Environment and Ecology 40 (3A) : 1349—1354, July—September 2022
ISSN 0970-0420

Cost Efficiency of Sugarcane Production : A Study of Samastipur and Begusarai Districts of Bihar (India)

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Received 9 May 2022, Accepted 18 June 2022, Published on 6 August 2022

ABSTRACT

The present investigation estimates the cost efficiency of sugarcane farming in Samastipur and Begusarai district of Bihar (India). Stochastic cost function model was applied to estimate the cost efficiency of sugarcane cultivation and for this, multistage sampling technique was applied to collect the primary data. The results of the study revealed that independent variables like human labor cost, tractor cost, irrigation cost, seed cost, fertilizers and manure cost were in conformity with the priori expectation but plant protection cost and production were found to be negative showing that inadequate plant protection measures could reduce the production. Further, inefficiency and factors affecting cost inefficiency were also assessed. The mean inefficiency score was found to be 1.10 indicating 10% inefficiency prevailed in the cost of production of sugarcane in the study area. The important factors like age, education level and area under sugarcane affecting inefficiency were found negative and significant reflecting that younger and educated people had better access to extension agencies and likely to have comparatively good knowledge of modern farming techniques. The expansion in area under sugarcane may reduce the cost of cultivation since large farm size had relatively good scope for mechanization which may reduce the cost of human labor resulting in reduced cost inefficiency.

Keywords Sugarcane, Stochastic cost frontier model, Cost efficiency, Age, Educational level.

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INTRODUCTION

Sugarcane is grown in more than 90 countries in the world. It is grown on around 26 million hectares of land with a world-wide production of about 1.83 billion tons. Brazil is the largest producer of sugarcane in the world, followed by India, China, Thailand, Pakistan and Mexico (Anonymous 2018).

India ranks second in the world in sugarcane production after Brazil. In India, during 2017-18 sugarcane was cultivated in an area of 5.1 million hectares with a production of 306.72 million tons and productivity of 67.57 tonnes per hectare. There are two distinct regions for sugarcane cultivation in India. Firstly, tropical region comprising cane producing southern states of Andhra Pradesh, Karnataka, Maharashtra, and Tamil Nadu and subtropical region comprising northern part of Bihar, Uttarakhand, Uttar Pradesh, Punjab and Haryana. Subtropical region, encompassing 55% of total cane area, contributes only 48% of total cane production, and 35% of total sugar production in the country, whereas tropical region covers 41% of the cane area, and contributes 49% of the cane production and 64% of sugar production. The domestic demand of sugar is hovering around 22-23 million tons annually as against the production of sugar in India during last five years was hovering around 24 to 26 million tons annually, that is self-sufficient with per capita consumption of 12 kg annually.

In sub-tropical region, Bihar is the second largest sugarcane producing state next to Uttar Pradesh with an area and production of sugarcane being about 2.69 lakh hectares and 176.10 lakh tons, respectively in the year 2017-18 (Anonymous 2018). The total cultivated land in the state is around 53 lakh hectares, out of which about 3.0 lakh hectares (3.7%) is under sugarcane cultivation. Bihar was once reckoned as second largest sugar producing state but it has lost its traditional position to peninsular states.

In Bihar, 11 sugar mills are presently in operation, of which 9 are part of private sector and two of public sector. In 2017-18 crushing season, sugar mills crushed 747.89 lakh quintals of sugarcane, 176.75 lakh quintals more than the previous year. The sugar recovery rate was 9.57% in 2017-18, marginally higher than in the previous year (9.17%). It is also important to mention that, on an average, sugar mills were in operation for 125 days a year, entailing better utilization of installed capacity (Anonymous 2019).

Ahmad *et al.* (2018) conducted a study based on plot level data of Comprehensive Cost of Cultivation Scheme, Ministry of Agriculture and Farmers Welfare, Government of India running in Bihar for the period 2013-14 with the objectives to determine technical efficiency of the cultivators in using resource inputs and to access the impact of socio-economic factors on sugarcane production in the state. The resource inputs were found inelastic and not being properly utilized. All the resource inputs were found significant at 1% and 5% level of probability except machine labor and fertilizers used. In inefficiency model, landholding size, age and family size were estimated negative, indicating positive impact on efficiency in sugarcane production. The effect of education was accessed positive indicating increase in formal education raised inefficiency. The mean technical efficiency was estimated to be 0.92 indicted that optimal and sustainable use of resource inputs may raise further, the sugarcane production by 8% and boost up the income of the sugarcane growers of the state.

Sugarcane is an important cash crop grown in the state of Bihar. Its cultivation is labor and cost intensive. In addition, there are many constraints and the farmers are resource poor. Very few works have been carried out to estimate cost efficiency and causes of inefficiency in sugarcane cultivation in the state ; hence, the study was taken up.

MATERIALS AND METHODS

The study was conducted in Samastipur and Begusarai districts which were purposively selected for the study because Hasanpur Sugar mill is located there and sugarcane cultivation is practiced in the study area. One block from each district was selected on the basis of highest area under sugarcane and from these blocks 100 sugarcane growers were randomly selected for investigation. The primary data relates to the cropping year 2016 was collected.

The stochastic frontier model based on Cobb-Douglas cost function was employed to test whether sugarcane farming households in Samastipur and Begusarai are cost efficient or not and also to estimate the inefficiency score, if inefficiency exists. The cost inefficiency scores were used as dependent variable in the inefficiency model and was thus regressed on households and farms' characteristics to explore the factors influencing cost inefficiency of sugarcane cultivation. The analysis was carried out using Frontier 41 software.

Stochastic frontier model

Stochastic frontier model was pioneered by Ainger *et al.* (1977) and Meeusen and Broek (1977). Since then, it has been used for empirical research in applied economics.

Coelli *et al.* (2005) and Hazarika and Alwang (2003) used the cost frontier model in their study which is generally expressed as

$$c_i \geq c(p_{1i}, p_{2i}\ldots\ldots\ldots p_{Ni}, q_{1i}, q_{2i}\ldots\ldots\ldots q_{Mi})$$

Where *ci* is the observed cost of producer i, pNi is the N[th] input price, qmi is the M-output and c (,) is a cost function that is non decreasing, linearly homogeneous and concave in prices. The cost function c (,) gives minimum cost of producing outputs $q_{1i}, q_{2i}\ldots\ldots$ qMi when producer incurs prices $p_{1i}, p_{2i}\ldots\ldots\ldots p_{Ni}$.

Cobb-Douglas form of the cost function is specified as follow

$$lnc_i \geq \beta_0 + \sum_{N=1}^{N} \beta_N l\, np_{Ni} + \sum_{M=1}^{M} \beta_M lnq_{Mi} + v_i$$

Where vi is a symmetric random variable and denotes the error of approximation and other sources of statistical noises. The above equation can be written as

$$lnc_i = \beta_0 + \sum_{N=1}^{N} \beta_N l\, np_{Ni} + \sum_{M=1}^{M} \beta_M lnq_{Mi} + v_i - u_i$$

In the above equation, there are two composite error terms, vi and ui vi is assumed to be independently and identically distributed which express the variation in production cost due to uncontrollable factors like weather shock or crop diseases. ui denotes producer's cost efficiency relative to the stochastic cost frontier, which may be on account of mismanagement or misallocation of production resources. ui is one sided and negatively distributed. In other ways, ui=0 if production cost is at minimum and if ui≥0, cost efficiency is imperfect.

If cost inefficiency is found then the determinants of cost inefficiency can be estimated using the following OLS equation as suggested by Hazarika nad Alwang (2003).

$$u_i = \delta_0 + \sum_{k=1}^{n} \delta_k z_{ki} + \xi_i$$

Where, *zki* are independent variables which affect the cost inefficiency. The procedure has been criticized as in OLS, the assumption of identically distributed inefficiency effects was violated (Battese and Coelli 1995).

To overcome the problem of assumption violation, Battese and Coelli (1995) combined the two steps into single one keeping the assumption of *vi* is independently and identically distributed, the cost inefficiency component was alternatively assumed to be independently but not identically distributed indicating that the mean cost efficiency was assumed to be a function of variable *zi* as specified in the above equation. The new model allows the estimation of the coefficients as well as the test of hypothesis in a single step. This study follows the single step estimation model.

The model used in this specific study is Cobb-Douglas stochastic frontier and is expressed as follows :

$$lnc_i = \beta_0 + \beta_1\, lnp_{1i} + \beta_2\, l^{np}{}_{2i} + \beta_3\, lnp_{3i} + \beta_4 lnp_{4\,i} + \beta_5\, lnp_{5i} + \beta_6\, lnp_{6i} + \beta_7 lnp_{7i} + \beta_8\, lnp_{8i} + \beta_9\, lnp_{9i} + (v_i + u_i)$$

Where,
ci =Total production cost of sugarcane (Rs/ha)
p1i= Human labor cost (Rs/ha)

Table 1. Summary statistics.

Variable	Mean	Standard error	Minimum	Maximum	% of total cost
Total cost (Rs/ha)	123959.09	2330.07	85205.00	198687.50	-
Human lab (Rs/ha)	43914.49	754.20	28321.43	61062.50	35.43
Tractor (Rs/ha)	28223.14	642.90	12416.67	40333.33	22.77
Irrigation (Rs/ha)	6742.02	89.82	5055.56	9000.00	5.44
Seed cost(Rs/ha)	17829.19	125.44	12100.00	19833.33	14.38
Fertilizer cost (Rs/ha)	8343.91	75.30	6214.29	9984.00	6.73
Weedicide cost (Rs/ha)	265.45	15.13	0.00	1230.00	0.21
Insecticide cost (Rs/ha)	5030.05	167.98	1533.75	8518.45	4.06
FYM cost (Rs/ha)	4439.33	252.96	0.00	9600.00	3.58
Production (q/ha)	743.92	8.46	327.92	1036.43	
Age (years)	46.70	1.05	30.00	80.00	
Education level	2.81	0.12	1.00	5.00	
Experience (years)	16.18	0.76	5.00	40.00	
Occupation category	3.14	0.09	1.00	6.00	
Area (ha) under sugarcane	1.07	0.14	0.15	12.00	

p2i= Tractor cost (Rs/hr)
p3i= Irrigation cost (Rs/hr)
p4i= Seed cost (Rs/q)
p5i= Fertilizer cost (Rs/Kg)
p6i= Weedicide cost (Rs/L)
p7i= Insecticide cost (Rs/kg)
p8i= FYM cost (Rs/q)
p9i= Production (q/ha)

The choice of Cobb-Douglas functional form is based upon the fact that the methodology requires the function to be self-dual as the case of cost function which the analysis is based on.

Moreover, the inefficiency model (ui) is specifically defined as

$$u_i = \delta_0+\delta_1 z_{1i}+\delta_2 z_{2i}+\delta_3 z_{3i}+\delta_4 z_{4i}+\delta_5 z_{5i}+\xi_i$$

Where,
ui= Cost inefficiency scores
z1i= Age of the farmer (years)
z2i= Educational level of the farmer (1 for illiterate, 2, literate and secondary, 3, higher secondary, 4, graduate and 5 post-graduate)
z3i= Farming experience (years)
z4i= Main occupation of the farmer (Agriculture-1, Dairy-2, Agriculture+Dairy-3, Service-4, Business-5 and others-6)
z5i= Area under sugarcane (ha)

RESULTS AND DISCUSSION

The summary statistics of the variables used in estimating the stochastic frontier cost function and inefficiency model are presented in Table 1. The table shows the mean, standard error, minimum and maximum value of each variable along with their contribution to the total cost for all cost variables. On an average, the cost of cultivation was Rs 123959.09/ha. Among all the cost variables, the percentage share of human labor was observed the highest (35.43%), followed by tractor cost and seed cost, respectively. These cost factors contributed about 92.6% of the total cost.

The socio-economic conditions of cultivators used to examine their effect on inefficiency level were age, education level, experience, occupation and area under sugarcane cultivation. The average age, education level, experience, occupation and area under sugarcane were assessed to be 46.70 years, 2.81(education score), 16.18 years, 3.14 (occupation categories) and 1.07 ha, indicating that most of the farmers were of middle age group having low level of education and having an average experiences 16.18 years of sugarcane farming.

Results of stochastic cost frontier model and factors influencing cost inefficiency as presented in

Table 2. Maximum-likelihood estimates of parameters of Cobb-Douglas frontier cost function. ***, ** and * denote. Significant at 1%, 5% and 10%level of probability.

Variables	Coefficients	Standard error	t-ratio
Constant	-2.261***	0.897	-2.520
Human lab (Rs/ha)	0.350***	0.035	10.075
Tractor (Rs/ha)	0.269***	0.026	10.296
Irrigation (Rs/ha)	0.009	0.046	0.189
Seed cost (Rs/ha)	0.745***	0.058	12.822
Fertilizer cost (Rs/ha)	0.029	0.067	0.437
Weedicides cost (Rs/ha)	-0.006*	0.005	-1.389
Insecticides cost (Rs/ha)	-0.005	0.018	-0.286
FYM cost (Rs/ha)	0.009**	0.002	3.743
Production (q/ha)	-0.034	0.044	-0.762
Inefficiency variables			
Constant	1.566*	1.173	1.335
Age (years)	-0.901**	0.387	-2.327
Education level (score)	-0.478***	0.151	-3.161
Experience (years)	0.422***	0.113	3.722
Occupation category	0.164*	0.103	1.595
Area (ha) under sugarcane	-0.341***	0.035	-9.804
σ^2	0.080***	0.017	4.638
Γ	0.993***	0.004	239.145
Log likelihood function	128.55		
Average CE	1.10		

Table 2 revealed that independent variables like human labor cost, tractor cost, irrigation cost, seed cost, fertilizers and manure cost were in conformity with the priori expectation but plant protection cost and production were found to be negative showing that inadequate plant protection measures could reduce the production.

Since the Cobb-Douglas type of cost function was used to estimate the stochastic frontier cost function, the coefficients of the cost function served as the cost elasticity of the production. Therefore, 1% increase in human labor cost, tractor cost, irrigation cost, seed cost, fertilizers and manure cost, the total cost will increase by 0.35%, 0.27%, 0.009%, 0.75%, 0.029% and 0.009%. Seed cost was the main important cost in cost function, followed by human labor cost and tractor cost.

The table also exhibited the statistical evidences of cost inefficiency among the sugarcane cultivating households. In addition, the efficiency scores of each of the sugarcane farming households may be assessed to examine how far from the cost frontier, the farmers are producing. If the efficiency score was equal to unity, the sugarcane growers were cost efficient. If the score was greater than unity, the farming households were not efficient; the greater the cost efficiency score was, the more inefficient the level the farming households were operating. The average efficiency score was estimated 1.10, indicating that 10% cost can be minimized by optimal allocation of human labor cost, tractor cost, seed cost and irrigation charges.

The factors affecting inefficiency were age, education level and area under sugarcane cultivation were estimated negative and significant indicating thereby younger and educated generations of growers had more access to extension services and were likely to have better knowledge of new technologies which could help in reducing the inefficiency. Coefficients of experience and occupation were assessed positive and significant revealing that elder farmers have more experiences of cultivation but most of them are illiterate and adhere to traditional farming, hence, their experience could not help in reducing cost inefficiency. The farmers engaged in other non-farm works were not in a position to pay proper attention in farming.

The variance parameters of the frontier cost model were Sigma square (σ^2) and Gamma (γ). The Sigma squared indicates the total amount of variance found in the model. It was found 0.080 which was statistically significant at 5% level of probability. Gamma explains the systematic effects that are unexplained by the cost function and the dominant sources of random errors. It was estimated 0.993. This shows that 99% variation in sugarcane cultivation cost was as a result of cost inefficiencies of the sugarcane cultivation. Thus, the results indicate that inefficiencies were present in cost of sugarcane cultivation in the study area.

CONCLUSION

The results revealed that independents variables like human labor cost, tractor cost, irrigation cost, seed cost fertilizers and manure cost were in conformity with the priori expectation but plant protection cost and production were found negative showing that inadequate plant protection measures could reduce the production. The factors affecting inefficiency were age, education level and area under sugarcane cultivation were estimated negative and significant indicating thereby younger and educated generations of growers had more access to extension services and were likely to have better knowledge of new technologies which could help in reducing the inefficiency. Coefficients of experience and occupation were assessed positive and significant revealing that elder farmers have more experiences of cultivation but most of them are illiterate and adhere to traditional farming, hence, their experience could not help in reducing cost inefficiency. The farmers engaged in other non-farm works were not in a position to pay proper attention in farming.

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