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USING DATA ENVELOPMENT ANALYSIS TO EVALUATE AND BENCHMARK TECHNICAL EFFICIENCY OF COOPERATIVE SUGAR MILLS IN UTTAR PRADESH

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ABSTRACT

Using cross sectional data, this paper attempts to evaluate and benchmark the relative performance of 23 cooperative sugar mills of Uttar Pradesh in terms of relative efficiency. Using Data Envelopment Analysis" (DEA), the technical efficiency of the cooperative sugar mills has been assessed. DEA results reveal that on an average there is 7% inefficiency in the operation of mills, in other words mills can make radial reduction in all its inputs by 7% without harming its output levels. On an average 5% of cane, 13% of permanent employee, 8% of seasonal employee and 15% of capacity could be saved with maintaining the current output level of sugar. Nearly 74 % of mills are facing increasing returns to scale implying that most of the mills are too small relative to the optimum size. Results revealed that mills can use their resources efficiently but they are suffering from disadvantageous plant size. If problem of disadvantageous plant size could be resolved mills can get rid of 4% scale inefficiency. The paper concludes with the remarks that improvement in the technical efficiency of cooperative sugar mills are necessary precondition to sustain in the today's competitive era. Management of the cooperative sugar mills must be guided through the policy of continuous assessment and improvement in the operations.

Keywords: Benchmarking, Data Envelopment Analysis, Performance, Returns to Scale, Scale Efficiency, Super Efficiency, Technical Efficiency.

I. INTRODUCTION

Sugar industry is one of the largest organized industries in Uttar Pradesh and plays, very crucial role in state's economy. Uttar Pradesh is the largest sugarcane producing state and the second largest producer of sugar in India after Maharashtra. Sugar industry in Uttar Pradesh, covers around 4.5 millions of cane grower's family and nearly 0.16 million labors are directly employed in this sector. This sector is contributing about 18 % of the state domestic product from agricultural sector and pays approximately Rs. 400 crore to state and national exchequer. The first sugar mill in Uttar Pradesh was established at pratappur (Deoria) in 1903. Till 1957, all of the sugar mills in Uttar Pradesh were in the private sector. Thereafter mills began to set up in cooperative sector. The first cooperative sugar mill in Uttar Pradesh was set up in 1957-58 in Bajpur (Nainital). Uttar Pradesh cooperative sugar factories federation was established at Lucknow in 1963 as an apex body of cooperative sugar factories of Uttar Pradesh. The public sector also came into existence in 1971-72. 50 years have been passed and this is the time to evaluate performance of these mills in a sound manner.

1.1 Statement of the Problem

"There are only two qualities in the world: efficiency and inefficiency, and only two sorts of people: efficient and inefficient."

George Bernard Shaw (John Bull's Other Island, 1904, P.113)

If any decision making unit has been taking its decisions for a long time without appraisal or measurements, which might assume incorrectly that things are going well (They may or may not be, but, without appraisal or measurements or review, there is no way to tell). When used in the long-term planning, target setting or benchmarking process and linked to the objectives of the organization, relevant performance measurement technique can help identify actual attainments. In general, evaluation of the performance of an organization means evaluation of the level to which organizational goals have been attained. In economic literature there is ample literature available on organizational performance measurement; most of them have utilized traditional methods like financial strength, financial accountability, effectiveness, productivity, growth rate, profitability, quality and rate of innovation and several other tools of ratio analysis etc. The problem over here is to use an appropriate indicator which could explore the actual condition of firms. In this most competitive world where efficiency is a crucial factor in viability of organization, evaluation of operational efficiency must be a part of performance evaluation of an organization as every performance indicator could be linked up with operational efficiency. In other words, the performance of the firm in terms of several other indicators like productivity, profitability, growth, quality etc. depends upon the operational efficiency of the firm. Therefore In this research paper, it is decided to take relative efficiency as an indicator of relative performance of cooperative sugar mills in Uttar Pradesh.

In this research paper section 1 explains the central problem, rationale and significance of the study, section 2 reviews the literature relevant to the study, section 3 provides objectives of the study, Section 4 discusses the methodology applied in this paper, and Section 5 describes the data and variables used for efficiency analysis, section 6 presents empirical results obtained from various models of Data Envelopment Analysis and section 7 presents conclusion and suggestions.

II. REVIEW OF LITERATURE

Sugar industry is one of the most important agro based industry in India which has very close linkage with sustainable and inclusive rural development, as well as socio-political life in India. This is the importance and significance of this sector that a number of economist, researchers, and policy makers attracted towards it and there is ample literature available on various aspect of this industry. Some of the studies, relevant to this research paper are reviewed as follows:

Datta et al. (2000)[1] studied the economic efficiency of Indian sugar mills by analyzing the data for the year 1997-98 from a sample of 115 mills. The study concentrated on the determinants of the three managerial functions- procurement, processing and marketing and their implications for the Indian sugar industry. To arrive at a relevant and unbiased result the paper utilizes a set of regression analysis. Kumar Krishna (2002)[2] addressed the issues about comparative behavior of the public sector enterprises and the private sector enterprises. The study reveals that overall performance of the state corporation mills (CMs) is better than that of cooperative sugar mills (FMs) and the private mills (PMs). A size-to-size comparison of mills of 2500 tcd capacity highlights the superior performance of corporation and cooperative mills vis-à-vis the private mills even more clearly. Khanna Gauri (2006)[3] has employed the stochastic production frontier to estimate technical efficiency at the farm level. The results of the study indicated the presence of technical inefficiency, which captures 51% to 55% of the differential between, observed and best practice output. The presence of inefficiency implies that through a redistribution of the current input bundle, farmers can improve their sugar cane production. Singh N.P. et al. (2007)[4] attempted to assess the performance of sugar mills in India in terms of technical efficiency. The stochastic frontier production function was applied to assess the sector wise efficiency scores of the mills in Uttar Pradesh. The study revealed that there were a majority of mills working in the efficiency range of 60-80 per cent. Private sector has enjoyed the higher average efficiency scores (81%) than that of public sector (73%) followed by co-operative (66%) sectors. Singh S. P. (2006)[5] applied data envelopment analysis in his paper to estimate the relative efficiencies of sugar mills of Uttar Pradesh. The study revealed that there is inefficiency in the working of mills and suggests appropriate targets of improvement for relatively inefficient mills in terms of input. While Mishra and Tripathi (2013)[6] attempted to evaluate 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 and mills can save a significant amount of inputs without affecting the level of output. Besides, most of the mills were functioning under increasing returns to scale condition implying that the mills were too small relative to the optimum size. If problem of disadvantageous plant size could be resolved mills can get rid of scale inefficiency.

III. OBJECTIVES OF THE STUDY

There are two main objectives of the study:

- To evaluate relative performance of cooperative sugar mills in Uttar Pradesh, India, in terms of technical efficiency.
- To Benchmark Performance for technically inefficient sugar mills

IV. METHODOLOGY OF RESEARCH:

To achieve the objectives of the study, the approach of Data Envelopment Analysis (DEA) has been utilized which is a relatively new approach of performance evaluation and benchmarking. To present the information in a convenient manner, information has been presented with the help of tables and figures.

It is well known that resources are limited and have competitive use. If management wants his firm to be efficient, it must adhere to optimally utilize all the resources in the production process, so that output could be maximized from a given set of inputs, and the extent to which a firm is able to do this, is an indicator of productive efficiency of the firm. Farrell (1957)[7] was the first, who defined productive efficiency as a product of technical efficiency and factor price efficiency. DEA is a non parametric linear programming based optimization technique, developed by Charnes, Cooper and Rhodes (1978)[8] and based on the concept of efficiency frontier analysis suggested by Farrell (1957). It was further extended by Banker, Charnes, and

Cooper (1984)[9] . An advantage of DEA is that it specifies shape of production frontier from observed data so it does not impose any kind of restriction on the structure of production frontier.

Following Zhu J (2008)[10], the basic input oriented (where inputs are minimized and outputs are kept at current level) CCR model can be defined as:

$\theta^* = \text{Min } \theta$

S.T.

$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{io}$ $\quad i = 1 \ldots\ldots m$ (1)

$\sum_{j=1}^{n} \lambda_j y_{kj} \geq y_{ko}$ $\quad k = 1 \ldots\ldots s$ (2)

$\lambda_j \geq 0$ $\quad j = 1 \ldots\ldots n$ (3)

θ^* = efficiency of firm

n = the number of DMUs,

j = firm under consideration

y_{kj} = amount of k^{th} output of DMU j,

x_{ij} = amount of i^{th} input of DMU j,

x_{io} = i^{th} input of DMU_O

y_{ko} = k^{th} output of DMU_O

λ_j = non negative scalar

The Charnes, Cooper and Rhodes model (CCR model) is applicable when technologies are characterized by constant returns to scale (CRS) and all firms operate at an optimal scale (Coelli et al., 1998)[11]. But, imperfect competition may cause a firm not to operate at optimal scale (Coelli, 1996). So, inefficiency in any decision making unit (DMU) can be due to inefficient operation of production or due to inefficient size of DMU or scale of production. In such a condition Banker, Charnes and Cooper (1984) extension of Data Envelopment Analysis model is used for measuring efficiency, which assumes variable return to scale (VRS). This BCC model includes an additional convexity constraint on λ_J i.e., $\sum\lambda_J = 1$ to ensure that variable returns to scale assumption is satisfied.

$\theta^* = \text{Min } \theta$

S.T.

$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{io}$ $\quad i = 1 \ldots\ldots m$ (4)

$\sum_{j=1}^{n} \lambda_j y_{kj} \geq y_{ko}$ $\quad r = 1 \ldots\ldots s$ (5)

$\lambda_J \geq 0$ $\quad j = 1 \ldots\ldots n$ (6)

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

θ^*= 1, implies that the current input levels cannot be reduced (proportionally), indicating that DMU is on the frontier. However, possibility of individual input reduction may exist i.e., existence of slacks. In fact, both input and output slack values may exist (Zhu J. 2008) that can be shown as:

$s_i^- = \theta^* x_{io} - \sum_{j=1}^{n} \lambda_j x_{ij}$ (7)

$s_k^+ = \sum_{j=1}^{n} \lambda_j y_{kj} - y_{ko}$ (8)

Where:

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s_i^- = input slack

s_k^+ = output slack

To be termed as efficient (Pareto-Koopmans efficient), DMU must satisfy two conditions first, it must score θ* =1 and second, there should not be any slack i.e., s_i^-, $s_k^+ = 0$. Any DMU that has θ* =1 but contains slacks for any input or output i.e. $s_i^- \neq 0$ or $s_k^+ \neq 0$, is weakly efficient (Farrell efficient) only. A DMU can be called efficient if and only if it scores θ* =1 and no slack exists. If DMU does not satisfy any condition, it will be termed as inefficient. Further it should be noted that efficiency scores obtained from DEA are relative efficiency because DEA compares the performance of all other DMU's in relation to best achieved performance. So, a change in sample size or DMU's will make different efficiency score.

The technical efficiency score obtained from CCR model is termed as 'Overall Technical Efficiency (OTE)' score, which varies within a range of 0 and 1. Further OTE can be decomposed into Pure Technical Efficiency (PTE) and scale efficiency (SE) by running BCC model, which provides 'Pure Technical Efficiency (PTE)' and excludes any scale effect. Due to exclusion of adverse scale effects (inefficiency), PTE is always greater than or equal to OTE. Since 'Scale Efficiency (SE)' is obtained by dividing OTE by PTE, SE score always lies between 0 and 1. This decomposition provides very useful insight about the sources of inefficiency. Further DEA identifies nature of returns to scale, under which a firm is working (by employing non-increasing returns to scale (NIRS) model with VRS model). Basic DEA models cannot distinguish between technically efficient mills, but super efficiency model makes it possible. The envelopment solution to DEA provides two by-products, namely information on the benchmarks and targets (Coelli et al., 1998) which can be used to improve the performance of firms.

V. DATA AND VARIABLE DESCRIPTION

This paper is based on cross sectional data of cooperative sugar mills of Uttar Pradesh, for the year 2007-08, obtained from the website of U.P. Cooperative Sugar Factories Federation Limited (UPCSFFL). Out of 27 functional cooperative sugar mills in Uttar Pradesh, 23 sugar mills have been selected for the present study. Compatibility of available data with DEA requirements was the only criterion used for selection of mills in the study. In the present study following four inputs and one output have been utilized:

Inputs:

- Cane: Total sugarcane crushed by mill, during the year 2007-08. It is measured in lakh (=1/10 million) quintals.
- Pemp: No. of Permanent workers employed by mill, during the year 2007-08.
- Semp: No. of seasonal workers employed by mill, during the year 2007-08.
- Capa: Cane crushing capacity per day (in tones) of mill. In the study this is used as a proxy for fixed capital. It is measured in tones crushing per day- TCD.

Output:

- Sugar: Total sugar produced by mill, during the year 2007-08. It is measured in lakh quintals.

Descriptive statistics of these variables are shown in the Table 1 below:

Table 1: Description of Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
cane	23	28.58522	13.41659	9.97	53.05
pemp	23	218.3043	55.87521	77	291
semp	23	381.0435	90.23025	197	525
capa	23	2483.696	983.0267	1250	5000
sugar	23	2.615652	1.234952	0.82	4.79

(Source: Author's calculations)

It is clear that this study satisfies the rule of the thumb for DEA implementation that the sample size should be greater than or equal to three times the sum of input and output factors.

VI. EMPIRICAL RESULTS

6.1 Ote, Pte & Se Results

Table 2 shows efficiency scores and peer count of mills obtained from running various input oriented DEA models. It is evident from the table that out of 23 cooperative sugar mills only 4 mills are overall technically efficient, having OTE score 1. This indicates that only 4 (17 %) mills are working on the efficiency frontier and rest of the mills are relatively inefficient. OTE scores ranged from 0.814 to 1 and mean OTE score is 0.93, implying that on an average there is scope for reduction in inputs by 7%, without affecting sugar production. Rasc has minimum OTE score 0.814, this score reveals that if Rasc can make nearly 19 % redial input contraction for the current production level, it can reach CRS efficiency frontier and then it may termed as OTE efficient. On the other hand technically efficient mills like Bagc cannot make redial reduction in its inputs without harming its output; this is why these mills are called OTE efficient, means they are already working on efficiency frontier under CRS assumption.

It is evident from Table 2 that PTE score ranged from 0.913 to 1 with an average PTE score of 0.973 suggesting that if an average mill wants to be relatively efficient it must reduce all inputs by nearly 3 %. As it is stated earlier PTE score is always greater than or equal to OTE score, it is obvious to find that number of efficient mills under VRS assumption is greater than number of efficient mils under CRS assumption. There are 11 (48 %) mills working on the VRS efficiency frontier, as they have PTE score of 1. Rest of the mills are PTE inefficient having efficiency score less than 1. Among inefficient mills Cooperative sugar mill Nanc has minimum PTE score of 0.913, implying that if Nanc can make about 9 % redial input reduction for the current production level, it can reach VRS efficiency frontier.

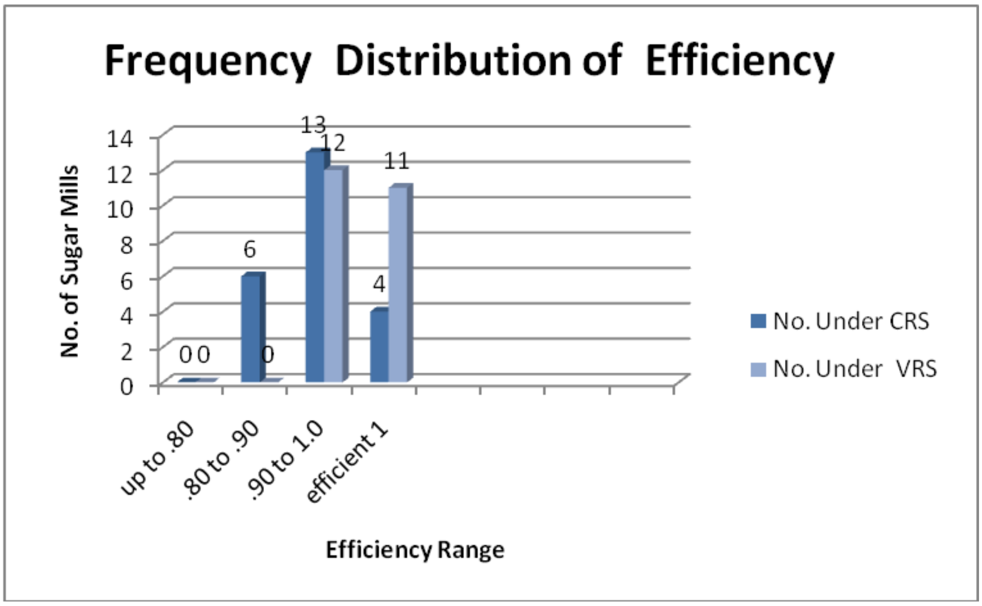
Table 2: Data Envelopment Analysis Results

No.	Mill	OTE	PTE	SE	Super Eff. (CRS)	Super.Eff rank	NIRS	RTS	Peer Count (VRS)
1	Anpc	0.913	0.927	0.985	0.913075	15	0.913	IRS	0
2	Bagc	1	1	1	1.476678	1	1	CRS	3
3	Morc	0.974	0.99	0.984	0.973814	6	0.974	IRS	0
4	Ramc	1	1	1	1.167201	2	1	CRS	1
5	Sarc	1	1	1	1.023948	4	1	CRS	1
6	Belc	0.992	1	0.992	0.991998	5	1	DRS	1
7	Bilc	0.95	0.993	0.957	0.95041	9	0.950	IRS	0
8	Bisc	0.901	0.942	0.956	0.900754	17	0.901	IRS	0
9	Gajc	0.924	0.94	0.984	0.924459	11	0.924	IRS	0
10	Powc	0.914	1	0.914	0.914051	14	0.914	IRS	7
11	Purc	0.879	0.927	0.948	0.879239	20	0.879	IRS	0
12	Samc	0.963	0.968	0.995	0.963382	8	0.968	DRS	0
13	Satc	0.92	1	0.92	0.919729	12	0.919	IRS	1
14	Semc	0.964	0.98	0.984	0.963512	7	0.964	IRS	0
15	Snec	1	1	1	1.074092	3	1	CRS	12*
16	Tilc	0.919	0.94	0.978	0.919142	13	0.919	IRS	0
17	Ghoc	0.875	0.938	0.933	0.875165	22	0.875	IRS	0
18	Mahc	0.89	0.92	0.967	0.890064	19	0.890	IRS	0
19	Nanc	0.895	0.913	0.98	0.895008	18	0.895	IRS	0
20	Sulc	0.93	1	0.93	0.929658	10	0.929	IRS	6
21	Kaic	0.904	1	0.904	0.903966	16	0.903	IRS	8
22	Badc	0.878	1	0.878	0.878471	21	0.878	IRS	0
23	Rasc	0.814	1	0.814	0.813642	23	0.814	IRS	1
	Mean	0.930	0.973	0.957	0.963		0.931		

(Source: Author's calculations)

Fig. 1 is the graphical illustration of no. of mills in various efficiency ranges under CRS or VRS assumption. It is evident from Fig 1 that there is no mill of VRS assumption in the efficiency range of 0.80 to .90 while 6 mills of CRS assumption are in the range. In the range of .90 to 1.0 no. of VRS mills is 12 while CRS mills is 13. While on the efficiency point i.e. 1, a contrast feature emerges that number of VRS efficient mills is more than CRS efficient mills. This feature shows the impact of scale inefficiency, attached with every OTE score that prevents most of the mills to achieve full efficiency score. Let's take an example of mill Rasc that has minimum OTE score of 0.814, has a PTE score of 1, clearly indicating that mills like Rasc are heavily impacted by disadvantageous plant size. This conclusion can be verified by Scale Efficiency scores, where it is evident that besides minimum OTE score, Rasc has minimum SE score of 0.814 also. Out of 23 mills Bagc, Ramc, Sarc, and Snec are 4 (17 %) scale efficient mills and they are OTE efficient also implying that these mills are working efficiently at optimal scale and there is no adverse impact of scale size on their performance. In other words these 4 mills are operating at Most Productive Scale Size (MPSS).

Figure 1: Frequency Distribution of Technical Efficiency



(Source: Author's calculations)

6.2 Super Efficiency, Returns to Scale and Slacks

Since out of 23 mills 4 mills have OTE score of 1, we cannot directly compare the relative performance of these mills. For the purpose of identification of extreme efficient mills and to distinguish between efficient mills, this paper utilizes the input oriented CRS super efficiency DEA model. The difference between the super-efficiency and the envelopment models is that this excludes the DMU under evaluation from the reference set in the super efficiency models. i.e., the super-efficiency DEA models are based on a reference technology constructed from all other DMUs (Zhu J 2008). It is clear from table 2 that among 4 OTE efficient mills (top 4 performers) Bagc holds first rank with the CRS super efficiency score of about 1.476, followed by Ramc (1.167), Snec(1.074) and Sarc(1.023). While Rasc is the least efficient mill having CRS super efficiency score of about 0.813, followed by Ghoc (0.875) Badc (0.878) Purc (0.879).

Banker and Thrall(1992)[12] revealed the procedure of estimation of returns to scale with Data Envelopment Analysis.It is evident from table 2 that 4 (17 %) mills are operating under constant returns to scale (CRS) i.e., optimal scale as their CRS score is equal to VRS score. Rest of the mills, are working either under increasing returns to scale (IRS) or decreasing returns to scale (DRS). For two mills Belc and Samc: VRS score is equal to NIRS score, implying that these 2 (9%) mills are working under DRS. These two mills are too big (5000 TCD) relative to their optimal size and must reduce their scale size to reach their optimum level. As expected, most of the mills (74 %) are facing IRS, as VRS score for these mills is greater than NIRS score, implying that these mills are too small relative to optimum level, so these mills must increase their plant size to reach their optimum level. This result suggests that uneconomic plant size is one of the major reasons behind unsatisfactory performance of cooperative sugar mills of Uttar Pradesh. Since 74% of the mills are operating under IRS condition, rest of the analysis is based on VRS assumption.

List of mills that have input slack and their respective slack values are shown in the table 3. A slack in input shows possible individual input reduction (after a radial input reduction that has already been done in order to reach the efficiency frontier) on the efficiency frontier.

Table 3: Slack in Inputs

		Slack In Inputs				Slack In Inputs					
N.	Mill	cane	Pemp	Semp	Capa	No.	Mill	cane	Pemp	Semp	Capa
1	Anpc	0	13.52	35.51	0	14	Semc	0	34.14	0	408.95
3	Morc	0	28.94	3.027	0	16	Tilc	0	0	0	190.95
7	Bilc	0	0	0	222.82	17	Ghoc	0	14.26	0	749.82
8	Bisc	0	0	0	578.70	18	Mahc	0	82.12	12.14	159.84
9	Gajc	0	15.33	45.27	0	19	Nanc	0	20.77	0	179.36
11	Purc	0	0	0	379.29	22	Badc	0.22	67.05	108.44	0
12	Samc	0	1.63	0	1022.77						

(Source: Author's calculations)

As it is evident from table 3, there is only one PTE efficient mill Badc which has input slacks. This is an important finding and requires an explanation. When we analyze our base data, we find that Badc is one of the 5 mills having minimum installed capacity of 1250 TCD in the sample. We find that although Badc is operating on VRS efficiency frontier, it is employing relatively too much input that is not consistent with its installed capacity. In this group Badc is the biggest employer of workers (permanent and seasonal workers both) and 4th biggest consumer of cane. However, its amount of sugar production exceeds only the amount of sugar produced by Rasc. These characteristics of Badc create various input slacks. Badc has highest seasonal worker slack, second highest permanent worker slack (after Mahc) and slack in cane crushed also, which is the only case of slack in cane crushed. By this investigation, we can say that Badc is severely affected by mismanagement of human resource and disadvantageous scale size indicated by its SE score of 0.878, which is second least SE score after Rasc. This is the reason why PTE efficient Badc cannot be used as benchmark for any PTE inefficient mill and termed as weakly efficient. Five firms have seasonal employee slack and nine firms have permanent employee slack and nine firms have installed capacity slacks. This implies that probably the mismanagement of permanent labours and disadvantageous plant size is the major sources of inefficiency in most of the cooperative sugar mills. This hypothesis is tested in the section 6 by employing Tobit regression.

6.3 Benchmarking and Input Target Setting

The benchmarks and input targeting has been illustrated in the Table 4 and 5 respectively. Benchmarking is a process of defining valid measures of performance comparison among peer DMUs, using them to determine the relative positions of the peer DMUs and, ultimately, establishing a standard of excellence (Zhu J., 2008)[10]. On the basis of relative efficiency scores and existence or non existence of slacks, benchmarking and input target setting is done in the analysis.

Table 4: Benchmarking and Input Target Setting

inefficint mill↓	Pareto-Efficient Mills ,Benchmarks & Peer Weights↓									
	Bagc	Ramc	Sarc	Belc	Powc	Satc	Snec	Sulc	Kaic	Rasc

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Anpc					0.15		0.535	0.315		
Morc		0.367					0.385		0.248	
Bilc					0.113		0.236	0.345	0.305	
Bisc			0.071		0.191		0.279		0.459	
Gajc					0.227		0.514	0.258		
Purc					0.429		0.18	0.039	0.353	
Samc	0.466			0.525			0.009			
Semc	0.44						0.277		0.283	
Tilc					0.119		0.46	0.251	0.17	
Ghoc	0.13						0.104		0.766	
Mahc					0.719		0.281			
Nanc							0.488	0.394	0.118	
Badc						0.707				0.293

(Source: Author's calculations)

In the table 2 peer counts for each mill are shown in the last column. The peer count value shows that how many times a DMU is used as benchmark for inefficient mills. It is evident that among 11 PTE efficient mills Snec has maximum peer counts implying that Snec is considered as benchmark for 12 mills followed by Kaic (8), Powc (7), Sulc (6) and Bagc (3). Since Snec has maximum peer counts, this mill can be termed as 'Global Leader'. While rest 6 PTE efficient mills rarely appear as benchmark for inefficient mills, among these mills 5 PTE efficient mills are used only ones as a benchmark. Only one PTE efficient mill Badc is not used as a benchmark for any of the inefficient mills because it is a 'weakly efficient' mill.

Table 4 shows benchmarks for non-pareto efficient mills and their respective weights. If an inefficient mill tries to emulate their benchmarks, it could convert itself into an efficient mill. For example Powc, Snec and Sulc together construct the benchmark set of Anpc and 0.15, 0.535, 0.315 are their respective Peer weights. This set defines the best achievable performance for Anpc and it should try to emulate their benchmarks in order to reach the efficiency frontier. In other words if Anpc wants to be efficient it must use inputs less than or equal to the weighted sum of inputs of their benchmarks (Powc, Snec and Sulc) to produce more than or equal to the weighted sum of their outputs.

Table 5: Targets and Required Input Reduction

		Targeted Input Level				**Required Input Reduction %**			
No.	mill	cane	pemp	semp	capa	cane	pemp	semp	capa

1	Anpc	29.132	238.673	446.619	2317.915	7%	12%	14%	7%
3	Morc	39.772	226.375	397.765	2474.024	1%	12%	2%	1%
7	Bilc	20.977	216.423	351.44	1762.712	1%	1%	1%	12%
8	Bisc	23.903	194.085	336.351	2012.237	6%	6%	6%	27%
9	Gajc	28.255	230.858	448.032	2349.074	6%	12%	15%	6%
11	Purc	18.26	182.693	353.331	1939.16	7%	7%	7%	22%
12	Samc	46.786	190.042	317.52	3817.466	3%	4%	3%	24%
14	Semc	33.915	159.826	300.748	2285.042	2%	19%	2%	17%
16	Tilc	27.316	230.3	406.08	2159.051	6%	6%	6%	14%
17	Ghoc	21.589	177.998	234.46	1594.778	6%	13%	6%	36%
18	Mahc	19.636	177.368	442.421	2370.614	8%	37%	10%	14%
19	Nanc	28.46	244.933	411.795	2103.324	9%	16%	9%	16%
22	Badc	12.276	206.951	338.561	1250	2%	24%	24%	0%
	Average	26.944	205.887	368.086	2187.338	5%	13%	8%	15%

(Source: Author's calculations)

Table 5 shows targeted input levels and potential savings of inputs in the form of required input reduction for non-pareto efficient mills .For every mill, targeting of input is done by considering their PTE score (θ^*), existing level of input j (x_j) and slack value (s_j^-) of the input. Targeted value (x_t) of input x_j can be defined as follows:

$$x_t = \theta^* x_j - s_j^- \qquad (9)$$

It could be observed from Table 5 that on an average 5% of cane, 13% of permanent employee, 8% of seasonal employee and 15% of capacity could be saved with maintaining the current output level of sugar. This indicates the extent to which variables are underutilized or over employed. These scores indicate the sources of inefficiency and their relative influence on the performance of individual mills. For example, the biggest source of inefficiency in Mahc is permanent workers as required input reduction for permanent workers is 37% and it is maximum required reduction in relation to other mills. Other sources of inefficiency in Mahc are installed capacity (14%), seasonal workers (10%) and cane (8%). If Mahc wants to be efficient it must reduce all the relevant inputs to the extent prescribed by the analysis.

VII. CONCLUSIONS AND SUGGESTIONS

For the purpose of evaluation of relative efficiency and identification of various factors that affects efficiency of cooperative sugar mills, this paper has applied a relatively new approach of performance measurement; Data Envelopment Analysis (DEA). The study has revealed several analytical issues. First, most of the mills are working sub optimally and on an average, mills can make radial reduction in all the inputs by 7% without harming their output levels. Second, nearly 74 % of mills are facing increasing returns to scale implying that most of the mills are too small relative to the optimum size. This Result reflects that mills can use their resources efficiently but they are suffering from disadvantageous plant size. If problem of disadvantageous plant size could be resolved mills can get rid of 4% scale inefficiency. Third, super efficiency results has identified Bagc (1.476), followed by Ramc(1.167), Snec(1.074) and Sarc(1.023) as extreme efficient mills. While Rasc

(0.813) followed by Ghoc (0.875) Badc (0.878) Purc (0.879) has been identified as least efficient mills. Fourth, in the group of 4 best practice mills (Powc, Snec, Sulc and Kaic), Snec has emerged as 'Global Leader'. Fifth, target setting model reveals that non- pareto efficient mills can become efficient if they could reduce capital (proxy by installed capacity) by 15%, permanent workers by 13%, seasonal workers by 8% and cane by 5% while maintaining the level of output. Improvement in the technical efficiency of cooperative sugar mills are necessary precondition to sustain in the today's competitive era. Management of the cooperative sugar mills must be guided through the policy of continuous assessment and improvement in the operations.

This paper would like to conclude with a quote of Charles Darwin (English naturalist and author of the theory of evolution by natural selection, 1809-1882):

"It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change."

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