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   STATEMENT OF THE PROBLEM

   OBJECTIVES

   HYPOTHESES

   RESEARCH METHODOLOGY

   RESULTS & DISCUSSION

   FINDINGS

   RECOMMENDATIONS/SUGGESTIONS

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# OPTIMUM PERFORMANCE OF TURMERIC EXTRACTION FIRMS: AN INPUT-OUTPUT ANALYSIS

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**ABSTRACT**

*This paper analyses Technical Efficiency of 14 Turmeric Oleoresin extraction firms located across South-India using DEA. The results suggests that out of 14 firms the operations of one firm is inefficient (efficiency < 60%) and three firms are moderate and four firms have very good efficiency. technical efficiency is 100% for another four firms. The optimum targeted input and output values have been predicted for an efficient production. It is observed that, DEA is an appropriate technique to analyze chemical manufacturing firms with multiple input/output variables.*

**KEYWORDS**

Data Envelopment Analysis, Technical Efficiency, Turmeric Oleoresin Extraction Industry.

## INTRODUCTION

Decision making in current competitive economy is the foremost requirement of any manufacturing industry or Decision Making Units (DMUs), for improving performance and efficiency. In this work, the performance of Turmeric Oleoresin Extraction Units belonging to the SME sector with similar process of manufacturing were chosen and compared for their technical efficiency (TE). Extraction firms manufacture turmeric oleoresin extract which is an anti-cancer drug and has many of medicinal values. This product is used in food industry as a natural coloring agent. This turmeric raw material is cultivated many states across south-India. Major contributors are Erode, Coimbatore districts in Tamil Nadu, Alappey in Kerala, Mysore district in Karnataka and some parts of Andra Pradesh. Technical efficiency provides the information on how the firms perform and can compare their optimum performance. This enhance the decision making process as it depends on the performance and efficiency of the manufacturing DMUs.

## LITERATURE REVIEW

Literature shows studies were done for various manufacturing like garment, cement, pharmaceutical industries and Agro based industries like horticulture and poultry and also in banking, etc. Simanti Banerjee (2007) studied the impact of environment regulation on TE of Indian Cement Industry and found TE score is higher for firms with effective regulation scenario. Putu Mahardika Adi Saptura (2011) examined TE level of Indonesian Manufacturing industries during the period from 1990 to 2011. Results obtained from DEA technique proved that basic industry performs better than other high technology firms. Mainak Mazumdar (2009) examines the competitiveness of Indian Pharmaceutical firms by computing their TE using non-parametric approach of DEA, results shows that R&D, Export Expenditure and imported technology does not contribute to improve TE. Dlamini (2010) studied small scale sugarcane farmers in Swaziland, investigated using stochastic frontier function of the Cobb-Douglas model of DEA, results revealed that TE decrease with increase in farm size. Niringiye Aggrey (2010) studied the relationship between the firm size and TE using DEA technique, found that there is a negative association between TE and Firm size. Belen Iraizo (2003) studied the Horticultural production to estimate TE using both Non-parametric and Parametric approach to a frontier production function. Studies show that TE was positively related with the Partial Productivity Indices. Sunil Kumar (2008) using DEA measures the extent of technical, pure technical and scale efficiency of 27 public sector banks. Vincent Mok (2010) studied 287 cloth manufacturing firms to estimate relation between TE and export orientation, studies show that high level of TE for the firms concentrating on either local market or overseas market and TE is Low for firms trying to conquer both the local and overseas market.

Based on the literature review, DEA technique has not been used in Turmeric Extraction firms of to find the technical efficiency. This paper is designed to measure and compare the technical efficiency of Turmeric Oleoresin extraction firms in south India. The paper is structured as follows. Research Methodology is explained in section III, Analysis - Variable selection is explained in Section IV, concepts of DEA models are explained in Section V, Results and Discussion in Section VI. Summary of Findings are explained in Section VII followed by conclusion in Section VIII.

## RESEARCH METHODOLOGY

### RESEARCH OBJECTIVE

This study aims at estimating the technical efficiency of 14 DMUs of Turmeric Oleoresin Extraction industry located across south India. The DMUs will be ranked according to their Technical Efficiency. This study also provides a optimum inputs and output for the not so efficient DMUs to achieve an efficiency similar to the top ranking DMUs.

### RESEARCH DESIGN

Experimental Research design has been used. This paper takes the manufacturing firms namely Turmeric Oleoresin extraction firms. These firms are located across the south – Indian peninsula where the raw material Turmeric mother rhizome is available in nearby areas. Primary Data is collected for a month. Several input information for the manufacture of TOE was obtained. The firms are SMEs, whose output product is the Turmeric oleoresin produced which is used mainly for medicinal purposes.

### DATA TYPE

We use primary data for the study collected from the Turmeric Oleoresin extraction firms. The data is collected from the firms willing to share their data. Data is collected through observation at the production plant and interviews conducted with production mangers of the firms, which was used in the analysis.

### RESEARCH METHODS

In this paper we are using non-parametric DEA technique, Constant Returns to Scale Model (CRS) for calculating the Technical Efficiency of the firms studied. For this study, the performance Analysis is done by analyzing kilograms of turmeric oleoresin produced per batch per day. Performance analysis in practice uses one or more inputs to produce one or more outputs. Inputs for this turmeric extraction process are raw material, electricity, number of extractors, number of operators and numbers of batches are used. Data Envelopment Analysis (DEA) is used in this work to measure efficiency and productivity as it takes into account many inputs and outputs.

**DEA TECHNIQUE**

**MEASURES OF PERFORMANCE**

In any DMU, measures of performance help in evaluating the productivity and efficiency of the firm. Productivity refers to total factor productivity (involving all factors of production).Assume that a DMU uses a single input X to produce a single Output Q, Productivity is the Ratio of output (s) to input(s).

$$Productivity = \frac{Q}{X}$$

Technical Efficiency (TE) reflects the ability of a firm to obtain maximum possible output from a given set of inputs and technology.

$$TE = \frac{\text{Actual output}}{\text{Potential output (or) maximum possible output}}$$

**MEASURING TECHNICAL EFFICIENCY**

The two principal methods of measuring technical efficiency:

1. Mathematical Programming based on non-parametric DEA
2. Econometric methods i.e., Stochastic frontiers.

Data Envelopment Analysis (DEA) is a linear programming methodology to measure the efficiency of multiple decision making units (DMUs) when the production process presents a structure of multiple inputs and outputs.

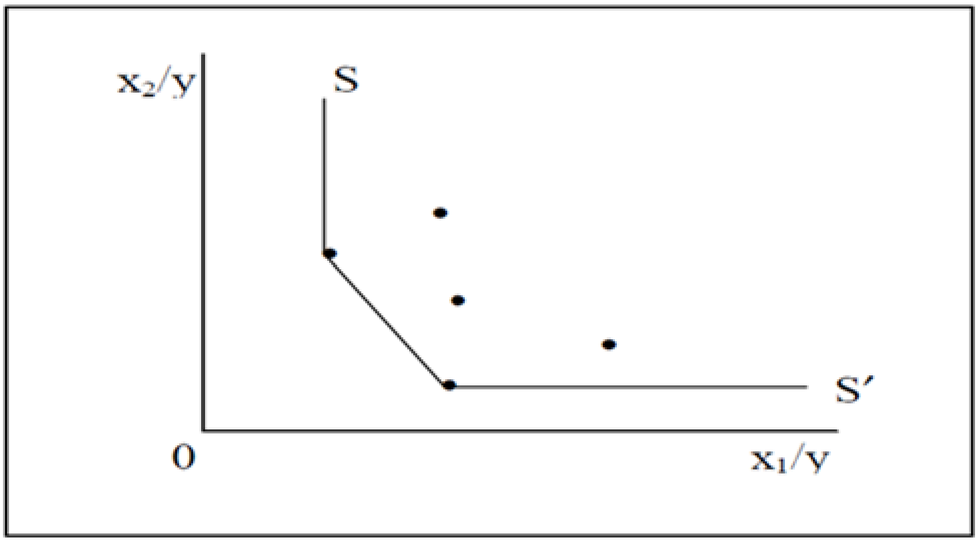
**DEA EFFICIENCY MEASUREMENT CONCEPTS**

DEA technique was first formulated by Charnes, Cooper and Rhodes (1978) , who proposed a model which had an input orientation and assumed constant returns to scale(CRS). Banker, Charnes and Cooper (1984) who proposed a variable returns to scale (VRS) model.

**THE CONSTANT RETURNS TO SCALE MODEL (CRS)**

Assume there are data on K inputs and M outputs on each of the firms or DMUs. For the i-th DMU these are represented by the vectors $X_i$ and $Y_i$ respectively. The KxN input matrix, X, and the MxN output matrix, Y, represent the data of all N DMUs. The purpose of DEA technique is to construct a non-parametric envelopment frontier over the data points such that all observed points lie on or below the production frontier. For the simple example of an industry where one output is produced using two inputs, it can be visualized as a number of intersecting planes forming a tight fitting cover over a scatter of plots in three dimensional spaces.

**FIGURE 1- PIECEWISE LINEAR CONVEX ISOQUANT**




Given the CRS assumption, this can also be represented by a unit isoquant in input/input space (refer Figure-1).

The best way to introduce DEA is via the ratio form. For each DMU we would like to obtain a measure of the ratio of all the outputs over all inputs. Such as $u'y_i / v'x_i$ where u is an Mx1 vector of output weights and v is an Kx1 vector of output weights. To select optimal weights we specify the mathematical programming problem

$\text{Max}_{u,v} (u'y_i / v'x_i)$,

st $u'y_i / v'x_i \leq 1$, j=1, 2,….,N,

$u, v \geq 0$.

This involves finding values for U and V, such that the efficiency measure of the i-th DMU is maximized, subject to the constraint that all efficiency measures must be less than or equal to one. One problem with this particular ration formulation is that it has an infinite number of solutions. To avoid this one can impose the constraint $r'x_i = 1$, which provides,

$\text{Max}_{\mu,r}(\mu' y_i)$,

st $r'x_i = 1$,

$\mu' y_i - r'x_j \leq 0$, j=1, 2,….,N,

$\mu, r \geq 0$

Where the notation changes from U and V to μ and r reflects the transformation. This form of the linear programming problem using the duality in linear programming, one can derive an equivalent envelopment form of this problem:

$\min_{\theta,\lambda} \theta$,

st $-y_i + Y\lambda \geq 0$,

$\theta x_i - X\lambda \geq 0$,

$\lambda \geq 0$,

Where θ is a scalar and λ is a Nx1 vector of constants. This envelopment form involves fewer constraints than the multiplier form (K+M < N + 1), and hence is generally the preferred form to solve. The value of θ obtained will be the efficiency score for the i-th DMU. It will satisfy θ < 1, with a value of 1 indicating a point on the frontier and hence a technically efficient DMU, according to the Farrell (1957) definition. Note that the linear programming problem must be solved N times, once for each DMU in the sample. A value of θ is then obtained for each DMU.

## ANALYSIS

### VARIABLE SELECTION

Data is collected from extraction firms spread across South-India on monthly basics for the current year. The analysis was conducted using DEA technique. For the analysis input variables taken into consideration are number of operators, number of extractors used, consumption of electricity, number of batches and raw material. Number of operators is measured by total number of operators, consumption of electricity is measured in units, and number of extractors used is measured in numbers and number of batches in numbers. Raw material (mother rhizome turmeric) is measured in kilograms. Output is the Turmeric Oleoresin produced measured in kilograms.

### DESCRIPTION OF DATA

Primary data collected at 14 various DMUs, consists of five inputs and an output. Table-1 shows the data collected for all the firms. The technical efficiency of the turmeric oleoresin extraction firms can be measured in terms of input and output variables. The technical efficiency means efficiency of turmeric extraction firms in utilizing input to generate output. The strength of the firms can be judged in terms of oleoresin produced by the firms. Therefore production got is taken as output variable. The production is achieved using raw material, extractors to process it, needed power, batches and employees the input variables taken for the study are number of operators, number of extractors, electricity consumption, raw materials (mother rhizome turmeric) and number of batches. The technical efficiency is measured by taking in to account of all firms in total.

**TABLE-1: DATA FOR 14 TURMERIC OLEORESIN EXTRACTION FIRMS OF SOUTH-INDIA**

| Firm | Output | Input 1 | Input 2 | Input 3 | Input 4 | Input 5 |
|---|---|---|---|---|---|---|
| | production kg | No. of operators | No. of Extractors | Electricity Consumption | Raw Material(Kg) | No. of Batches |
| 1 | 3612.6 | 900 | 90 | 50000 | 90 | 60 |
| 2 | 1500 | 450 | 30 | 20000 | 30 | 15 |
| 3 | 1128.6 | 450 | 60 | 50000 | 45 | 30 |
| 4 | 5100 | 750 | 120 | 75000 | 120 | 75 |
| 5 | 2840.4 | 750 | 120 | 65000 | 90 | 75 |
| 6 | 2145 | 510 | 90 | 60000 | 75 | 60 |
| 7 | 3690 | 600 | 90 | 60000 | 90 | 60 |
| 8 | 5737.5 | 1500 | 150 | 100000 | 135 | 90 |
| 9 | 4050 | 900 | 120 | 65000 | 90 | 75 |
| 10 | 7308 | 1800 | 270 | 120000 | 210 | 180 |
| 11 | 3600 | 540 | 90 | 50000 | 90 | 60 |
| 12 | 10800 | 1350 | 240 | 175000 | 240 | 180 |
| 13 | 988.2 | 540 | 30 | 50000 | 30 | 15 |
| 14 | 4050 | 900 | 90 | 125000 | 90 | 60 |

## RESULTS AND DISCUSSION

### TECHNICAL EFFICIENCY SUMMARY

**TABLE 2: TECHNICAL EFFICIENCY SUMMARY**

| Firm | Technical Efficiency | Rank |
|---|---|---|
| 1 | 0.978 | 5 |
| 2 | 1 | 1 |
| 3 | 0.53 | 14 |
| 4 | 1 | 1 |
| 5 | 0.68 | 11 |
| 6 | 0.627 | 13 |
| 7 | 0.932 | 8 |
| 8 | 0.887 | 9 |
| 9 | 0.951 | 6 |
| 10 | 0.833 | 10 |
| 11 | 1 | 1 |
| 12 | 1 | 1 |
| 13 | 0.659 | 12 |
| 14 | 0.951 | 6 |
| | Average 0.859 | |

Around 14 firms are taken for study. The technical efficiency is measured by using DEA method. Table 2 contains technical efficiency score for turmeric extraction firms. The rank for the firms is derived based on efficiency score. Four firms, firm 2, 3 and 4 shows 100% efficiency. Another four firms shows maximum efficiency above 90%, two firms i.e firm 8 and 10 has efficiency greater than 80%. Three firms i.e firm 5,6,13 are moderately efficient i.e., less than 75%. The lowest efficiency is less than 60% for the firm 3.

### OPTIMUM SETTING FOR INEFFICIENT FIRMS

**TABLE 3: OPTIMUM VALUE OF INPUTS AND OUTPUTS**

| Firm | | | | | | |
|---|---|---|---|---|---|---|
| **Firm #** | **output** | **Input 1** | **Input 2** | **Input 3** | **Input 4** | **Input 5** |
| **1** | **3692.308** | **900** | **80.769** | **50000** | **80.769** | **46.154** |
| **2** | **1500** | **450** | **30** | **20000** | **30** | **15** |
| **3** | **2130** | **450** | **45** | **31500** | **45** | **28.5** |
| **4** | **5100** | **750** | **120** | **75000** | **120** | **75** |
| **5** | **4180** | **750** | **90** | **64000** | **90** | **61** |
| **6** | **3422** | **510** | **75** | **54100** | **75** | **53.9** |
| **7** | **3958.333** | **600** | **90** | **60000** | **90** | **59.583** |
| **8** | **6470** | **1500** | **135** | **93500** | **135** | **81.5** |
| **9** | **4260** | **900** | **90** | **63000** | **90** | **57** |
| **10** | **8769.231** | **1800** | **203.077** | **120000** | **203.077** | **124.615** |
| **11** | **3600** | **540** | **90** | **50000** | **90** | **60** |
| **12** | **10800** | **1350** | **240** | **175000** | **240** | **180** |
| **13** | **1500** | **450** | **30** | **20000** | **30** | **15** |
| **14** | **4260** | **900** | **90** | **63000** | **90** | **57** |

The inefficient firms can become relatively efficient by achieving the target set by DEA. The results of DEA show that the inefficient firms can become efficient firms by achieving the target input and maximizing the output. Table 3 provide the input and output values for the turmeric oleoresin extraction firms to achieve efficiency.

## SUMMARY OF FINDINGS
This paper analyses Technical Efficiency of 14 Turmeric Oleoresin extraction firms located across South-India using DEA. The results suggests that out of 14 firms Four firms, firm 2, 3 and 4 show 100% efficiency. Another four firms show maximum efficiency above 90%. Two firms, firm 8 and 10 has efficiency greater than 80%. Three firms, firm 5,6,13 are moderately efficient i.e., less than 75%. The lowest efficiency is less than 60% for the firm 3. Also by using this DEA technique, the targeted input and output values were predicted for an efficient production. So it can be concluded that, DEA is an appropriate technique to analyses chemical manufacturing firms with multiple input/output variables.

## CONCLUSION
The purpose of the paper is to find the technical efficiency of Turmeric Oleoresin extraction firms located across South-India. Analyses started by identifying the firms. As these firms measure their performance based on the output production, the technique chosen is non-parametric DEA with output oriented methodology. We have about five inputs, which is used to maximize the output. After selection of input and output variables, data is collected for these 14 DMUs and technical efficiency of these firms were calculated. The results show the most efficient firms and the least efficient firms. Some firms are operating under moderate conditions.

Based on the output and input, we also find the targeted output and input parameters so that all the inefficient firms can improve on their performance and become efficient if they achieve the targeted output and input quantities. So in conclusion similar manufacturing firms can use this non-parametric DEA technique to study the efficiency of the output production with optimum performance.

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