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Research Note

Sugar Industry in Uttar Pradesh: Efficiency Still Holds the Key

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Abstract

The sugar industry is a major agro-based industry of Uttar Pradesh where cropping pattern is largely subsistence-oriented and sugarcane is one of the important cash crops. During 2001-02, the state had 20.35 lakh ha area under sugarcane out of the total 44.03 lakh ha area under sugarcane in the country. The sugar industry has shown considerable instability in the level of production as a result of inter-dependence and inter-relationship between sugarcane, gur, khandsari and white sugar, leading to fluctuations in the production of sugarcane as well as sugar. These fluctuations emanate from the presence of various processing sectors and the differential governmental policies. Such an uncertain state of affairs is neither conducive to sound growth of the industry nor the growers. In view of this scenario, it was felt necessary to carry out an investigation, which can reveal the present status of sugar industry in terms of its efficiency in operations. The study has revealed that most of the mills were in the efficiency range of 60-80 per cent. Efficiency was higher in the private sector (81%), followed by the public (73%) and co-operative (66%) sectors. Though this study has advocated the continuation of partial decontrol policy, it has urged the policymakers to streamline strategies that promote stabilization of sugarcane economy and make the state a credible supplier of sugar in the international market, benefiting growers, processors and, in turn, consumers.

Introduction

The state of Uttar Pradesh (UP) is one of the major sugar-producing states in the country. Sugar industry of the state has a symbiotic relationship

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with the rural masses and serves as a nerve centre for the rural development. The state had 20.35 lakh ha area under sugarcane out of the total 44.03 lakh ha area under sugarcane cultivation in the country in 2002-03 (CMIE, 2004). During this period, the production of cane was 11.62 million tones, accounting for 38.61 per cent of the total cane production in the country. During the period 1961-2002, the state experienced a growth of 2.84 per cent, 1.38 per cent and 1.43 per cent annually in sugarcane production, productivity and acreage, respectively. There is a network of 113 sugar factories in the state out of the total of 453 sugar factories in the country (Annonymous, 2003). In spite of being good forward and backward linkages in the state, there was considerable instability in the sugar industry compared with other industries as a result of interdependence and interrelationship between gur, khandsari and white sugar. Nearly 60 per cent of the cane produced in the state is sold to gur and khandsari production units. Cane growers take advantage of the present system of operation and depending upon the acreage of crop, and price of gur relative to sugar prices, they regulate the supply of cane to the factories, thereby posing a serious threat to the sugar industry, affecting its performance adversely.

Although the state holds the leading position in sugar production (28.6 per cent of total), its average recovery (9.05 per cent) is below the country's average recovery (9.75 per cent). In view of the slow growth and increasing instability in production, the sugar economy of the state could be benefitted to a great deal from its inefficiency studies.

Moreover, estimates on the extent and sources of inefficiencies could help improve the efficiency or develop new technology to raise the sugar productivity in Uttar Pradesh. This necessitates efficiency analysis of the sugar factories across different regions of the state, which in turn, will help in formulating the policy measures to mitigate various constraints in the Indian sugar industry, particularly in Uttar Pradesh.

Methodology

Sampling Design

There were about 113 sugar factories in the state in March 2003 of which 45 were in the private sector, 37 in the public sector and 31 in the cooperative sector. During 2000-01, 47 sugar factories in eastern UP, 41 in central UP and 25 in western UP were in operation in the state.

For selection of sugar factories, these were grouped into 3 regions, viz. western, central and eastern. This grouping was made in consonance with sugar zoning concept adopted by the Government of India and Indian Sugar

Manufacturers Association (ISMA) and not according to the administrative zoning (see end notes). Further, twenty-one factories, seven each in private, public and cooperative sectors were selected from each region randomly. Thus in all, 63 factories were selected and manufacturing details and other data on costing parameters were collected from ISMA, New Delhi, UP Cooperative Sugar Federation, Lucknow, UP Sugar Corporation, Lucknow, and CMIE prowess database for the year 2000-01.

A cursory look at Table 1 indicates that there were 67 sugar factories till the end of Second Five-Year Plan period, of which nearly half were in the eastern region. The private sector accounted for the maximum number of factories (36). The co-operative sector had only two factories, one each in western and central regions. Though a major thrust was given to setting up of co-operative factories after the Fourth Plan, the concentration was mainly in the central and eastern regions.

Details about crushing capacity and crushing duration across various sectors and zones in the state are given in Table 2. The private sector with 41 sugar factories had the crushing capacity of 159400 TCD, commanding nearly 55 per cent share in the total cane crushed, while the public and co-operative sectors had 20 and 25 per cent shares, respectively. This clearly reflects the lower capacity of plants in these two sectors. Most of the plants had the capacity of 2500 TCD or even less in these sectors, which eventually affected the performance of factories.

The crushing duration of factories across different zones of UP varied between 129 days and 162 days in 2000-01, with maximum in western zone, followed by central and eastern zones. The private sector generally crushed the cane for a longer period, than by co-operative and public sectors, contrary to the popular belief that the private sector is whimsical about their opening and closing dates of the cane crushing, coupled with lesser duration of operation.

Table 1. Sector-wise and zone-wise establishment of sugar factories in U.P.

Year	Western			Central			Eastern		
	Private	Public	Coop.	Private	Public	Coop.	Private	Public	Coop.
Before 1960	9	7	1	10	5	1	17	17	Nil
1961-70	0	0	1	0	0	1	0	0	0
1971-80	1	0	3	1	3	7	0	3	3
1981-90	0	0	1	0	1	9	1	0	4
1991-02	1	1	0	3	0	0	2	0	0
Total	11	8	6	14	9	18	20	20	7

Table 2. Number of factories, their crushing capacity and crushing duration across various sectors and zones of UP: 2001-02

Zone/ Sector	Crushing capacity (TCD)	Crushing duration (Days)	No. of mills
	Eastern		
Public	23 %	129	43 %
Private	58 %	137	43 %
Co-operative	19 %	132	15 %
Total	86808		47
	Central		
Public	19 %	135	18 %
Private	47 %	142	47 %
Co-operative	34 %	139	35 %
Total	107636		41
	Western		
Public	18 %	154	32 %
Private	67 %	162	44 %
Co-operative	16 %	161	24 %
Total	86829		25

Analytical Methods

The stochastic frontier production function was fitted for the sugar industry in UP to assess the efficiency of various factories under different sectors across the state.

The stochastic frontier production function was defined as per Equation (1):

$$y_i = (x_{i;}\beta) \exp (v_i - u_i) \qquad \text{where, } i = 1,\ldots,N \qquad \ldots(1)$$

where, v_i is the random error having zero mean and is associated with random factors that are not under the control of the firm. The model is such that the possible production, y_i, is bounded above by the stochastic quantity $(x_{i;}\beta)$ exp (v_i), hence the term stochastic frontier (Jondrow *et al.*, 1982; Russel and Young, 1983). The random errors, v_i =1,…,N were assumed to be independently and identically distributed as $N(0, \sigma_v^2)$ random variables, independent of u_i's, which were assumed to be non-negative truncations of $N(0, \sigma_u^2)$ distribution (i.e. half normal distribution or having exponential distribution).

Through maximum likelihood estimator (MLE) approach, the source of difference between the farmer's yield and the estimated value from the frontier production function was examined by calculating the variance ratio parameter (γ).

Now, let σ^2u and σ^2v be the variances of parameters one-sided (u) and symmetric (v). Therefore,

$$\sigma^2 = \sigma^2_u + \sigma^2_v \quad \ldots(2)$$

and the ratio of the two standard errors is

$$\lambda = \sigma_u / \sigma_v \quad \ldots(3)$$

Then the variance ratio parameter (γ), which relates the variability of σ^2u to the total variability σ^2, is given by Equation (4):

$$\gamma = \sigma^2_u / \sigma^2 \quad \ldots(4)$$

Here, γ is defined as the total variation of output from the frontier and can be attributed to technical efficiency. Hence, on the assumption that u_i and v_i are independent, the variance ratio from frontier (γ) has two important characteristics, viz.:

(i) When σ_v tends to zero, u is the predominant error in Equation (1) and γ tends to one. It indicates the differences in technical efficiencies, and

(ii) When σ_u tends to zero, the symmetric error is the predominant error in Equation (1), so it tends to zero.

Thus, based on the value of γ, it was possible to identify whether the difference between a firm's output and efficient output was principally due to statistical errors or firm's less efficient use of technology. The u_i and v_i parameters of the production frontier equation were estimated using maximum likelihood method. Further, given a multiplicative production frontier for which, the Cobb-Douglas production frontier was specified, the technical efficiency of individual farm was estimated by using expectations of u_i, conditional on the random variable E_i

$$TE_i = \text{Exp}\ (-u_i); \qquad 0 < TE_i < 1 \quad \ldots(5)$$

Economic Efficiency (EE)

The economic efficiency is the product of technical efficiency (TE) and allocative efficiency (AE). In classical economic theory, it is equal to AE itself, as TE is pre-supposed to be one. In the ensuing analysis, various cost components in the sugar industry were converted with prices of each input, to directly estimate EE.

Empirical Model

The empirical model used in the present study was

$$\ln y_j = \ln B_o + \Sigma_1^5 B_i \ln x_{ij} + v_i - u_i$$

(i = Number of observations, 1,…..,63)

(j = Number of variables, 1,….,5)

where,

y_j = Value of sugar production

x_{1j} = Value of raw material

x_{2j} = Wages and salaries

x_{3j} = Manufacturing costs

x_{4j} = Depreciation,and

x_{5j} = Interest payments

This was the broad methodological framework employed to analyze the data for fulfilling the objective of the study.

Results and Discussion

General Characteristics of Processing Units

The cane processing industry in the state comprises all the three sectors, viz., sugar, gur and khandsari. Each of these sectors competes for the cane and the optimal distribution amongst them or availability of cane for sugar processors is a complex political issue. Two elements that have a direct bearing on the efficiency of processing plants are: 'load factor' and 'scale factor'. The former is related to the utilization of available capacities and the latter is an attribute of economies of scale, which is associated with the scale of operation. In this context, it is important to discuss the general characteristics of the processing units in the study area.

Average Crushing Capacity

It is apparent from Table 3, that the average crushing capacity of the sugar mills in the private sector of western zone of the state was maximum [5255 TCD (tonnes crushing per day)], followed by the central and eastern zones. This indicates the presence of more large-sized sugar mills in this zone. However, the cooperative sector mills in the eastern zone recorded the highest average crushing capacity, followed by western and eastern zones.

The average crushing capacity of the public sector mills in the eastern zone was the lowest (1005 TCD), followed by western and central zones. This implies that a large proportion of sugar mills in the cooperative and private sectors fall in the capacity-size group of 1250 TCD. Sen Enquiry Commission (1965), and Tariff Commission (1969 and 1973), have suggested

that the sugar units should have a minimum crushing capacity of 1250 TCD to derive the benefits of economies of scale. But, Government of India in 1988 had stipulated the norm of 2500 TCD as the minimum economic size. Judging by this standard, the sugar units in the private sector are at an advantageous position to derive the benefits of economies of scale.

Average Capacity Utilization

The utilization of available capacity has a direct bearing on the economies of scale, which in turn, is determined by the availability of cane. The average capacity utilization presented in Table 3 signals some curious trends. It is noteworthy that three sectors of processing units in the eastern zone had experienced very low capacity utilization, ranging between 80 per cent and 93 per cent. The reason could be well attributed to the possible shrinkage in the cane acreage, limiting the responsiveness of cane supply to price. However, the average capacity utilization in the western and central regions was satisfactory. In the case of sugar units, capacity utilization in the western and central regions was around 96 per cent and 84 per cent in the private sector, 90 and 84 per cent in the public sector and 88 per cent and 82 per cent in the cooperative sector, respectively.

Operating Days during Season

Sugar mills showed a higher average of capacity utilization than other sweeteners processing units, but the total number of crushing or operating

Table 3. General characteristics of sugar processing units in UP

Sectors	Average crushing capacity (TCD)	Average crushing capacity utilization (%)	No. of operating days during season	Average recovery percentage
		Western zone		
Private	5255	96	162	9.58
Public	1908	90	154	9.40
Cooperative	2291	88	161	9.32
		Central zone		
Private	3651	94	142	9.49
Public	2252	84	135	9.35
Cooperative	2013	82	139	9.25
		Eastern zone		
Private	2523	93	137	9.15
Public	1005	85	129	9.22
Cooperative	2322	80	132	9.60

days during a season was the lowest in sugar mills than khandsari and gur processing units. The number of operating days in the sugar units ranged from129 to 132 days in the eastern region, 135 to 142 days in the central region and 154 to 162 days in the western region. However, the number of operating days for khandsari and gur processing was 150-200, as they enjoyed the relative price advantage owing to mismatch between demand and supply of cane in the region.

A competition was noticed between sugar mills and khandsari/gur processing units when there was shortage or high prices of gur. During the surplus period, both gur and khandsari units could not absorb the excess quantity of cane and hence the farmers supplied the cane to the sugar mills. But, the sugar mills could reduce the price of sugarcane unlike their counterparts to take advantage of the surplus production. The implication is that the government should implement certain regulatory measures wherein it can restrict variations in the prices offered by the khandsari units in an operating season so that they do not pose a stiff competition to sugar units during the time of scarcity. By such a policy induced mechanism, the farmers will also be benefitted, because at the time of glut, they need not sell the cane to khandsari units at throw away prices.

Recovery Percentage

This is an important indicator of technical efficiency with regard to the conversion of sugarcane to sugar. The recovery percentage in case of sugar processing units of the state ranged from 9.15 per cent to 9.60 per cent and did not have any distinct trend with regard to the region or sector of sugar processing in UP.

Production Function

Estimates of Cobb-Douglas production function for the sugar industry are presented in Table 4. The coefficient of determination (R^2) was 0.73, indicating that 73 per cent of the variations in the sugar output were explained by the explanatory variables included in the model for all the sugar factories included in the sample. All the variables had the expected signs. Among the explanatory variables, raw materials and manufacturing costs had a positive and significant influence on the production of sugar. The coefficient of raw materials and stores (x_1) was 0.71 and it implied that one per cent increase in the raw material will result in 0.71 per cent increase in the total sugar production, keeping other factors constant at their mean level. Similarly, the coefficient for depreciation cost (x_4) of the plant showed that for every one per cent increase in the depreciation cost, production will increase by 0.22

per cent. The variable wages and salaries (x_2) were negative and came out to be non-significant. This might be due to the over employment of labour in the industry.

The regression coefficients in the Cobb-Douglas production function are the production elasticities and their sum indicates the returns to scale. The estimates for returns to scale were much higher and significantly different from unity, indicating increasing returns to scale. Returns to scale for sugar industry were estimated to be 1.69, showing an overall efficiency of resource-use in the sugar units of the state. This showed that an increase in use of selected variables would result in more than adequate increase in the total sugar production of the state.

Frontier Production Function

The maximum likelihood estimates of the frontier production function are shown in Table 4. The R^2 and maximum likelihood estimate of the frontier production function have shown a good fit for the selected model. The OLS function could narrate the response of the average units/firms while the frontier function reflects the responses of the best and efficiently managed firm/unit. 'λ' which is the ratio of variance of the factory-specific production behaviour $\sigma^2(u)$ to the variance of the statistical noise $\sigma^2(v)$. This was 1.27 and was significant at one per cent level, indicating that one-sided error component had dominated relative to symmetric error component.

The variance ratio 'λ' showed that firm-specific variability contributed more to the variation in production among firms/units, which means that the total variation in output from the frontier was attributable to the technical efficiency. The estimate of 'γ', which is the ratio of the variance of firm-specific performance of economic efficiency to total variance of output, was 0.62. This indicates that 62 per cent of the variations in output among the firm/units were due to the difference in efficiencies.

The constant term in stochastic frontier function was higher by 15 per cent than that of the OLS method. Thus, compared to the OLS model, the frontier production could shift vertically upwards. In the case of coefficients of the inputs used, the OLS and frontier were different, indicating that the frontier function was different from OLS in terms of slopes also. The raw materials, manufacturing costs and depreciation costs were significant at one per cent level, indicating that one per cent increase in raw materials would result in change in sugar output by 0.68 per cent, keeping all other variables constant. The wages and salaries of the labourers and the interest on loan had a negative sign and were non-significant also. This might be due to the over employment of the labour force and the huge amount of loan taken by some of the units, especially in the cooperative and private sectors.

Table 4. Results of OLS and frontier production function of sugar industry in UP

Variables	OLS		Frontier production function	
	Coeff.	't' Value	Coeff.	't' Value
Constant	0.48	4.67	0.55	4.46
Raw materials & stores	0.71*	8.52	0.68*	6.66
Wages & salaries	-0.24	-0.47	-0.24	-0.38
Manufacturing costs	0.86*	2.08	0.91*	2.25
Depreciation	0.22*	4.97	0.24*	5.61
Interest on loan	-0.14	-0.22	-0.11	-1.17
	R^2= 0.73		R^2=0.71	
	Returns to scale= 1.69		Returns to scale= 1.48	
			log likelihood = 81.419	
			σ^2 (u)= 0.0246	
			σ^2 (v)= 0.0401	
			γ = 0.619	
			λ = 1.2767	

* Significant at 1 per cent level of significance

Efficiency of Sugar Industry

The efficiency of sugar processing industry across various regions and sectors in UP was estimated by pooling the factory/firm-specific efficiencies. It is seen from Table 5 that the private sector factories in the western region belonged to the most efficient category (84.29 per cent), while the cooperative sector mills in the eastern region were the least efficient, with efficiency level of around 60 per cent.

The average efficiency of cooperative sector was low due to the presence of few factories, operating at less than 50 per cent of the efficiency level. However, the public sector sugar factories had almost a similar efficiency range in all the three regions, highest (75.28 per cent) being in the western region. Thus, public sector was found about 10 per cent more

Table 5. Efficiency of sugar processing industry across regions and sectors in UP

Zone/Sector	Private	Public	Co-operative	Total
Central	79.37	73.87	66.31	73.18
	(70.42-88.25)	(63.79-80.72)	(58.72-79.39)	
Western	84.29	75.28	70.63	76.73
	(78.89-92.06)	(64.50-82.94)	(62.65-80.63)	
Eastern	80.30	70.83	60.82	70.65
	(75.75-86.97)	(61.87-77.57)	(45.24-72.99)	
Total	81.32	73.33	65.92	73.52

Note: Figures within the parentheses indicate efficiency ranges

Table 6. Frequency distribution of economic efficiency among sugar factories in UP

Economic efficiency %	Region								
	Western			Central			Eastern		
	Private	Public	Co-op	Private	Public	Co-op	Private	Public	Co-op
45-50									1 (14.28)
51-55									1 (14.28)
56-60						2 (28.57)			
61-65		1 (14.28)	1 (14.28)		1 (14.28)	2 (28.57)		2 (28.57)	2 (28.57)
66-70			2 (28.57)	1 (14.28)	1 (14.28)	1 (14.28)		2 (28.57)	2 (28.57)
71-75		2 (28.57)	2 (28.57)	1 (14.28)	2 (28.57)	1 (14.28)	1 (14.28)	1 (14.28)	1 (14.28)
76-80	1 (14.28)	3 (42.86)	1 (14.28)	1 (14.28)	3 (42.86)	1 (14.28)	4 (57.14)	2 (28.57)	
81-85	4 (57.14)	1 (14.28)	1 (14.28)	3 (42.86)			1 (14.28)		
86-90	1 (14.28)			1 (14.28)			1 (14.28)		
>90	1 (14.28)								
Total	7 (100)	7 (100)	7 (100)	7 (100)	7 (100)	7 (100)	7 (100)	7 (100)	7 (100)

*Figures within the parentheses indicate percentages to total.

efficient than the cooperative sector. The overall efficiency of the sugar industry was 73.5 per cent, and was highest in the western region, followed by the central (73.18 per cent) and eastern (70.65 per cent) regions.

Factory / Firm-specific Efficiency

The factory/ firm-specific efficiencies were estimated and are shown as frequency distribution in Table 6. It was found that these efficiencies ranged from 45.24 per cent to 92.06 per cent. It was also observed that 14 factories belonged to the most efficient (81-95%) category and 13 factories to the least efficient (45-65%) group, in 63 factories selected for observation.

In general, it was observed that almost half of the mills in the state were operating at efficiency level of above 75 per cent. Of these, 18 belonged to the private and 3 to the cooperative sector.

It has been discerned that only through comparative organizational analysis it becomes possible to determine whether the cooperative and public sectors can really compete in the liberalized scenario and how far they are useful in providing economic advantage. Given the present constraints in sugarcane production system and its interface with the sugar industry, it becomes more imperative to analyze the sugarcane economy and its related policy mix.

It can be inferred from the Table 6 that variation in efficiencies was largely due to the systems of operation and managemental skills. As mentioned earlier, the private sector mills are mostly new, with a larger plant size and professional management, which reduce the manufacturing costs and other operating expenses. On other hand, public and cooperative sectors have half the average crushing capacity of the private sector. This needs to be considered while formulating strategies for the efficient management of the sugar industry.

Conclusions and Policy Implications

It is apparent from the study that the average crushing capacity of sugar mills in the private sector is maximum in western region, followed by central and eastern regions of the state. This indicates the presence of more and larger-sized sugar mills in the western region, which have a bearing on the responsiveness of cane supply, eventually affecting the capacity utilisation and number of operating days. On the whole, the installed capacities of sugar mills continue to be substantially below the cane processing requirements in almost all the regions of the state. The capacities of installed sugar mills in the state could handle just about 50 per cent of the cane production, paving way for diversion of cane to gur and khandsari units.

Although profitability and efficiency go side by side, efficiency norms clearly reflect the operational and technological parameters of the processing units. Private sector factories in the western region have been found most efficient owing to their higher capacity, and thereby get benefits from scale economies. On the other hand, the cooperative sector mills in the eastern region are least efficient. The overall efficiency of the sugar industry has been found 73.5 per cent, highest being in the western region, followed by central and eastern regions, due to assured cane supply in the crushing season.

The firm/factory-specific efficiencies range from 45 per cent to 92 per cent. Further, 14 factories out of 63 factories included in the sample, belong to the most efficient category and 13 factories to the least efficient group, i.e., below 50 per cent level. However, almost half of the sugar units in the

state have been found operating above 75 per cent level of efficiency, mostly being in the private sector. This variation in the level of efficiencies has largely been due to the nature and scale of operation. The study has shown that even with the existing technology, potential exists for improving the efficiency of sugar processing units in public and cooperative sectors, by stabilizing the sugar cane production, modernization, capacity enhancement and more professional management of these two sectors. The government can develop a number of short- and medium-term strategies that could be easily merged into a long-term policy framework guided by emerging economic parameters. The strategies to serve the overall policy goals should incorporate the following:

(1) Strategies promoting stabilization of sugarcane area at the current levels.

(2) Restraining the state government from effecting increase in cane price through the system of state advised prices (SAPs).

(3) A package of measures for revival and modernisation of the sugar factories, especially in public and cooperative sectors.

(4) Gradual phasing out of khandsari units.

(5) Subjecting khandsari sector to duties/tax regimes at comparable rates to sugar mills, and

(6) Allowing sugar prices under the dual pricing system, keeping pace with the general price index.

This integrated approach of increasing sugarcane production, expansion of sugar industry and ensuring its cost effectiveness would benefit both the sugarcane growers and the sugar industry. The consumers would gain in terms of steady availability of sugar at reasonable prices. This can easily put the country in a position of a sustained sugar surplus economy and makes it a credible supplier of sugar in the international market.

End notes

Before selection of sugar factories, three important parameters conforming to the homogeneity of sugar mills in different sectors, viz. private, public and cooperative, were considered. These were:

*Nature of Plant***:** There are four different types of plants currently in operation in the Indian Sugar Industry. But, the most commonly used and widely acclaimed one is di-sulphitation process plant. Hence, the factories having di-sulphitation plant were considered for selection.

Installed Capacity: The Government of India in 1993 has stipulated 1250 tonnes crushing capacity per day as the minimum size for licensing new sugar mills. Hence, the factories having 1250 TCD installed capacity or more were chosen for the detailed analysis.

Operational Condition: The factory having successfully operated in preceding five years were selected.

After taking into account the above-mentioned considerations, the factories were grouped into three categories and on the basis of Stratified Random Sampling; seven factories from each category were selected for the detailed study.

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