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INTRODUCTION

REVIEW OF LITERATURE

NEED/IMPORTANCE OF THE STUDY

STATEMENT OF THE PROBLEM

OBJECTIVES

HYPOTHESIS (ES)

RESEARCH METHODOLOGY

RESULTS & DISCUSSION

FINDINGS

RECOMMENDATIONS/SUGGESTIONS

CONCLUSIONS

LIMITATIONS

SCOPE FOR FURTHER RESEARCH

REFERENCES

APPENDIX/ANNEXURE

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- Bowersox, Donald J., Closs, David J., (1996), "Logistical Management." Tata McGraw, Hill, New Delhi.
- Hunker, H.L. and A.J. Wright (1963), "Factors of Industrial Location in Ohio" Ohio State University, Nigeria.

CONTRIBUTIONS TO BOOKS

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

UNPUBLISHED DISSERTATIONS

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

ONLINE RESOURCES

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WEBSITES

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

EFFICIENCY OF THE SUGAR MANUFACTURING FIRMS OF INDIA

RAMA RANI
RESEARCH SCHOLAR
PUNJABI UNIVERSITY
PATIALA

ABSTRACT
We found that the Indian Sugar industry operated with an average overall technical inefficiency (OTIE) to the tune of 18.6% during the period 2009-13. The overall inefficiency is driven by managerial efficiency rather than the scale efficiency which shows that there is a need to improve the managerial efficiency in Indian sugar manufacturing firms. We saw that the total factor productivity change of the sugar industry shows a regress from 2009 to 2013. The productivity declined by 5.1%. This decline is majorly driven by the negative technological progress scores. This thus leads us to conclude the sugar industry of India is suffering from obsolete and outdated technology and needs technological innovation. Furthermore we see that the technical efficiency growth is driven more by scale efficiency growth and not by the managerial efficiency growth for majority of firms. This reestablishes the fact that there is a need to improve the managerial efficiency in our government protected sugar industry. We conclude by stating that the sugar firms can eliminate the inefficiency that are currently operating with if they improve their managerial efficiency and are made to function more competitively by reducing the amount of government protection given to them.

KEYWORDS
sugar industry, managerial efficiency, negaitive technological progress score.

INTRODUCTION
In the world, sugar consumption rate is highest in India as shown in the statistics received from USDA Foreign Agricultural Service. Sugar in India is majorly produced from the sugarcane. India is the world's largest producer of sugarcane and second largest producer of sugar in the world after Cuba. Within India, sugar industry is the second largest agro-based industry after cotton textiles. Since Indian sugar industry uses sugarcane in the production of sugar, maximum number of the firms are found in the sugarcane growing states of India including Uttar Pradesh, Maharashtra, Gujarat, Tamil Nadu, Karnataka, and Andhra Pradesh. Uttar Pradesh alone accounts for 24% of the overall sugar production in the nation and Maharashtra's contribution is about 20%. There are 453 sugar mills in India. Co-operative sector has 252 mills and private sector has 134 mills. Public sector has 67 mills.

Sugar Industry has always been under the direct control of the Government ever since. It is highly politicized and closely controlled by authorities set by the Governments (State & Central). The authorities control the minimum prices for sugar canes as well as rate of sugar both as commercial and domestic uses. They also control the licensing of sugar manufacturing business and Imports and exports. The country has a dual sugar pricing policy, where raw material price is fixed by the Government, which goes up every year. Sugar price for the levy sugar (40% of production) is fixed without taking into consideration of all factors that go into production, i.e. 40% of the sugar is sold below cost of production. Thus Government has protected the farmer and the consumer who gets levied sugar.

With Indian Sugar industry, being an agro-based industry heavily protected by the government, one expects the stagnation or a lack to technological progress in it. We find out if this is true in our study which aims to analyse the efficiency and productivity of Indian sugar industry and firms over 2009-2013.

OBJECTIVE OF THE STUDY
The objective of the study is to measure and analyse the efficiency and productivity of the Indian sugar industry and sugar firms for the time period 2009-2013. This is done by finding the efficiency scores and productivity change indices for a sample of 46 Indian sugar firms for 2009-2013 using the output-oriented Malmquist-DEA (Data Envelopment Analysis) model. The scores and indices are obtained by running the DEAP Version 2.1- Data Envelopment Analysis (Computer) Program written by Tim Coelli.

The output oriented Malmquist Productivity model of Data Envelopment Analysis (DEA) for 46 sugar firms of India is run using two outputs —Total Sales and Profit after Tax; and three inputs — Raw Materials, Stores and Spare; Compensation of Employees and Selling and Distribution Expenses. Our study is for the period 2009 – 2013. All required data for the 46 representative firms was collected from the CMIE (Centre for Monitoring Indian Economy) data base using PROWESS (steps explained in 'Research and Methodology' section).

LITERATURE REVIEW

TABLE 1

Author(s) & Paper	Period of study	Methodological Framework	Inputs	Outputs	Major conclusions
Amit Kumar Dwivedi & Priyanko Ghosh ***Efficiency Measurement of Indian Sugar Manufacturing Firms: A DEA Approach***	2006-2010	Data Envelopment analysis (DEA)–Input and output oriented Variable returns to scale (VRS) and Constant Returns to Scale (CRS)	Three inputs- 1. Total costs of goods sold 2. Total selling and Administration expenses 3. Total assets held by the firm during the year	Two outputs- 1.Total sales of the firm during the year 2.Total Profit after tax of the firm during the financial year	Analysis shows that Indian sugar manufacturing firms operate with an overall technical inefficiency of 10-15% .
Sunil Kumar and Nitin Arora ***Analyzing Regional Variations in Capacity Utilization of Indian Sugar Industry using Non-parametric Frontier Technique***	1974/1975 to 2004/2005	DEA based Capacity Utilization Model	Three Inputs- 1. Labor 2. Intermediate Inputs 3.Gross Fixed Capital	One Output- 1. Gross output	The analysis presents a gloomy picture of the capacity utilization in Indian sugar industry. The causes of incessantly falling levels of CU are: i) lack of raw material (i.e., sugarcane) caused by a) untimely payments for the purchase of sugarcane by sugar mills, and b) low per hectare productivity of sugarcane; ii) lack of labour inputs caused by the observed lack of the supply of sugarcane; iii) excessive government control over the industry.
Sunil Kumar and Nitin Arora ***Evaluation of Technical Efficiency in Indian Sugar Industry: An Application of Full Cumulative Data Envelopment Analysis***	1974/1975 to 2004/05	Full cumulative data envelopment analysis (FCDEA)	Three Inputs- 1. Labour Production 2. Intermediate Inputs 3. Gross Fixed Capital in Use	One Output- 1. Gross Output	Sugar industry of India is operating with a high level of Overall Technical Inefficiency (OTIE) which is about 35.55 percent. Further, it has been observed that the dominant source of OTIE is managerial inefficiency and scale inefficiency is relatively less dominating.
Nitin Arora ***Testing of Technical Efficiency Catching-up in Indian Sugar Industry: A Longitudinal Analysis of Sugar Producing States***	1974/75 to 2004/05	Full cumulative data envelopment analysis (DEA)	Three Inputs- 1. Total Workers 2. Intermediate inputs 3. Capacity Adjusted GFC	One Output- 1. Gross Output	-Overall inefficiency in sugar industry to the tune of 35.55%, driven by high levels of managerial inefficiency. -Decline in the average efficiency in the post 91-reforms period. -Convergence is positive in the pre-reform period, but the phenomenon of convergence, which was present in pre-reforms years, has been found completely disappeared from the scene during the post-reforms period.
SP Singh ***Performance of Sugar Mills in Uttar Pradesh by Ownership, Size and Location***	1996-97 to 2002-03	DEA model	Six inputs- 1. Net fixed capital 2. Working capital 3. Labour 4. Raw material 5. Energy 6. Fuel	Two Outputs- 1. Sugar production 2. Molasses production	- Average overall technical efficiency (OTE) in the sugar mills of UP has been 93 per cent i.e. an average mill operates with an inefficiency of 7%. - The private sector mills achieve the highest efficiency scores, followed by the cooperative sector. It has also been observed that the mills with bigger plant size attain relatively higher efficiency scores.
Sunil Kumar and Nitin Arora ***Assessing Technical Efficiency of Sugar Industry in Uttar Pradesh: An Application of Data Envelopment Analysis***	2003-04	DEA model	Four inputs- 1. Gross fixed capital 2. Fuel consumed 3. Material consumed 4. Labour	Two outputs- 1. Sugar produced 2. Molasses produced	The empirical results reveal that mean overall technical inefficiency (OTIE) is about 19 percent, and both managerial and scale inefficiencies contribute almost equal to observed OTIE. Also, a majority of firms need downsizing in the scale of their operations.
Nitin Arora ***Technical Efficiency and Profitability in the Sugar Industry of Punjab: A Firm Level Non-parametric Analysis***	2003-04	DEA model	Three inputs- 1. Gross fixed capital, 2. Labour 3. Intermediate inputs	Two outputs- 1. Ex-factory gross output 2. Ex-factory Molasses produced	-Average overall technical inefficiency to the tune of 18.44 percent in the sugar industry of Punjab driven by managerial efficiency. -Low-Profitability of Sugar firms in Punjab is, 27% firms operating with negative profitability
M. Balasubramanian ***Financial Performance of Sugar Industries in India***	1994-2004	Econometric analysis of growth and capital utilisation	The analysis studies Sugarcane area, production and Yield; and ethanol consumption	Molasses production; Export, import and domestic consumption of sugar	Most of sugar units in India utilize production capacity below 50%. Low capacity utilization, Mounting losses and decreasing net worth of sugar factories have been responsible for sickness of India's sugar industry.
Sarbapriya Ray ***Reviewing Performance of Indian Sugar Industry: An Economic Analysis***	1979-80 to 2008-09	Econometric analysis of capacity utilization	Analysis used inputs of labour, fuel and capital stock	Real value added by the manufacturers was used as output.	There has been diminishing capacity utilization growth rate in this industry during post reform period. The impact of liberalization on economic capacity utilization of Indian sugar industry is noticed to have significant negative impact.

RESEARCH AND METHODOLOGY

The notion of efficiency in economics, as developed by Farrell (1957), refers to the minimization of inputs used by a firm to produce a given level of outputs or the maximization of outputs produced by a given set of inputs under a given state of technology. This is also known as technical efficiency where the efficient units cannot reduce any of inputs without increasing another or reducing the output. However, for any given firm or industry the absolute level of efficiency is not known. What may be known is the efficiency of a firm relative to another firm or to some benchmark for the industry, which is the reference technology giving rise to the frontier analysis in efficiency measurement.

Among the non-parametric techniques, formalized first by Charnes, et al. (1978), the Data Envelopment Analysis (DEA) is the most widely used for efficiency measurement in many industries. The project uses the DEA (Data Envelopment Analysis) — a non-parametric approach of mathematical programming, comprising the work of Farrell, strengthened Charnes, Cooper and Rhodes (1978), Fare, Grosskopf and Lovell (1983), Banker, Charnes and Cooper (1984), and Byrens, Fare and Grosskopf (1984). Malmquist productivity indices have been used to analyse the efficiency of the Sugar firms using three inputs and two outputs.

THE ANALYTICAL MODEL – DEA

DEA is a linear programming base technique to workout technical efficiency scores of Decision Making Units (DMUs) in a multiple input and multiple output setting.

Technical efficiency, as explained above, can basically be seen as the managerial ability to avoid waste of resources and how successfully can inputs be converted to outputs.

As per the DEA model, each firm or the DMU is interested to maximize its efficiency where efficiency must be less than one. This acts as our constraint, i.e the maximum score a firm can obtain or the score of a fully efficient firm is 1.

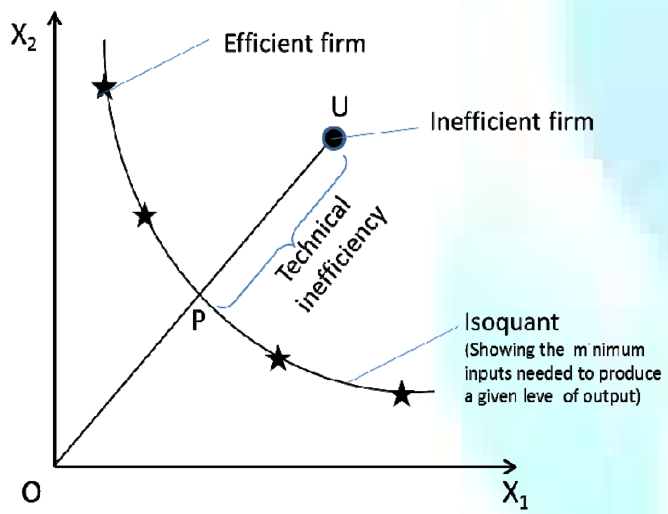
Technical efficiency can be analyzed from two perspectives:

a) Input Perspective: keeping the outputs fixed and minimizing the inputs.

b) Output Perspective: keeping the inputs fixed and maximizing the outputs.

The technical inefficiency exists if it is possible to reduce input for a given level of output, or if it is possible to increase output for a given level of inputs.

FIG. 1: INPUT ORIENTED FRONTIER ANALYSIS

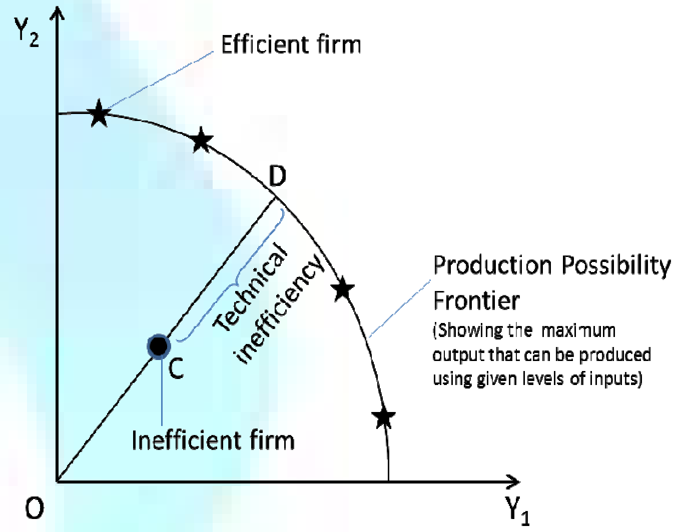


Technical Efficiency = Minimum Input/Actual input = OP/PU

Efficient firms score 1.
Inefficient firms score < 1.

Inefficiency = 1 – Technical efficiency

FIG. 2: OUTPUT ORIENTED FRONTIER ANALYSIS



Technical Efficiency = Actual output/Maximum output = OC/OD

Efficient firms score 1.
Inefficient firms score < 1.

Inefficiency = 1 – Technical efficiency

We in our study use the Output oriented approach which we feel is better suited to our objective of analyzing efficiency of manufacturing firms.

OPTIMIZATION PROBLEMS OF DEA IN ENVELOPMENT FORM

Let

x = Input vector = (x_1, ...X_m)

y = Output vector = ((x_1, ... X_m)

n = No. of firms/ DMU's (Decision making Units)

m = Total no. of inputs

s = Total no. of outputs

j = 1,……n

I = 1,……m

r = 1,……s

Now, there are two basic models of DEA – the CCR model and the BCC model.

CCR MODEL OF DEA – CONSTANT RETURNS TO SCALE

Named after its developers Charnes, Cooper and Rhoders, the CCR model assumes Constant returns to scale. This means that the CCR model cannot distinguish between scale efficiency and pure technical (or managerial efficiency).

The optimization problem under CCR-I *(input oriented CCR model where we minimize inputs):*

Minimise Θ_k

Subject to:
$\Sigma\Lambda_j x_{ij} \leq \Theta^I_k x_{ik}$
$\Sigma\Lambda_j y_{ij} \geq y_{rk}$
$\Lambda_j \geq 0$ (Λ_j are the weights of the inputs)
The optimization problem under CCR-O *(output oriented CCR model where we maximize outputs):*
Maximise Θ^o_k
Subject to:
$\Sigma\Lambda_j x_{ij} \leq x_{ik}$
$\Sigma\Lambda_j y_{ij} \geq \Theta^o_k y_{rk}$
$\Lambda_j \geq 0$ (Λ_j are the weights of the outputs)
Solving the optimisation problems of CCR-I and CCR-O models will give us the CRS-based *Overall (or Global) Technical efficiency scores* also called *Farrell Efficiency scores,* without any distinction between scale efficiency and pure technical (or managerial efficiency.

BCC MODEL OF DEA – VARIABLE RETURNS TO SCALE

The Constant Returns to Scale assumption is quite restrictive assumption as it does not prevail in real life. Banker, Carnus and Cooper (1984) relax the assumption of CRS in their model called the BCC model. The BCC model assumes that Variable Returns to Scale (VRS) prevails in the industry; returns to scale may be increasing (IRS), Decreasing (DRS) or Constant (CRS). The BCC model gives us pure efficiency score which reflects only the managerial efficiency and not the scale efficiency.
The optimization problem under BCC-I *(input oriented BCC model where we minimize inputs):*
Minimise Θ'^I_k
Subject to:
$\Sigma\Lambda_j x_{ij} \leq \Theta'^I_k x_{ik}$
$\Sigma\Lambda_j y_{ij} \geq y_{rk}$
$\Sigma\Lambda_j = 1$ (This is the *convexity constraint.* Adding this constraint to CCR model gives us the BCC model)
$\Lambda_j \geq 0$ (Λ_j are the weights of the inputs)
The optimization problem under BCC-O *(output oriented BCC model where we maximize outputs):*
Maximise Θ'^o_k
Subject to:
$\Sigma\Lambda_j x_{ij} \leq x_{ik}$
$\Sigma\Lambda_j y_{ij} \geq \Theta'^o_k y_{rk}$
$\Sigma\Lambda_j = 1$ (This is the *convexity constraint.* Adding this constraint to CCR model gives us the BCC model)
$\Lambda_j \geq 0$ (Λ_j are the weights of the outputs)
Solving the optimisation problems of BCC-I and BCC-O models will give us the VRS-based *Pure Technical efficiency scores* which show the managerial efficiency of a DMU.

SCALE EFFICIENCY

The scale efficiency of a DMU can be calculated as follows-

$$\text{Scale efficiency} = \frac{\text{CRS-based Overall Technical Efficiency (CCR model)}}{\text{VRS-based Pure Technical Efficiency (BCC model)}}$$

i.e. Overall Technical Efficiency (OTE) = Pure Technical Efficiency (PTE) X Scale Efficiency (SE)

MALMQUIST PRODUCTIVITY INDEX

The change productivity of a firm/ an industry over time is an important topic of study.
Malmquist Total Factor Productivity Index is used to capture the total factor productivity growth over a period of time.
Output is a function of the inputs, say Labour (L) and Capital (K)-
Y = f(K,L)
Labour Productivity = Y/L ; Capital Productivity = Y/K
These however are only partial measures of productivity which capture the impact of only one input and ignore the impact of factor substitution. Thus a more holistic measure is required.

$$\text{Total Factor Productivity (TFP)} = \frac{Y}{wL+rK}$$; w and r are the weights.

This captures the effect of both L and K.
Growth in TFP (TFPG) = Output growth – Input growth
$= Y_t - Y_{t-1}/ Y_{t-1} - \{ K_t - K_{t-1}/ K_{t-1} + L_t - L_{t-1}/ L_{t-1}\}$
Caves, Christensen, and Diewert (1982) introduced the Malmquist index to measure productivity through distance functions. Färe et al. (1994) showed that the index can be directly estimated using nonparametric techniques like data envelopment analysis (DEA). Change in Total Factor Productivity over time can be analyzed if we have panel data (observations of variables over multiple periods of time) with us.
To capture growth, we require at least 2 time periods.
The optimization problems (using Output Oriented approach) can be elucidated as follows-

1. For period t

$\Theta_k^t (x_k^t, y_k^t) = \max \Theta_k$
subject to : $\Sigma\lambda_j x_{ij}^t \leq x_{ik}^t$
$\Sigma\lambda_j y_{rj}^t \geq y_{rk}^t \Theta_k$
$\lambda_j \geq 0$

2. For period t+1

$\Theta_k^{t+1} (x_k^{t+1}, y_k^{t+1}) = \max \Theta_k$
subject to : $\Sigma\lambda_j x_{ij}^{t+1} \leq x_{ik}^{t+1}$
$\Sigma\lambda_j y_{rj}^{t+1} \geq y_{rk}^{t+1} \Theta_k$
$\lambda_j \geq 0$

3. To measure technological change (positive or negative),

$\Theta_k^t (x_k^{t+1}, y_k^{t+1}) = \max \Theta_k$
subject to : $\Sigma\lambda_j x_{ij}^t \leq x_{ik}^{t+1}$
$\Sigma\lambda_j y_{rj}^t \geq y_{rk}^{t+1} \Theta_k$
$\lambda_j \geq 0$

and,

4. $\Theta_k^{t+1} (x_k^t, y_k^t) = \max \Theta_k$

subject to : $\Sigma\lambda_j x_{ij}^{t+1} \leq x_{ik}^t$
$\Sigma\lambda_j y_{rj}^{t+1} \geq y_{rk}^t \Theta_k$

$\lambda_j \geq 0$

Using the four optimization problems, we get the Malmquist Productivity Index-

$$MPI = \underbrace{\frac{\theta_K^{t}(x^{t},y^{t})}{\theta_K^{t+1}(x^{t+1},y^{t+1})}}_{\text{Technical efficiency change (Catching-up effect)}} \times \underbrace{\left(\frac{\theta_K^{t+1}(x^{t+1},y^{t+1})}{\theta_K^{t}(x^{t},y^{t})} \times \frac{\theta_K^{t}(x^{t},y^{t})}{\theta_K^{t+1}(x^{t+1},y^{t+1})} \right)}_{\text{Technological change (Innovation effect)}}$$

The MPI is composed of 2 parts-

1. *The Technical Efficiency Change*- The first term in the expression shows the technical efficiency change. This captures the catching-up effect, i.e., how successfully a firm has been able to move towards the efficient frontier over time.
2. *The Technological Progress*- The second term shows the technological progress of firm over time. This captures the innovation effect and the how the firm's production frontier has changed in shape due to technological advancement/ progress over time.

The Technical Efficiency Change (the first term), as we know is, further comprises of two components-

a) The Pure Technical Efficiency (the managerial efficiency) change

b) The Scale Efficiency change

Thus,

Malmquist Productivity Index (MPI) = Technical Efficiency change (TECH) X Technological Progress (TC)

= [Pure Technical Efficiency Change (PTECH) X Scale Efficiency change (SECH)] X Technical Change (TC)

$$MPI = \underbrace{PTECH \times SECH}_{TECH} \times TC$$

MPI = 1 → No Growth

MPI > 1 → TFP Growth

MPI < 1 → TFP deceleration

Total Factor Productivity Growth, TFPG = (MPI – 1) X 100

TIME PERIOD OF STUDY

The project attempts to analyze the efficiency of Sugar Manufacturing industry of India and the individual firms over a period of five years — 2009-2013.

CHOICE OF FIRMS AND DATA COLLECTION

A sample of 46 sugar manufacturing firms of India was chosen, on the basis of the availability of data study period.

The firms are as follows:

TABLE 2

1	Bajaj Hindusthan Sugar Ltd.	24	RaiBahadurNarain Singh Sugar Mills Ltd.
2	Bannari Amman Sugars Ltd.	25	Rajshree Sugars & Chemicals Ltd.
3	Dalmia Bharat Sugar &Inds. Ltd.	26	Rana Sugars Ltd.
4	Dewan Sugars Ltd.	27	Riga Sugar Co. Ltd.
5	Dhampur Sugar Mills Ltd.	28	S B E C Sugar Ltd.
6	Dharani Sugars & Chemicals Ltd.	29	Sakthi Sugars Ltd.
7	Dwarikesh Sugar Inds. Ltd.	30	SeksariaBiswan Sugar Factory Pvt. Ltd.
8	E I D-Parry (India) Ltd.	31	Shakumbari Sugar & Allied Inds. Ltd.
9	Gayatri Sugars Ltd.	32	Shamanur Sugars Ltd.
10	Gobind Sugar Mills Ltd.	33	Shree Ambika Sugars Ltd.
11	Indian Sucrose Ltd.	34	Shree Renuka Sugars Ltd.
12	Jeypore Sugar Co. Ltd.	35	Simbhaoli Sugars Ltd.
13	K C P Sugar &Inds. Corpn. Ltd.	36	Sir ShadiLal Enterprises Ltd.
14	K M Sugar Mills Ltd.	37	Sri Chamundeswari Sugars Ltd.
15	Khaitan (India) Ltd.	38	Tamil Nadu Sugar Corpn. Ltd.
16	Kothari Sugars & Chemicals Ltd.	39	ThiruArooran Sugars Ltd.
17	Mawana Sugars Ltd.	40	Tikaula Sugar Mills Ltd.
18	Modi Industries Ltd.	41	Trident Sugars Ltd.
19	Naraingarh Sugar Mills Ltd.	42	Triveni Engineering &Inds. Ltd.
20	Oudh Sugar Mills Ltd.	43	Ugar Sugar Works Ltd.
21	Parrys Sugar Inds. Ltd.	44	United Provinces Sugar Co. Ltd.
22	Ponni Sugars (Erode) Ltd.	45	Upper Ganges Sugar &Inds. Ltd.
23	Prudential Sugar Corpn. Ltd.	46	Uttam Sugar Mills Ltd.

SELECTION OF INPUTS AND OUTPUTS

We use two outputs and three inputs.

OUTPUTS

1. Total Sales
2. Profit after Tax

INPUTS

1. Raw Materials, Stores and Spare
2. Compensation of Employees
3. Selling and Distribution Expenses

All data for the firms was collected from the CMIE (Centre for Monitoring Indian Economy) data base using PROWESS

1. In the query builder, a new OSC (Output Sheet for Companies) was created by selecting sugar manufacturing industries in 'Select company by pre-defined sets' and clicking on 'Send to new OSC'. This added a list of all Indian sugar manufacturing firms which are in records in CMIE in our output sheet.

2. Next, 'Annual Financial Statement' was selected under 'Query by Financial Statements'. All our required data variables (i.e. Total Sales, Profit after Tax, Raw Materials, Stores and Spare, Compensation of Employees and Selling and Distribution Expenses) were selected in the Annual Financial Statement.
3. Query on date and output on date field was filled as 032009-032013 (which shows the time period for which we need data i.e. March 2009 to March 2013, annually).
4. All selected variables were added to the output sheet with the firms by clicking on 'Send to current OSC' (the *standalone* values were taken for all variables). This gave us our output sheet with all sugar firms with selected data. The output sheet was saved as Excel file.
5. Next, the firms for which any data for any year was unavailable were dropped from the list. Finally, we had a sample of 46 firms with the required data for both outputs and all three inputs for the period 2009-2013.

DEFLATING THE MONETARY VALUES

TABLE 3: WPI OF SUGAR 2009-13

Financial Year	WPI of Sugar (Base 2004-05)
2013-14	**188.42**
2012-13	**193.1**
2011-12	**173.44**
2010-11	**165.02**
2009-10	**166.79**
2008-09	**108.54**

The values of all the inputs and outputs were deflated using the Whole price indices of Sugar as shown in the table.
The indices were taken from office of economic adviser, Ministry of Commerce and Industry, Government if India website. The base year is 2004 - 2005.
The DEAP Version 2.1- The Data Envelopment Analysis (Computer) Program written by Tim Coelli, Department of Econometrics, University of New England was used to run the output oriented Malmquist-DEA Model.

RESULTS AND INTERPRETATION

MEAN EFFICIENCY SCORES

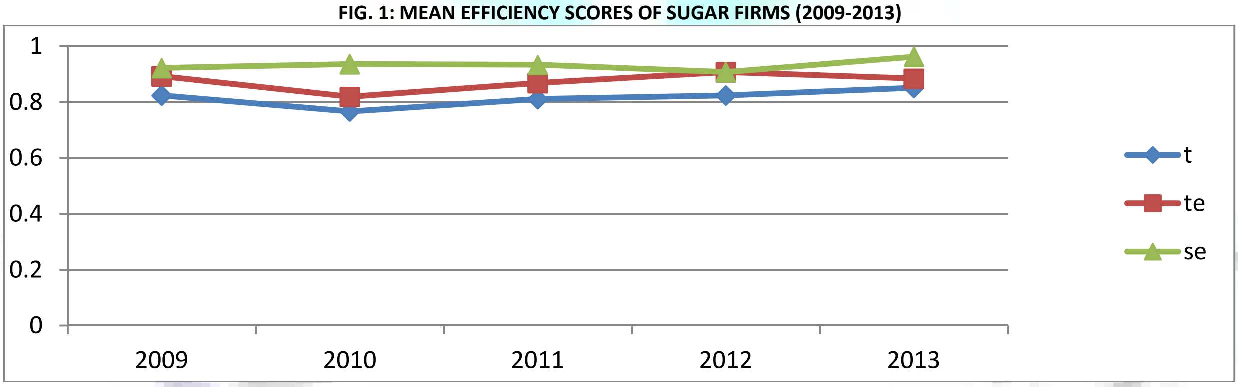
First we analyze the overall technical efficiency, the pure technical efficiency and the scale efficiency of India's sugar industry as a whole for the study period. The table showing these scores for is as follows.

TABLE 4: MEAN EFFICIENCY SCORES OF SUGAR FIRMS (2009-2013)

Year	Mean Overall Technical Efficiency Score of all Firms (t)	Mean Pure Technical Efficiency Score of all Firms (te)	Mean Scale Efficiency Score of all Firms (se= t/te)
2009	0.824	0.893	0.922732363
2010	0.767	0.819	0.936507937
2011	0.811	0.869	0.933256617
2012	0.824	0.908	0.907488987
2013	0.851	0.884	0.962669683
Average	0.814	0.874	0.932355185

On an average (found using geometric mean), the sugar industry achieved an efficiency score of 0.814 over the period 2009-13. This implies that the sugar industry operated with an overall technical inefficiency (OTIE) to the tune of 18.6% during our study period. This suggests that by adopting best-practices, on an average, a representative sugar mill can increase its output by 18.5% percent by deploying the same level of inputs. The OTIE is driven by the scale efficiency rather than the pure technical inefficiency. For all periods excluding the year 2012 the overall efficiency scores are driven by the scale efficiency scores. For year 2012, the pure technical efficiency and the scale efficiency are almost the same, thus we conclude that for four out of five periods the efficiency scores are driven more by the scale efficiency scores rather than the pure technical efficiency. This shows that Indian sugar industrial suffers from managerial inefficiency.
The overall technical efficiency showed a decline in 2010. The again it shows an upward trend from 2011 which continues till 2013. The reason for decline in 2010 was low production of sugarcane in this year due to unfavourable weather conditions.

FIG. 1: MEAN EFFICIENCY SCORES OF SUGAR FIRMS (2009-2013)



MALMQUIST PRODUCTIVITY INDICES

As explained in methodology, DEA Malmquist model gives us five indices over the study period namely, technical efficiency change (which shows us the catching up effect), technological change which shows (the innovation effects), pure technical efficiency change, scale efficiency change and finally the total factor productivity (TFP) change.

I. FOR THE INDUSTRY

The mean Malmquist indices for the period 2009 – 2013 are given as follows:

TABLE 5: MALMQUIST INDICES FOR SUGAR INDUSTRIES (2009 – 2013)

Technical Efficiency Change (Catching up effect)	Technological Progress/Change (innovation Effect)	Pure Technical Efficiency Change	Scale Efficiency Change	Total Factor Productivity Change
1.01	0.94	0.998	1.011	0.949

Total Factor Productivity Growth, TFPG = (0.949-1) X 100 = -5.1%

We see that the total factor productivity shows a regress. That is over the period of five years the factor productivity of the sugar industries of India has declined by 5%. We next observe that this decline is driven by the technological progress (which shows a regress). The technical efficiency change is positive (greater than 1). This means that the firms have done well on catching up and moving towards the efficient frontier. However since the change in technological progress is negative, not enough innovation has taken place and there is a technological regress which pulls down the total factor productive change and makes it negative.

We further observe that the technical efficiency improvement is driven by the scale efficiency change (which is positive). However the pure technical efficiency change is less than one.

This leads us to conclude that India's sugar industry has grown in scalebetween 2009 - 2013 but the technology used in the industry is becoming outdated and obsolete.

II. FOR THE FIRMS

We will do a group wise analysis of a firm based on Malmquist indices.

- First let us look at the firms whose total factor productivity change has been positive over our study period.

TABLE 6: FIRMS SHOWING A POSITIVE TOTAL FACTOR PRODUCTIVITY CHANGE OVER 2009-2013

S. No.	Company	Technical Efficiency Change (Catching up effect)	Technological Progress (innovation Effect)	Total Factor Productivity Change
1	Dewan Sugars Ltd.	1.059	0.994	1.053
2	Gayatri Sugars Ltd.	1.003	1.057	1.06
3	Indian Sucrose Ltd.	1.055	0.959	1.012
4	Kothari Sugars & Chemicals Ltd.	1.1	0.923	1.015
5	Parrys Sugar Inds. Ltd.	1.041	1.265	1.318
6	Prudential Sugar Corpn. Ltd.	1.141	0.957	1.092
7	Rajshree Sugars & Chemicals Ltd.	1.072	0.937	1.004
8	Rana Sugars Ltd.	1.116	0.905	1.01
9	SeksariaBiswan Sugar Factory Pvt. Ltd.	1.038	0.966	1.002
10	Shree Renuka Sugars Ltd.	1	1.029	1.029
11	Tamil Nadu Sugar Corpn. Ltd.	1.054	1.011	1.066
12	United Provinces Sugar Co. Ltd.	1.055	1.044	1.102
13	Uttam Sugar Mills Ltd.	1.065	0.983	1.046

There are 13 sugar firms for which the total factor productivity change was positive over our study period.

Parrys Sugar Inds Ltd. Is the firm which shows the maximum total factor productivity growth.

There are only six firms (highlighted) out of 46, including Parrys Sugar Inds Ltd, in which both the technical efficiency change and technological progress are positive leading to a total factor productivity growth to be positive i.e. greater than one. These firms are Parrys Sugar Inds Ltd, United Provinces Sugar Co. Ltd, Gayatri Sugars Ltd, Tamil Nadu Sugar Corpn Ltd and Shree Renuka Sugars Ltd. So these six firms have been able to perform well on catching up as well as innovating.

We see that in all the remaining seven firms where total factor productivity growth is positive, the technical efficiency change is greater than one. It is the lack of sufficient technological progress which has pulled down the Total Factor Productivity growth. However, the technical efficiency change is more dominant and hence the Total Factor Productivity growth is positive.

- Now let us look at the firms which technical efficiency change is positive but the technological progress and Total Factor Productivity change both are negative.

TABLE 7: FIRMS SHOWING A POSITIVE TECHNICAL EFFICIENCY CHANGE OVER 2009-2013

S.No.	Company	Technical Efficiency Change (Catching up effect)	Technological Progress (innovation Effect)	Total Factor Productivity Change
1	Bannari Amman Sugars Ltd.	1.038	0.899	0.933
2	Dharani Sugars & Chemicals Ltd.	1.046	0.943	0.987
3	E I D-Parry (India) Ltd.	1	0.747	0.747
4	Jeypore Sugar Co. Ltd.	1.052	0.943	0.992
5	K C P Sugar &Inds. Corpn. Ltd.	1.029	0.971	0.999
6	Khaitan (India) Ltd.	1.034	0.844	0.872
7	Mawana Sugars Ltd.	1.048	0.942	0.987
8	Modi Industries Ltd.	1.068	0.861	0.92
9	Naraingarh Sugar Mills Ltd.	1	0.921	0.921
10	Ponni Sugars (Erode) Ltd.	1	0.975	0.975
11	RaiBahadurNarain Singh Sugar Mills Ltd	1.002	0.938	0.94
12	Sakthi Sugars Ltd.	1.06	0.9	0.954
13	Sir ShadiLal Enterprises Ltd.	1.08	0.854	0.922
14	Ugar Sugar Works Ltd.	1.063	0.937	0.996

In all the above 14 firms the technical efficiency is positive but it not enough to drive the Total Factor Productivity change to positive. The negative effect of the technological progress dominates the positive effect of technical efficiency change and hence the total factor productivity growth is negative.

- It was found from the results that among the firms with negative total efficiency change, the negative change in technological progress was greater than the negative change in total efficiency for majority of the firms. There were only five firms for which the negative change of technological progress was less than the negative change in total efficiency; for rest all, the negative change in technological progress was higher, reinforcing the fact that there is lack of technological innovation in the sugar firms.
- There are only six firms for which the technological progress is positive and for all these firms the Total Factor Productivity growth is positive (see Table 6). There is no firm for which the technological progress is positive and the Total Factor Productivity growth is negative.

Now let us look at the scale efficiency and the pure technical efficiency scores.
First we look at the firms whose scale efficiency change has been positive.

TABLE 8: FIRMS SHOWING A POSITIVE SCALE EFFICIENCY CHANGE OVER 2009-2013

S.No.	Company	Scale Efficiency Change
1	Bannari Amman Sugars Ltd.	1.017
2	Dewan Sugars Ltd.	1.116
3	Dhampur Sugar Mills Ltd.	1.057
4	E I D-Parry (India) Ltd.	1
5	Gayatri Sugars Ltd.	1.009
6	Gobind Sugar Mills Ltd.	1
7	Indian Sucrose Ltd.	1.028
8	Jeypore Sugar Co. Ltd.	1.016
9	K C P Sugar & Inds. Corpn. Ltd.	1.003
10	Khaitan (India) Ltd.	1.034
11	Kothari Sugars & Chemicals Ltd.	1.021
12	Mawana Sugars Ltd.	1.039
13	Modi Industries Ltd.	1.016
14	Naraingarh Sugar Mills Ltd.	1
15	Parrys Sugar Inds. Ltd.	1.041
16	Ponni Sugars (Erode) Ltd.	1
17	Prudential Sugar Corpn. Ltd.	1.009
18	Rai Bahadur Narain Singh Sugar Mills Ltd.	1.001
19	Rajshree Sugars & Chemicals Ltd.	1.017
20	Rana Sugars Ltd.	1.036
21	S B E C Sugar Ltd.	1.001
22	Sakthi Sugars Ltd.	1.054
23	Seksaria Biswan Sugar Factory Pvt. Ltd.	1.011
24	Shakumbari Sugar & Allied Inds. Ltd.	1.001
25	Shree Renuka Sugars Ltd.	1
26	Simbhaoli Sugars Ltd.	1.021
27	Sir Shadi Lal Enterprises Ltd.	1.01
28	Sri Chamundeswari Sugars Ltd.	1.007
29	Tamil Nadu Sugar Corpn. Ltd.	1.014
30	Tikaula Sugar Mills Ltd.	1
31	Ugar Sugar Works Ltd.	1.035
32	United Provinces Sugar Co. Ltd.	1.019
33	Upper Ganges Sugar & Inds. Ltd.	1.007
34	Uttam Sugar Mills Ltd.	1.061

There are 34 firms out of 46 for which the scale efficiency change has been positive. That is around 73 % firms in the industry have grown in scale efficiency.
Now let us look at the firms for which the pure technical efficiency change is positive.

TABLE 9: FIRMS SHOWING A POSITIVE PURE TECHNICAL EFFICIENCY CHANGE OVER 2009-2013

S.No.	Company	Pure Technical Efficiency Change
1	Bajaj Hindusthan Sugar Ltd.	1
2	Bannari Amman Sugars Ltd.	1.021
3	Dalmia Bharat Sugar & Inds. Ltd.	1
4	Dharani Sugars & Chemicals Ltd.	1.05
5	E I D-Parry (India) Ltd.	1
6	Indian Sucrose Ltd.	1.026
7	Jeypore Sugar Co. Ltd.	1.035
8	K C P Sugar & Inds. Corpn. Ltd.	1.026
9	Khaitan (India) Ltd.	1
10	Kothari Sugars & Chemicals Ltd.	1.077
11	Mawana Sugars Ltd.	1.008
12	Modi Industries Ltd.	1.052
13	Naraingarh Sugar Mills Ltd.	1
14	Parrys Sugar Inds. Ltd.	1
15	Ponni Sugars (Erode) Ltd.	1
16	Prudential Sugar Corpn. Ltd.	1.131
17	Rai Bahadur Narain Singh Sugar Mills Ltd.	1.001
18	Rajshree Sugars & Chemicals Ltd.	1.054
19	Rana Sugars Ltd.	1.078
20	Sakthi Sugars Ltd.	1.005
21	Seksaria Biswan Sugar Factory Pvt. Ltd.	1.027
22	Shree Renuka Sugars Ltd.	1
23	Sir Shadi Lal Enterprises Ltd.	1.068
24	Tamil Nadu Sugar Corpn. Ltd.	1.039
25	Ugar Sugar Works Ltd.	1.027
26	United Provinces Sugar Co. Ltd.	1.035
27	Uttam Sugar Mills Ltd.	1.003

We see that there are only 27 out of 46 firms which show a positive growth in pure technical efficiency (managerial efficiency) i.e. 58% firms showed a growth in pure technical efficiency. This is less than the percentage of firms which showed a growth in scale efficiency (73%), thus more firms showed a growth in scale efficiency than pure technical efficiency.

Comparing scale efficiency change and pure technical efficiency change.

TABLE 10: COMPARISON OF SCALE EFFICIENCY CHANGE AND PURE TECHNICAL EFFICIENCY CHANGE OF FIRMS (2009-13)

S.No.	Company	Technical efficiency change	Pure technical efficiency change	Scale Efficiency Change	Total Factor Productivity Change
1	Bajaj Hindusthan Sugar Ltd.	0.933	1	0.933	0.88
2	Bannari Amman Sugars Ltd.	1.038	1.021	1.017	0.933
3	Dalmia Bharat Sugar & Inds. Ltd.	0.98	1	0.98	0.811
4	Dewan Sugars Ltd.	1.059	0.949	1.116	1.053
5	Dhampur Sugar Mills Ltd.	0.946	0.895	1.057	0.88
6	Dharani Sugars & Chemicals Ltd.	1.046	1.05	0.997	0.987
7	Dwarikesh Sugar Inds. Ltd.	0.975	0.988	0.986	0.904
8	E I D-Parry (India) Ltd.	1	1	1	0.747
9	Gayatri Sugars Ltd.	1.003	0.994	1.009	1.06
10	Gobind Sugar Mills Ltd.	0.93	0.93	1	0.874
11	Indian Sucrose Ltd.	1.055	1.026	1.028	1.012
12	Jeypore Sugar Co. Ltd.	1.052	1.035	1.016	0.992
13	K C P Sugar & Inds. Corpn. Ltd.	1.029	1.026	1.003	0.999
14	K M Sugar Mills Ltd.	0.996	0.999	0.997	0.955
15	Khaitan (India) Ltd.	1.034	1	1.034	0.872
16	Kothari Sugars & Chemicals Ltd.	1.1	1.077	1.021	1.015
17	Mawana Sugars Ltd.	1.048	1.008	1.039	0.987
18	Modi Industries Ltd.	1.068	1.052	1.016	0.92
19	Naraingarh Sugar Mills Ltd.	1	1	1	0.921
20	Oudh Sugar Mills Ltd.	0.962	0.964	0.998	0.916
21	Parrys Sugar Inds. Ltd.	1.041	1	1.041	1.318
22	Ponni Sugars (Erode) Ltd.	1	1	1	0.975
23	Prudential Sugar Corpn. Ltd.	1.141	1.131	1.009	1.092
24	Rai Bahadur Narain Singh Sugar Mills Ltd.	1.002	1.001	1.001	0.94
25	Rajshree Sugars & Chemicals Ltd.	1.072	1.054	1.017	1.004
26	Rana Sugars Ltd.	1.116	1.078	1.036	1.01
27	Riga Sugar Co. Ltd.	0.976	0.988	0.988	0.9
28	S B E C Sugar Ltd.	0.979	0.978	1.001	0.968
29	Sakthi Sugars Ltd.	1.06	1.005	1.054	0.954
30	Seksaria Biswan Sugar Factory Pvt. Ltd.	1.038	1.027	1.011	1.002
31	Shakumbari Sugar & Allied Inds. Ltd.	0.961	0.96	1.001	0.899
32	Shamanur Sugars Ltd.	0.974	0.989	0.984	0.936
33	Shree Ambika Sugars Ltd.	0.932	0.935	0.997	0.853
34	Shree Renuka Sugars Ltd.	1	1	1	1.029
35	Simbhaoli Sugars Ltd.	0.969	0.949	1.021	0.923
36	Sir Shadi Lal Enterprises Ltd.	1.08	1.068	1.01	0.922
37	Sri Chamundeswari Sugars Ltd.	0.986	0.979	1.007	0.831
38	Tamil Nadu Sugar Corpn. Ltd.	1.054	1.039	1.014	1.066
39	Thiru Arooran Sugars Ltd.	0.933	0.937	0.996	0.843
40	Tikaula Sugar Mills Ltd.	0.962	0.962	1	0.952
41	Trident Sugars Ltd.	0.934	0.937	0.997	0.864
42	Triveni Engineering & Inds. Ltd.	0.959	0.981	0.978	0.86
43	Ugar Sugar Works Ltd.	1.063	1.027	1.035	0.996
44	United Provinces Sugar Co. Ltd.	1.055	1.035	1.019	1.102
45	Upper Ganges Sugar & Inds. Ltd.	0.898	0.893	1.007	0.838
46	Uttam Sugar Mills Ltd.	1.065	1.003	1.061	1.046

There are 21 firms (highlighted in yellow) for which the scale efficiency change out performs the pure technical efficiency change. The pure technical efficiency change in these firms plays a bigger role in driving down the overall technical efficiency scores and hence the total factor productivity change.

There are 19 firms (highlighted in blue) for which the pure technical efficiency change out performs the scale efficiency change. The scale efficiency change in these firms plays a bigger role in driving down the overall technical efficiency scores and hence the total factor productivity change.

Thus we see that overall the number of firms where scale efficiency out performs the pure technical is higher. This means that it is the scale efficiency which majorly drives the technical efficiency which in turn drives the total factor productivity.

CONCLUSION

We found that the Indian Sugar industry operated with an average overall technical inefficiency (OTIE) to the tune of 18.6% during the period 2009-13. The overall inefficiency is driven by managerial efficiency rather than the scale efficiency which shows that there is a need to improve the managerial efficiency in Indian sugar manufacturing firms. We saw that the total factor productivity change of the sugar industry shows a regress from 2009 to 2013. The productivity declined by 5.1%. This decline is majorly driven by the negative technological progress scores. This thus leads us to conclude the sugar industry of India is suffering from obsolete and outdated technology and needs technological innovation. Furthermore we see that the technical efficiency growth is driven more by scale efficiency growth and not by the managerial efficiency growth for majority of firms. This reestablishes the fact that there is a need to improve the managerial efficiency in our government protected sugar industry. We conclude by stating that the sugar firms can eliminate the inefficiency that are currently operating with if they improve their managerial efficiency and are made to function more competitively by reducing the amount of government protection given to them.

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