Technical Efficiency in Sugarcane crop -A Stochastics Frontier Analysis

Abstract

In this paper we have tried to estimate socio-economicstructure, Efficiency and Inefficiency on sugarcane farm/farmers. The socio-economic profile of the farms indicated that marginal farmerswere more younger and medium farmers were more educated and wealthier than the others. The study pointed out the efficiency and inefficiency of farm resources human labour, seed and irrigation found statically significant in all groups of farms. Inefficiency was impacted negatively and significantly by farm equipment and positively and significantly by family size; Farmers can improve profit efficiency by increasing farm equipment and a smaller number of family members was inversely affect the efficiency. Distribution of sugarcane farm maximum under 70-80 percent of 49 farms (40.0 per cent) and only 4 farms (3.30 per cent) have the maximum efficiency score above 90 per cent.

Key words: Efficiency and Inefficiency and socio-Economics of Farms

JEL codes: C13, C21, D22, Q12 Q18

Introduction

Sugarcane is the most important crop to fulfil the daily requirement of sugar, around 60 per cent share of world sugar production by the sugarcane and rest of the 40 per cent comes from sugar beet.India is the second largest sugarcane producer after the Brazil in the world producing 20.73% o in 2019 (Agricultural statistics at a glance 2021) area under sugarcane crop 4.75 million hectares and production 362.07 million tonnes with the per hectare productivity of 761.81 quantal per ha. Sugarcane is a yearly crop andprovide the employment around 45 million skilled and unskilled labour throughout the year (Raut et al 2017) Uttar Pradesh is the largest producer of sugarcanewith area under 2.21 million hectares, and production of 117.954 million tonnes, with 47.97 percent of area and 58.46 % of production with the productivity of 813.13 quintal per hectare, Uttar Pradesh is an agrarian economy where 47% of the population is directly dependent on agriculture for their livelihood. Even though the share of agriculture in overall GSDP has dropped to only 12% in TE 2017–18, agriculture still remains an important sector because the income of a substantial section of the workforce still comes from this sector (Gulati et al. eds. 2021) sugarcane in India is cultivated in two distinct agro-climatic region viz tropical and sub-tropical in the sub-tropical region Uttar Pradesh divided in nine agro-climatic zone,witaround 96.2 per cent area under irrigation in Uttar Pradesh and 100 per cent area under irrigation in Maharashtra, Tamil Nadu. Haryana and Madhya Pradesh (Agricultural statistics at a glance 2021).

Therefore, an analysis of farm label is desirable to get a clear understanding of existence of gap between actual and potential output of agriculture crop.It is stated in the literature that the ratio between the actual and potential output is the measure of technical efficiency of a farm/farmer and the various socio- economic characteristics of the farmer and

otherGeographical(ecological) factors determine the variation in the efficiency level of farmer(Kaliranjan and Shand 1994)we estimate the profit efficiency using farm label cross sectional household data have studies efficiency using the stochastic Frontier analysis which employed data(Swati and Rajani 2018) have studied efficiency using the stochastic Frontier analysis (Bhatt and Bhat 2014). Stochastic Frontier analyses has been used to measure technical efficiency in sugarcane production.It is helpful to understand the gain through the adoption of improved Agriculture practises with the given technology as also point to saving in inputs used to assessment of technical efficiency in agriculture production become important.

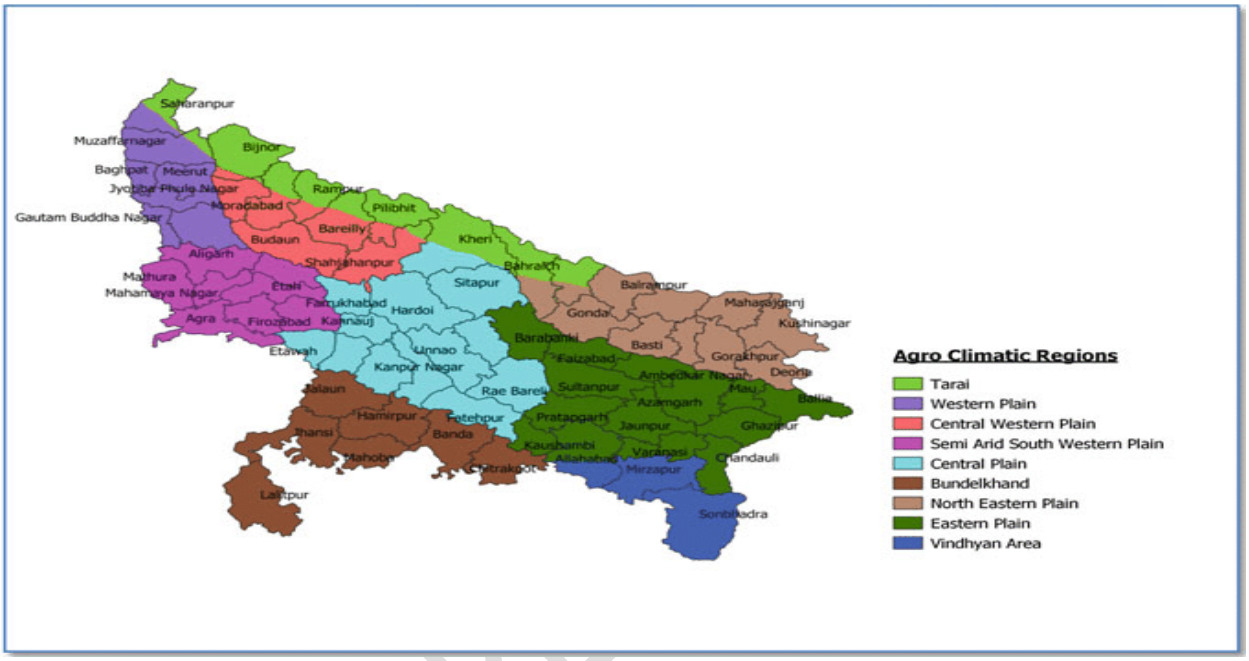

Fig 1. Map showing study location

Methodology

This paper seeks to technical efficiency in sugarcane production. Meerut District of Uttar Pradesh was purposely selected to ignore the inconvenience of the study. two sub-district was selected according to the situation near Doral sugar factory and in four villages 120 farmers of three categories of land Marginal blow 1 ha, Small 1 to 2 ha and medium more than 2 ha was purposely selected, a well examined primary schedule was to use for data collection.The study was conducted in 2022, through a case study comparing sugar cane farmer. This study conducts in two phases. In first phase, we assume profit efficiency and in second phase, contradicts inefficiency effect are Identically distributed (Battese and Coelli 1995, Fari et al 2001).

This stochastic frontier model was independently proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977). The model is such that the possible production, Y_i , is bounded above by the stochastic quantity, $f(x_i;\beta)\exp(V_i)$; hence the term stochastic Frontier. The random error, V_i, i=1,2,….,N, were assumed to be independently and identically distributed as $N(0,\boldsymbol{\sigma}_v^2)$ random variables, independent of the U_i's, which were assumed to be non-negative truncations of the $N(0,\boldsymbol{\sigma}^2)$ distribution (i.e., half-normal

distribution) or have exponential distribution. Meeusen and Van den Broeck (1977) considered only the case in which the U_i's had exponential distribution (i.e., gamma distribution with parameters r=1 and $\lambda>0$) and noted that the model was not as restrictive as the one-parameter gamma distribution (i.e., gamma distribution with parameters r=n and $\lambda>0$) considered by Richmond (1974).

$Yi= f(X_{ij}, B_{ik}). Exp(€_j)$

Y_i is the normalized profit of the ith farm, defined as gross revenue less variable cost, divided by farm-specific output price.

X_{ij} is the price of jth variable input faced by the jth farm divided by output price

B_{ik} is the level of the kth fixed factor on the ith farm

€ is the error term: and

I is 1…..n, number of farm in the sample.

The error term € is assumed to behave in a manner consistent with the frontier concept.

$€ = u – v$

Where

Vi assumed to be independently and identically distributed with $N (0,\sigma^2_y)$ two sided error term independent of u_i.

u_i represent non negative random variable associated with inefficiency in production.

The profit efficiency of farm 'I' in the context of stochastic frontier function is:

$EFFi = E[exp(- u_{i)} /€_I] = E[exp(-\varphi_0-\Sigma^D_{d=1} \varphi_d M_{di)} /€_I]$

Where,

The empirical Stochastic frontier Production model is specified as given below,

$InY_j=ß_0+ß_1InX_1+ß_2InX_2+ß_3InX_3+ß_4InX_4+ß_5InX_5+$

$(V_j-U_j)……(1)$

Where

Y= Production of sugarcane (tonnens/ha)

X_1 = Human Labour (hr/ha)

X_2 = *Seed (setts) (q/ha)*

X_3 =*Fertilizer (kg/ha)*

X_4 = *Plant Protection (kg/ha)*

X_5=*Irrigation (per hour)*

V_j= Stochastic error term

U_j= *Technical inefficiency effect predict by the model*

The a prior expectation is that the coefficient of all the input X_1 *to* X_5 which are $ß_1$ to $ß_5$ should be positive, respectively.

The inefficiency model as follows.

$$U_j = \acute{O}_0 + \Sigma^5_{d=1} \acute{O}_{di} M_{di}$$

M_1= age of the sugarcane farmers (in year).

M_2= Education of the Sugarcane farmers

M_3= family size (numbers)

M_4= farm equipment (Rs)

Result and Discussions

Farmers Characteristics:

The socio economics attributes of sugarcane householdwere shown in Table 1 that the overall mean age of sugarcane farmers were48-year-old and marginal farmers were more younger than the small and medium farmers. The average year of schooling in overall farmers were 5.0 year and the medium farmers are more educated. The Land area was distributed according to the farm category but average land area was 1.60 hector. Availability of farm equipment on average were 234057 Rs per farm but the medium farms have more implement than the small and marginal farm and the on an average size of family inversely related with farm size and equipment availability on the farm, marginal farmers had a greater number of family members than the small and medium farms overall mean family size of sugarcane farm were 5 members per farm.

Table:1 Sugarcane farms/farmers in our sample.

Variable	Marginal	Small	Medium	Overall
Age	42.0	49.0	52.0	48.0
Education	4.80	5.20	5.80	5.0

Land area	0.72	1.31	2.78	1.60
Farm equipment	72718	191239	438215	234057
Family size	6.0	5.0	4.0	5.0

Source Authors′ own calculation

Maximum likelihood estimates of profit frontier function:

The study pointed on the technical efficiency of farm the maximum likelihood technique was used on the basic of the stochastic production frontier, the maximum likelihood estimate provides the estimate of stochastic production frontier and ordinary least square function, the estimate of the average production function. The parameter estimate obtained was the elasticity of the profit with respect to the different inputs in (Table1).

The result point to a positive and statistically significant at 1% level of human labour in all groups of farms indicate that sugarcane is a labour-intensive cropand timely and efficiently use of human labour in differentculturespractise (like sowing, tying, dying and weeding and hoeing) have been very useful to improve the production of sugarcane crop. The positive and statistically significant at 1% level of setts (seed) of sugarcane were chance of improvement of quality that were the positively increase the production and profit simultaneously, in the study area red rot (cancer of sugarcane) is a seed/sett born severe disease of sugarcane and need to substitution and resistant variety for further improvement. The fertilizer and plant protection resource had a negative effect on cost of cultivation of sugarcane, both resources were not used as a recommended does and over use of these resources were only negative impact on cost and profit also. Irrigation was the positive and statistically significant in overall and also in case of marginal farms. In general, marginal farmers were irrigated sugarcane farms on paid/hours basic because maximum farms had not own tube wells by which very limited and efficient quantitate water used for irrigation.The coefficient of cobb-Douglas function was treated as elasticities and if the price rise by 1% for human labour, seed and irrigation the profit would increase respectively by 38.0%, 21.0% and 8.0%.

Technical efficiency is defined as a ratio observed output and frontier output and is bounded between 0 and 1 such that y=0 inefficiency is not present and if y=1 there is no random noise. The estimated value of y is close to 1 and different from 0 across all farms categories, establishing that inefficiencyexist among sugarcane farms. The value of y was significant for marginal farms and the estimates of y was 0.961 overall, or difference in farms practise rather than random variability explain 96% of the variation in the profit, The value of y indicates the fitness and correctness of the specified distributional assumption of the composite error term. The estimated across all farms size categories was significant indicating a good fit. The sugarcane yield per farm was positively related to profit efficiency an increase the sugarcane yield will ultimately improve the profit efficiency of farms

Table: 2 Estimation of maximum likelihood estimate of parameters of stochastic cobb-DouglasProfit frontiers function

Variables	Marginal	Small	Medium	Overall
Intercept	0.212	0.793	0.984	0.421

	(0.672)	(0.781)	(0.592)	(0.692)
Human labour	3.512** (0.945)	2.672** (1.178)	4.732** (1.248)	0.380** (0.014)
Seed	0.243** (0.125)	0.193** (0.045)	0.821** (0.136)	0.219** (0.072)
Fertilizer	-0.248 (0.814)	-0.395 (0.541)	-0.641 (0.931)	-0.516 (0.472)
Plant Projection	-0.618 (0.925)	-0.511 (0.871)	-0.498 (0.399)	-0.211 (0.718)
Irrigation	1.178** (0.012)	0.491* (0.231)	0.744* (0.338)	0.081** (0.012)
σ^2	0.398** (0.019)	0.192** (0.037)	0.441** (0.106)	0.207 (0.312)
σ	0.968** (0.021)	0.548 (0.432)	0.757 (0.548)	0.961** (0.231)
Log Likelihood	-0.412	-0.292	-0.098	-0.011
LR test of one side crore	0.652	0.235	0.107	0.144

Note Figures in parentheses indicate standard error; *significant at 5%; **significant at 1% level of significance

Source Authors' own calculation

Profit inefficiency in Sugarcane farms

Inefficiency existed in the study area. We fitted stochastic frontier model to obtained inefficiency from the model and regressed the model on factors like age, education, family size and farm equipment to see the effects of the factors on inefficiency (Table 3)

The marginal farms were significant and negative sign indicate age factor determines the risk bearing ability depend upon the adoption of new technique and technology, younger farmers were interested in taking risk thereby urn supernormal profit and increasing profit efficiency (Kamlesh at al 2021, Adamu and Bakari 2015). The education coefficient for all farms were negative and significant for marginal, small and medium farms depict that a additional year of schooling of farmers were improve management skill and ability to use limited resources efficiently on farms.Family size coefficient were significant in marginal, small and overall, except medium farm and negative only for marginal farm shows that a greater number of family members are positively contributed in profit efficiency. In case of farm equipment all farms had negative sign and marginal small, medium and overall farm were significant indicate that more farm equipment was contributed in profit efficientlypositively.

Table: 3 Technical inefficiencies in sugarcane farms

Variables	Marginal	Small	Medium	Overall
Intercept	0.447 (0.521)	0.598 (0.329)	0.381 (0.648)	0.684 (0.320)
Age	-0.072**	0.241	0.108	0.080

	(0.013)	(0.208)	(0.132)	(0.107)
Education	-0.005** (0.001)	-0.025* (0.017)	-0.011* (0.006)	-0.104 (0.121)
Family size	-0.030* (0.018)	0.131* (0.072)	0.017 (0.064)	0.027** (0.005)
Farm Equipment	-0.0002 (0.0001)	-0.007** (0.001)	-0.119** (0.013	-0.108* (0.036)
R^2	0.8231	0.8475	0.7981	0.8103
Number of observations	40	40	40	120

Note Figures in parentheses indicate standard error; *significant at 5%; **significant at 1% level of significance

Source Authors' own calculation

Distribution of Efficiency of SFA model.

The distribution of efficiency estimates of the 120 sugarcane farms depicts in figure 2, that the mean efficiency of the sample farms 0.732 per cent, further the frequency distribution of 120 farms indicates that under SFA model, 14 farms (11.6 per cent) had an efficiency score that range between 60-70 per cent, whereas maximum number of 49 farms (40.0 per cent) have a 70-80 per cent, efficiency score, 43 (35.0 per cent) farms efficiency score between 80-90 per cent and very small number of farms 4(3.30 per cent) have the maximum efficiency score above 90 per cent. Hence it can be pointed that the maximum percentage of farm operate an efficiency level between 70-90 per cent indicate that a very high level of inefficiency and resources were not utilised efficiently.

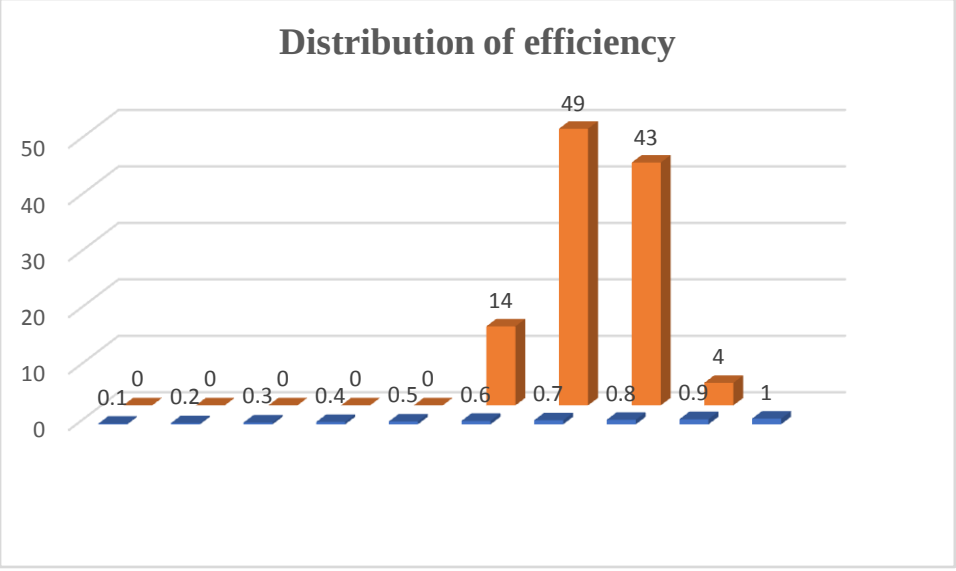

Figure 2 . Distribution of efficiency of Sugarcane Farms.

Conclusion

The study conducted in the Meerut District of Uttar Pradesh was purposely selected to ignore the inconvenience of the study. two sub-district was selected according to the situation near Doral sugar factory. In this paper we have tried to estimate socio-economicstructure on sugarcane farm/farmers. The socio-economic profile of the farms indicated that marginal farmers were more younger and medium farmers were more educated and wealthier than the others. The study pointed out the efficiency of sugarcane farm was using the stochastic production function model and inefficiency of farm resources human labour, seed and irrigation found statically significant in all groups of farms. Inefficiency was impacted negatively and significantly by farm equipment and positively and significantly by family size; Farmers can improve profit efficiency by increasing farm equipment and a smaller number of family members was inversely affect the efficiency. Distribution of sugarcane farm maximum under 70-80 percent of 49 farms (40.0 per cent) and only 4 farms (3.30 per cent) have the maximum efficiency score above 90 per cent.

References:

Abdulai, A and W Huffman. 2000. Structural adjustment and economics efficiency of rice farmer of northern Ghana. Economics Development and Cultural Change 48(3): 503-20. https://dx.doi.org/1010.1086/452608

Adamu, T and U Bakari. 2015. Profit efficiency among rainfed rice farmer in northern Taraba state, Nigeria. Journal of Biology, Agriculture and Healthcare 5(8):113-19. https://core.ac.uk/download/pdf/234660941.pdf

Agricultural statistics at a glance 2021, Government of India.

Aigner, D.J. , Lowell, C.A.K. and Schmidt, P., 1977. Formilation and estimation of stochastic frontier production model. J. Econometrics, 6: 21-37.

Ashok Gulati, Prerna Terway, and Siraj Hussain (eds) (2021). Performance of Agriculture in Uttar Pradesh, Revitalizing Indian Agriculture and Boosting Farmer Incomes,Indian Studies Business and Economics.

Battese, G and T. Coelli. 1995. A model for technical inefficiency effects in a stochastic frontier production function for panel data.Empirical Economics 20(2):325-32. https://dx.doi.org/10.1007/BF01205442

Bhatt, M.S. and S.A. Bhat (2014) "Technical efficiency and farm size productivity a micro level evidence, "International journal of and Agriculture Economics ISSN, Vol. 2, No. 4, pp. 2147-8988.

Coelli, T. 1996. A guide to FRONTIER version 4.1: A computer program for stochastic frontier production and cost function estimation. https://iranarze.ir/wp-content/uploads/2017/07/7209-English-IranArze.pdf

Calsamiglia, S,SAstiz, J Baucells, and L Castillejos.2018. A stochastic dynamic model of a dairy farm to evaluate the technical and economic performance under different scenarios. Journal of Dairy Science 101(8):7517-530. https://dx.doi.org/10.3168/jds.2017-12980

Chattopadhyay, M., and A. Sen Gupta, A. (2001) "Tenancy inefficiency: A Study based on west Bangel", Economics and Political Weekly, vol. 36, No. 5,3 February, pp. 497-502.

Chavas, J. P.; R. Petrie and M. Roth (2005) "Farm House Hold Production Efficiency: Evidence from the Gambia", American Journal of Agricultural Economics, vol. 87, No. 1, pp. 106- 179.

Coelli, T. J. and G. E. Battese (1996) "Identification of factors which influence the technical inefficiency of Indian farmers", Australian journal of Agricultural Economics, Vol. 44, No. 2, pp. 103-128.

Dhungana, B. R.; P. L. Nuthall and G.V. Nartea (2004), "Measuring the economics inefficiency of Nepalese rice farm using data envelopment analysis; Australian journal of Agricultural and Resource Economics vol 48, No. 2 pp. 347-369

Fandel, G and M Lorth. 2009. On the technical (in)efficiency of a profit maximum. https://dx.doi.org./10.1016/j.ijpe.2009.05.028

Kalirajan, K.P., and R. T. Shand (1989), "Economics in Disequilibrium An approach from the Macmillan India ltd New Delhi.

Kalirajan, K.P., and R. T. Shand (1989), "A Generalised Measure of Technical Efficiency; Applied Economics, vol. 21,No. 1 pp. 25-34.

Kamlesh Kumar Acharya, Ravinder Malhotra, R. Sendhil and Binita Kumari. 2021. Profit Efficiency among peri urban dairy farmsin Odisha; an application of the stochastic frontier function. Agricultural Economics Research Review 34(2) 207-215 Doi: 10.5958/0974-0279.2021.00029X.

Lalrinsangpuii, R Malhotra, L Priscilla, and B G Nagarle.2016. Profit efficiency among jhum practicing tribal people of Mizoram state. Indian Journal of Agricultural Economics 71(3): 374-82. https://dx.doi.org/10.22004/ag.econ.30222

Lockheed, M.E.; T. Jamison, L.J. Lau, D.T. Jamison and W. Bank(1980), "Farmer Education and Farm Efficiency: A Survey Efficiency: A Survey Educational Testing Service", Source: Economics Development and Cultural Change, Vol.29, No.1, pp.37-76.

Meeusen, W, Van den Broeck J, 1977. Efficiency estimation Cobb-Douglas Production function with composed error- International Economics Review 18; 435-44

Mohapatra, R. (2011), "Farmer' Education and Profit Efficiency in Sugarcane Production: A Stochastic Frontier Profit Function Approach", IUP Journal of Agricultural Economics, Vol.8, No.2, pp.18.

Murali, P.; R. Balakrishnan, Prathap D. Puthira, C. Karpagam and G.N. Govindaraj (2012), Productivity Improvement of Sugarcane Farming in Tamil Nadu (India): Parametric

and Non-Parametric Analysis, International Association of Agricultural Economists.

Raut, R.K., Behera A. K. Padhlory, P. K., Nanda, A. Nayak. D. Behra and Das, T. 2017A study on resources use efficiency of sugarcane farm, evidence from village level study in Orissa, India. Int; J. Curr. Microbial app sci. 6(11) 1955-1962

Reddy, A.R. and C. Sen (2004), "Technical Inefficiency in Rice Production and Its Relationship with Farm-Specific Socio-Economic Characteristics", Indian Journal of Agricultural Economics, Vol.59, No.2, April-June, pp.259-267.

Reserve Bank of India, (2017), Handbook of Statistics for the Indian Economy and Earlier Issues.

Swati Raju and Rajani Mathur 2018. Efficiency among sugarcane farmers of Bhirdachiwadi. Maharashtra: A case study, Indian journal of Agricultural economics. Vol 73, No. 2, April-June-2018

Trivedi, G and U Pareek. 1963. Socio-economic status scale (rural) in measurement in extension research. Instrument developed at ICRA-IARI, New Delhi, 1-15. https://www.researchgate.net/figure/Udai-Pareek-and- G-Trivedi-socio-econoic-status-scale-for-rural- India_tb11_329287402