost by Rs. -713.729467 Lakhs, Conversion Cost by Rs. -228.591671 Lakhs, Total Interest by Rs. -536.338482 Lakhs, Over Heads by Rs. -633.856661 Lakhs and Salary and Wages by Rs. -207.874777 Lakhs.
- Examination of the above table reveals that for Tiruttani Sugar mill to become efficient under Variable Return to Scale model, it has to reduce Cane Purchase by Rs. -761.286628 Lakhs, Transport Cost by Rs. -150.827649 Lakhs, Material Cost by Rs. -914.078871 Lakhs, Conversion Cost by Rs. -128.889965 Lakhs, Total Interest by Rs. -642.936956 Lakhs, Over Heads by Rs. -721.337642 Lakhs and Salary and Wages by Rs. -164.521627 Lakhs.
- The above table shows that for N.P.K.R.R. Sugar mill to become efficient under Variable Return to Scale model, it has to reduce Cane Purchase by Rs. -567.905266 Lakhs, Transport Cost by Rs. -9.816475 Lakhs, Material Cost by Rs. -605.241395 Lakhs, Conversion Cost by Rs. -70.738431 Lakhs, Total Interest by Rs. -1156.933567 Lakhs, Over Heads by Rs. -1497.663302 Lakhs and Salary and Wages by Rs. -139.196551 Lakhs.
- It can be seen from the above table that for M.R.K. Sugar mill to become efficient under Variable Return to Scale model, it has to reduce Cane Purchase by Rs. -567.905266 Lakhs, Transport Cost by Rs. -9.816475 Lakhs, Material Cost by Rs. -605.241395 Lakhs, Conversion Cost by Rs. -70.738431 Lakhs, Total Interest by Rs. -1156.933567 Lakhs, Over Heads by Rs. -1497.663302 Lakhs and Salary and Wages by Rs. -139.196551 Lakhs.
- The perusal of the above table shows that for Cheyyar Sugar mill to become efficient under Variable Return to Scale model, it has to reduce Cane Purchase by Rs. -578.721626 Lakhs, Transport Cost by Rs. -12.5242 Lakhs, Material Cost by Rs. -615.232276 Lakhs, Conversion Cost by Rs. -72.231008 Lakhs, Total Interest by Rs. -25.778324 Lakhs, Over Heads by Rs. -194.210832 Lakhs and Salary and Wages by Rs. -42.168676 Lakhs.

**EFFICIENCY AND INEFFICIENCY ANALYSIS**

In this section, Overall Technical Efficiency (OTE), Pure Technical Efficiency (PTE) and Scale Efficiency (SE) scores are obtained by executing the CCR and BCC Data Envelopment Analysis models. The results pertaining to Return To Scale (RTS) are also provided. It should be noted that the OTE and PTE are the same as that derived in earlier sections. The results of the analysis are tabulated in Table 7.

TABLE 7: EFFICIENCIES, INEFFICIENCIES AND RETURN TO SCALE OF SUGAR MILLS

| Sugar mills | OTE | PTE | SE | RTS | OTIE | PTIE | SIE |
|---|---|---|---|---|---|---|---|
| Ambur | 0.855907 | 1 | 0.855907 | Increasing | 14.4093 | 0 | 14.4093 |
| Amaravathi | 0.964304 | 1 | 0.964304 | Increasing | 3.5696 | 0 | 3.5696 |
| Salem | 0.968718 | 0.971252 | 0.997391 | Decreasing | 3.1282 | 2.8748 | 0.2609 |
| Kallakurichi-I | 1 | 1 | 1 | Constant | 0 | 0 | 0 |
| National | 0.860146 | 0.889526 | 0.96697 | Increasing | 13.9854 | 11.0474 | 3.303 |
| Dharmapuri | 1 | 1 | 1 | Constant | 0 | 0 | 0 |
| Tirupattur | 0.972328 | 1 | 0.972328 | Increasing | 2.7672 | 0 | 2.7672 |
| Vellore | 0.877822 | 0.90288 | 0.972247 | Increasing | 12.2178 | 9.712 | 2.7753 |
| Chengalrayan | 0.892851 | 0.906195 | 0.985274 | Decreasing | 10.7149 | 9.3805 | 1.4726 |
| Tiruttani | 0.761316 | 0.811179 | 0.93853 | Increasing | 23.8684 | 18.8821 | 6.147 |
| N.P.K.R.R. | 0.800853 | 0.941422 | 0.850684 | Increasing | 19.9147 | 5.8578 | 14.9316 |
| M.R.K. | 0.876578 | 0.949479 | 0.92322 | Increasing | 12.3422 | 5.0521 | 7.678 |
| Cheyyar | 1 | 1 | 1 | Constant | 0 | 0 | 0 |
| Subramania Siva | 1 | 1 | 1 | Constant | 0 | 0 | 0 |
| Kallakurichi-II | 1 | 1 | 1 | Constant | 0 | 0 | 0 |

*OTE: Overall Technical Efficiency Score, PTE: Pure Technical Efficiency Score,*
*SE : Scale Efficiency Score, RTS: Return to Scale, OTIE: Over all Technical Inefficiency,*
*PTIE: Pure Technical Inefficiency, SIE: Scale Inefficiency*

From the table it can be seen that five sugar mills are relatively efficient under Constant Return to Scale assumption in CCR Model with an OTE score equal to 1. Eight Sugar mills attained PTE score equal to 1 and can be considered as relatively efficient under Variable Return to Scale in BCC Model. **Out of these eight sugar mills, only in three sugar mills the Overall Technical Inefficiency (OTIE) is caused entirely by inappropriate choice of the scale size instead of managerial incapability to organize the resources in the production process. These three sugar mills are Ambur, Amaravathi and Tirupattur sugar mills.**

It can be noted from the table that there are significant variations in OTIE at the level of individual sugar mills. The highest and lowest levels of OTIE have been recorded for Tiruttani sugar Mill with an OTIE score of 23.8684 percent and Tirupattur sugar mill with OTEI score of 2.7672 percent.

One of the most significant features of DEA is its capacity to determine whether a DMU is operating in the region of Constant Return to Scale (CRS), Increasing Return to Scale (IRS), or Decreasing Return to Scale (DRS). A DMU exhibiting CRS has optimum or most productive scale size (MPSS), and operates at flatter portion of long-run average cost curve. On the other hand, when a DMU exhibits DRS, a percentage increase in inputs produces less than proportional expansion of outputs. The DMUs experiencing DRS lie above the optimal scale of operations (i.e., at the rising portion of long-run average cost curve) and would improve their efficiency by downsizing their scale of operations (e.g., by splitting into two or more production units). Further, a DMU is considered to exhibit IRS when a percentage increase in inputs produces more than proportional expansion of outputs. The DMUs experiencing IRS lies below the optimal scale of operations (i.e., at the declining portion of long-run average cost curve) and would improve their efficiency by expanding the size of their scale of operations. As noted above, the existence of increasing or decreasing returns-to-scale can be identified by the equality or inequality of the efficiency scores under CRS, VRS and NIRS assumptions. Table 7 provides the nature of RTS for individual sugar mills. **It can be inferred from the table that 8 (53.34 percent) sugar mills are operating below their optimal scale size and, thus, experiencing IRS. These sugar mills have sub-optimal scale size and increase in average productivity in these sugar mills would require an expansion in terms of size. In contrast, 2 (13.34 percent) sugar mills experience DRS. These sugar mills have supra-optimal scale size and downsizing is needed for achieving efficiency gains. Further, 5 (33.34 percent) sugar mills are found to be operating at MPSS and experiencing CRS.**

In order to get deeper understanding of efficiencies, the descriptive statistics of the efficiency score is tabulate in Table 8 and frequencies of the scores are tabulated in Table 9.

TABLE 8: DESCRIPTIVE STATISTICS OF OTE PTE AND SE

| Statistics | OTE | PTE | SE |
|---|---|---|---|
| Sugar mills numbers | 15 | 15 | 15 |
| Mean | .922055 | .958129 | .961790 |
| Median | .964304 | 1.000000 | .972328 |
| Std. Deviation | .0803918 | .0576949 | .0499692 |
| Minimum | .7613 | .8112 | .8507 |
| Maximum | 1.0000 | 1.0000 | 1.0000 |
| 25 th Percentile | .860146 | .906195 | .938530 |
| 50 th Percentile | .964304 | 1.000000 | .972328 |
| 75 th Percentile | 1.000000 | 1.000000 | 1.000000 |

TABLE 9: FREQUENCY DISTRIBUTION OF SCORES

| Efficiency Score (ES) | OTE | PTE | SE |
|---|---|---|---|
| ES < 0.5 | 0(0 %) | 0(0 %) | 0(0 %) |
| 0.5 ≤ ES <0.6 | 0(0 %) | 0(0 %) | 0(0 %) |
| 0.6 ≤ ES <0.7 | 0(0 %) | 0(0 %) | 0(0 %) |
| 0.7 ≤ ES <0.8 | 1(6.7 %) | 0(0 %) | 0(0 %) |
| 0.8 ≤ ES <0.9 | 6(40 %) | 2(13.3 %) | 2(13.3 %) |
| 0.9 ≤ ES <1.0 | 3(20 %) | 5(33.3 %) | 8(53.3 %) |
| ES = 1.0 | 5(33.3 %) | 8(53.3 %) | 5(33.3 %) |

From table 8, it can be observed that OTE scores range between 0.7613 and 1, and their mean and standard deviation (Std. Deviation) are 0.922 and 0.080 respectively. This indicates that the average level of Overall Technical Inefficiency (OTIE) in Sugar mills under study is 7.8 percent. **It can thus be concluded that the same level of outputs in the sugar mills could be produced with 7.8 percent lesser inputs.**

The analysis of frequency distribution of OTE scores reveals that about **6.7 percent of sugar mills have efficiency score below 0.8 and, thus, have OTIE more than 20 percent.**

From table 9, it can have deduced that mean value of PTE scores is 0.9581 (with SD of 0.057), and PTE scores range from the lowest figure of 0.8112 to the highest of 1. The extent of pure technical inefficiency (PTIE) in sugar mills under study is 4.19 percent. The results show that 4.19 percentage points of 6.7 percent of OTIE identified earlier in the sugar mills under study is due to inappropriate management practices that are being followed by sugar mill managers in organizing inputs in sugar mill operations. The remaining part of OTIE is due to the sugar mills operating at sub-optimal scale size. This implies that in South Indian sugar industry, PTIE is a more dominant source of OTIE, and scale inefficiency (SIE) is relatively small.

**SCALE EFFICIENCY (SE)**

The SE score for each Sugar mill can be obtained by taking a ratio of OTE score to PTE score. The value of SE equal to 1 implies that the sugar mill is operating at most productive scale size (MPSS) which corresponds to constant returns-to-scale. At MPSS, the sugar mill operates at minimum point of its long-run average cost

curve. SE<1 also implies that the sugar mill is experiencing OTIE because it is not operating at its optimal scale size. An inspection of Table 8 reveals that mean SE for sugar mills as a whole is quite high being 0.961 (with SD equal to 0.0499), and SE scores range from a minimum of 0.8507 to maximum of 1. The connotation of this finding is that average level of SIE in the sugar mills is to the tune of about 3.83 percent. **This finding reiterates the earlier findings that SIE is smaller source of OTIE relative to that of PTIE in the sugar mills. Further, 5 sugar mills attained SE score equal to 1 and thus it can be concluded that they are operating at most productive scale size (MPSS). The remaining 10 sugar mills are operating with some degree of SIE and have either Decreasing RTS or Increasing RTS. Further it can be concluded that all sugar mills are operating with scale efficiency above 80 percent.**

**SUPER EFFICIENCY**

The Anderson and Peterson's super-efficiency scores obtained for the efficient sugar mills and their ranks are tabulated in Table 10.

**TABLE 10: SUPER-EFFICIENCY SCORES AND RANKS OF EFFICIENT SUGAR MILLS**

| Sugar mills | Super efficiency score | Rank |
|---|---|---|
| Kallakurichi-II | 1.5471 | 1 |
| Cheyyar | 1.3046 | 2 |
| Dharmapuri | 1.149 | 3 |
| Subramania Siva | 1.0616 | 4 |
| Kallakurichi-I | 1.0291 | 5 |

It can be inferred from the table that among the Overall Technical Efficient sugar mills, **Kallakurichi-II sugar mill dominates the sugar mills under study with a super-efficiency score equal to 1.5471** and is hence ranked first among the 15 sugar mills under consideration. Cheyyar, Dharmapuri, Subramania Siva and Kallakurichi-I sugar mills occupy second, third, fourth and fifth place respectively.

## 5. FINDINGS AND DISCUSSION

The efficiencies and inefficiencies of all 15 sugar mills were derived using Data Envelopment Analysis CCR, BCC and Super efficiency model. The benchmarks and lambda was calculated and the amount of reduction in inputs required to achieve efficiency was calculated for all inefficient sugar mills under study. The study shows that out of 15 Sugar mills, five sugar mills viz., Kallakurichi-I, Dharmapuri, Cheyyar, Subramania Siva and Kallakurichi-II Sugar mills are technically efficient. OTE, PTE and SE analysis showed that the existing level of outputs in the sugar mills could be produced with 7.8 percent lesser inputs. All sugar mills are operating with scale efficiency above 80 percent. 5 sugar mills are operating at most productive scale size (MPSS). In Ambur, Amaravathi and Tirupattur sugar mills, Overall Technical Inefficiency (OTIE) was caused entirely by inappropriate choice of the scale size instead of managerial incapability to organize the resources. It was also found that eight (53.34 percent) sugar mills are operating below their optimal scale size are experiencing Increasing Return to Scale. These sugar mills have sub-optimal scale size and increase in average productivity in these sugar mills would require an expansion in terms of size. In contrast, 2 (13.34 percent) sugar mills experience Decreasing Return to Scale. These sugar mills have supra-optimal scale size and downsizing is needed for achieving efficiency gains. Five (33.34 percent) sugar mills are found to be operating at MPSS and experiencing Constant Return to Scale. Super efficiency analysis indicates that Kallakurichi-II sugar mill dominates the sugar mills under study with a super-efficiency score equal to 1.5471.Cheyyar, Dharmapuri, Subramania Siva and Kallakurichi-I sugar mills occupy second, third, fourth and fifth place respectively.

## 6. CONCLUSION

The research highlights the super-efficient co-operative sugar mills and shows the methodology to use these sugar mills to benchmark other inefficient sugar mills. The methodology can be adapted to make sugar mills in other states more productive. The methodology used in this research can also be extended to other industry clusters and an inter-company efficiency cluster can be created to improve efficiencies of other industries. This study contributes to technical efficiency literature and can form the basis of more extended study in super efficiency measures.

## REFERENCES


1. Benni B.S. (2007). Inter-State Sugar factory efficiency – A Comparative Analysis. The Journal of Indian Management and Strategy. 12(2). 15 – 22.
2. Benni. B. S. (2006). Sugar Factory Efficiency Measurement: Application of Data Envelopment Analysis-A New Insight for Managers. *Paradigm. 10*(2). 46-54.
3. Charnes A. Cooper, W W and Rhodes E (1978). Measuring the Efficiency of Decision Making Units. European Journal of Operation Research. 2(6).429 – 444.
4. Farrell,M J (1957). The Measurement of Productive Efficiency. Journal of the Royal Statistical Society Series A (General). 120(3).253 - 290.
5. Khanna Gauri (2006) Technical Efficiency in Production and Resource Use in Sugar Cane: A Stochastic Production Function Analysis. http://graduateinstitute.ch/ webdav/site/international_economics/shared/international_economics/working papers/HEIWP15-2006.pdf. Retrieved February 25, 2017, from http://graduateinstitute.ch/
6. KPMG (2007). http://www.in.kpmg.com/pdf/indian_sugar_industry.pdf. Retrieved February 25, 2017, from www.in.kpmg.com
7. Kumar Krishna (1998). Making The Crippled Dance: A Model for Rejuvenating the Ailing Public Sector Enterprises. www.dspace.iimk.ac.in/bitstream/123456789/156/1/Education.pdf. Retrieved February 25, 2017, from www.dspace.iimk.ac.in.
8. Liang, L., Wu, J., Cook, W. D., & Zhu, J. (2008). The DEA Game Cross-Efficiency Model and Its Nash Equilibrium. Operations Research, 56(5).1278-1288.
9. Mishra Vivek Kumar.Tripathi, G.C. (2013). Benchmarking Operational Efficiency of Selected Sugar Mills in Maharashtra Using Data Envelopment Analysis. International Conference on Changing Dynamics in the Global Village. Delhi: Bloomsbury Publishing India Pvt. Ltd
10. R Core Team (2016). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL: https://www.R-project.org/.
11. Singh, N.P. Singh, R.P. (2007) Sugar Industry in Uttar Pradesh: Efficiency Still Holds the Key Agricultural Economics Research Review. 157-170
12. Singh, S P (2006) Efficiency Measurement of Sugar Mills in Uttar Pradesh. The ICFAI Journal of Industrial Economics. 3(3). 22 -38

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