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An Empirical Study on Technical Efficiency of Sugarcane Production in Rajshahi District of Bangladesh

S. Khatun[1*], M. Kamruzzaman[1], M.S. Islam[1] and M.H. Rahman[2]
[2]Professor, Agricultural Economics Division, Stamford University Bangladesh
[1]Agricultural Economics Division
Bangladesh Sugarcrop Research Institute, Ishurdi-6620, Pabna, Bangladesh

ABSTRACT

The present study was undertaken to find out the technical efficiency and factors affecting on inefficiency of sugarcane production in Rajshahi district. The study employed farm level cross sectional data from three sugarcane growing areas of Bangladesh during the period of 2013-2014. Stochastic frontier model was employed in this study. In the study, human labour, organic manure (OM), Muriate of Potash (MP), Urea and irrigation cost has found positive and significant effect on sugarcane production. The average technical efficiency of sugarcane farmers was found 80 percent. This indicates a good potential result for increasing sugarcane output by 20 percent with the existing technology by rearranging their resources. Experience, farm size and extension contacts were found negative and significant effect technical inefficiency of sugarcane farmers. That means, the experience, farm size and extension contacts had the significant effect on technical efficiency. Therefore, experience, farm size and extension contact are the important factors for obtaining maximum achievable yield.

Key Words: Technical efficiency, sugarcane growers, experience, extension contact

INTRODUCTION

The farm level performance can be attained in two alternative ways: by maximizing output with the given set of inputs under existing production technology or by minimizing production cost to produce a prescribed level of output. The measurement of farming efficiency is an important issue in agriculture, both in developed and developing countries. Estimation of technical efficiency may help to decide whether to improve efficiency or to develop new technologies to raise sugarcane productivity in Bangladesh. Technical efficiency refers to the ability of a firm to obtain maximum output of a given set of inputs under certain production technology. There is potentiality of increasing sugarcane production from existing cultivating areas using available resources if the farmers can operate at maximum obtainable yield level. Generally, adoption of modern technology and production practices vary across the farms. Some of farmers may produce maximum obtainable sugarcane yield and some farmers may not produce due to some inefficiency factors. Therefore, it is essential to determine the maximum level of sugarcane production per unit of land using the existing level of resources and factors

* Corresponding author: S.Khatun, Principal Scientific Officer
e-mail: skbsri@yahoo.com

affecting inefficiency of not obtaining the maximum yield level by using stochastic frontier production function. A technically efficient farm operates on its frontier production function. Given the relationship of inputs in a particular production function, the farm is technically efficient if it produces on its outer bound production function to obtain the maximum possible output, which is feasible under the current technology. The measurement of farm-size-specific technical efficiency get momentum to meet the increasing demands of sugarcane in Bangladesh. The measurement of the productive efficiency of a farm related to other farms or to the "best practice" in an industry has long been of interest to agricultural economists. Efficiency measurement has received considerable attention by both theoretical and applied economists. From a theoretical point of view, there has been a spirited exchange about the relative importance of various components of farm efficiency (Leibenstein,1966; Leibenstein,1977; Comanor and Leibenstein,1969; Stigler, 1976). Several studies have been attempted to estimate technical efficiency of farmers on other agricultural crops in Bangladesh, which is very important for policy makers (Kamruzzaman, *et. al.*, 2008; Hossain, *et.al.*, 2008; Bakh, *et.al.*, 2005).

Sugarcane is one of the agro-based industrial crops of Bangladesh and sustains in large number of rural people of our economy, is the main source of sugar and *goor*. About 70% of total world's sugar is produced from sugarcane and 30% from sugarbeet (Jamil and Gopang, 2004). Except diabetic patients, more than 99 percent of the people take sugar/*gur* and sugar products everyday. Sugar is an essential food item with great importance to our dietary table. The present production of sugarcane can meet neither the total sugar nor nutrient requirements of the country. In Bangladesh, per hectare yield of sugarcane is 46 t ha^{-1} (Anonymous, 2014) which is less than other sugar producing countries. Average cane yield in Pakistan, India, Thailand, China and Brazil was 53.20 t ha^{-1}, 66.93 t ha^{-1}, 63.71 t ha^{-1}, 80.82 t ha^{-1} and 74.42 t ha^{-1} respectively (FAO, 2007). There is a great scope to increase sugarcane productivity, by increasing area it is not possible, since total cultivable area is decreasing day by day due to the increased use of land for non-agricultural purposes. Therefore, it is needed to increase productivity through improving efficiency. If the farmers are found to be technically inefficient, production can be increased to a large extent with the existing level of inputs and available technology by rearranging input combinations. On the other hand, if the farmers are found to be technically efficient, then the government can increase investment on information and education and can try to promote new technologies in order to increase production. Efficiency measurement is the first step in a process that might lead to substantial resource savings. These resource savings have important implications for both policy formulation and farm management.

Currently, on an average, sugarcane is grown in 0.18 million hectare of land of which almost 50% is located in the mill zones, where sugarcane is mostly utilized for sugar production and remaining 50% is situated in the non-mill zone, which is used for goor and juice production (Alam, 2005). Most of the sugar mills of Bangladesh are located in the North Western zones of the country where concentration of sugarcane cultivation is higher. Rajshahi district is a potential sugarcane producing area and is situated in the north Western part of Bangladesh and a total of 12.54 percent sugarcane area is covered by Rajshahi district.

The objectives of this study are: (i) to estimate the technical efficiency of sugarcane farmers of Rajshahi district (ii) to identify the factors affecting variations in technical inefficiencies which effects (or technical efficiencies) among the sample farmers; (iii) to suggest certain development policy.

MATERIALS AND METHODS

Primary data were collected from total 100 sample farmers from the four upazilla namely, Charghat, Poba, Putia and Godagari, taking 25 farmers randomly from each upazilla during the cropping season of 2013-14 through interview schedule. A pre-tested interview schedule was applied to collect data.

Selecting the Functional form of the Production Function

Cobb-Douglas is a special form of the translog production function where coefficients of the squired and interaction terms of input variables are assumed to be zero. In order best specification for the production (Cobb-Douglas or translog) for the stochastic frontier model using the generalized likelihood-ratio statistic "LR" defined by

$LR = -2 \ln[L(H_0) / L(H_1)]$ ....(i)

where, $L(H_0)$ is value of the likelihood function of the Cobb-Douglas stochastic production frontier model, in which the parameter restrictions specified by the null hypothesis, $H_0 = \beta_{ij}=0$, (i.e. the coefficient on the squared and interaction terms of input variable are not zero). If the null hypothesis is true, then "LR" has approximately a chi-square distribution with degrees of freedom equal to the difference between the number of parameters estimated under H_1 and H_0, respectively. We use the Cobb- Douglas and translog production function and on the basis of the test statistic we discover that the CD is the best fit to our data set. On the basis of this test statistic we selected the Cobb-Douglas production function. Besides this, its coefficients directly represent the elasticity of production. The Cobb-Douglas form was used in many empirical studies, particularly those relating to developing country in agriculture. In this study, it is assumed that the Cobb- Douglas is the appropriate form of the frontier production function.

Stochastic frontier production model

A stochastic frontier production model was used to determine the technical efficiency of sugarcane farmers. The modeling and estimation of stochastic frontier production function originally proposed by Aigner *et. al.* (1977) and Meeusen and Van Den Broeck (1977) which has been an important area of economic study in the last two decades. The stochastic production frontier model is specified with error terms, the models is as follows:

$Y= f(X_i,\beta) + (v_i - u_i)$ .... (1)

Where, Y_i was output for observation i (i.e., yield/ha), X_i denotes the actual input vector (i.e., input use/ha), ? was the vector of production function parameters, v was distributed randomly and symmetrical two-sided error term that can not be influenced by producers, it was identically and independently distributed as N (0, $?^2_v$) and may be considered as the 'normal' error term. The u was a non-negative one-sided error term and distributed half-normal as N(0, $?^2_u$) which captures deviations from the frontier due to inequality.

Empirical model

The Cobb-Douglas form was used in many empirical studies, particularly those relating to developing countries in agriculture. In this study, it is assumed that the Cobb- Dauglas is the appropriate form of the frontier production function. The stochastic production which is used for the sugarcane producers was specified as:

$$Ln\ Y_i = ?_0 + ?_1 LnX_{1i} + ?_2 LnX_{2i} + ?_3 LnX_{3i} + ?_4 LnX_{4i} + ?_5 LnX_{5i} + ?_6 LnX_{6i} + ?_7 LnX_{7i} + ?_8 LnX_{8i} + ?_9 LnX_{9i} + v_i - u_i \ldots\ldots (2)$$

Where, Ln = Natural logarithm, Y_i = Yield of sugarcane (t ha^{-1}), X_{1i} = Human labour(man-days ha^{-1}), X_{2i} = Animal labour (pair-days ha^{-1}), X_{3i} = Seed (kg ha^{-1}), X_{4i}= Organic manure (kg ha^{-1}), X_{5i} = Urea (kg ha^{-1}), X_{6i} = TSP (kg ha^{-1}), X_{7i} = MP (kg ha^{-1}), X_{8i} = Furadan (kg ha^{-1}), X_{9i} = Irrigation cost (Tk ha^{-1}), $v_i - u_i$ = error term

The empirical model of farm specific technical inefficiency model is:

$$u_i = ?_0 + ?_1 z_{1i} + ?_2 z_{2i} + ?_3 z_{3i} + ?_4 z_{4i} + ?_5 z_{5i} + ?_6 z_{6i} + ?_7 z_{7i} + W_i \ldots\ldots (3)$$

Where, z_{1i} = Experience in sugarcane farming (years), z_{2i} = Age of the operator (years),

z_{3i} = Education level of the operator (year of schooling), z_{4i} = Visited by the field worker, z_{5i} = Farm size of the operator (ha), z_{6i} = Dummy for sugarcane training of the operator (1 = yes, 0 = otherwise), W_i are unobservable random variable, which are assumed to be independently distributed, obtained by truncation of the normal distribution with mean zero and unknown variance $?^2$, such that u_i is non-negative.

The ?, ? and ? coefficients are unknown parameters to be estimated, together with the variance parameters which are expressed in term of

$$?^2 = ?^2_u + ?^2_v \ldots\ldots (4)$$

$$? = ?^2_u / ?^2 \ldots\ldots (5)$$

The maximum likelihood estimates (MLE) methods of the parameters of the stochastic production frontier were obtained by using the programme, computer software, FRONTIER 4.1 (Coelli, 1996).

RESULTS AND DISCUSSION

Estimates of stochastic frontier production

The maximum likelihood Estimates (MLE) of the coefficients of stochastic Cobb-Douglas production frontier and inefficiency model showing the maximum production performances are presented in Table1.

In this study to estimate farm specific technical efficiency for sugarcane production, the stochastic frontier production function with yield as dependent variable was estimated in which all variables were standardized on the basis of per hectare of land area. The empirical results indicated that the coefficients of human labour, organic manure, MP, Furadan and irrigation cost were positive and significant at 1 percent level and urea was significant at 5 percent level, while that of animal labour, seed, TSP were positive but not significant. It indicated that human labour, organic manure, MP, Urea, Furadan and irrigation cost had positive and significant impacts on sugarcane production. At 1% level of significance human labour had the largest positive coefficient compared to other inputs. In other words, the elasticity of human labour (0.415) was the biggest amount followed by urea (0.167), MP(0.102), Furadan(0.022), organic manure (0.012) and irrigation cost (0.011). Holding other things remain constant, the yield of sugarcane would increase by 0.415, 0.102,0.022,0.012 and 0.011 percent if farmers apply 1 percent additional human labour, MP, Furadan, organic manure and irrigation cost respectively (Table 1).

Table 1. Maximum likelyhood estimates of the stochastic Cobb-Douglas frontier production function and technical inefficiency model for sugarcane

Independent variables	Parameters	Coefficients	Standard Error	t- ratio
Constant	$?_0$	6.845	0.762	8.982
Ln Human labour	$?_1$	0.415*	0.040	10.375
Ln Animal labour	$?_2$	0.002	0.069	0.029
Ln Seed	$?_3$	0.035	0.095	0.368
Ln Organic manure	$?_4$	0.012*	0.002	6.000
Ln Urea	$?_5$	0.167**	0.082	2.036
Ln TSP	$?_6$	0.072	0.042	1.714
Ln MP	$?_7$	0.102*	0.023	4.434
Ln Furadan	$?_8$	0.022*	0.007	3.142
Ln Irrgation	$?_9$	0.011*	0.002	5.500
Technical inefficiency model:				
Constant	δ_0	0.512	0.301	1.701
Experience	δ_1	-0.017**	0.007	-2.429
Age	δ_2	-0.013	0.011	-1.182
Education (year)	δ_3	-0.020	0.019	-1.053
Frequency of the extension contact	δ_4	-0.049*	0.015	-3.267
Farm size	δ_5	-0.035*	0.016	-2.188
Dummy for sugarcane training (1=Yes, 0= otherwise) Dt	δ_6	-0.037	0.013	-2.846
Variance parameters :				
Sigma- squared	$?^2$	0.009*	0.003	3
Gamma	γ	0.366	0.274	1.3358
Log likelihood function		114.199		
* and ** indicate significant at 1% and 5% level of probability.				

Inefficiency factors of sugarcane production

In order to quantify the determinants of efficiency or inefficiency of sugarcane production, some socio- economic variables were included in the stochastic frontier production function. The coefficients of the explanatory variable in the model of the technical inefficiency effects, defined by equation (3), was of particular interest to this study. The negative and significant coefficient of experience indicated that farmers' experience decreases the inefficiency level i. e. increases efficiency level. This result supports the findings of Khan and Makki (1979) and Coelli (1996).

The coefficient of frequency of the extension contact is negative and significant, which indicated that the farmers were technically more efficient that who make frequent contact with the extension personnel than the farmers who do not contact frequently. Similarly, the negative and significant coefficient of farm size is indicated that larger farmers are more efficient than small farmers and this is similar to Hoassain (2008). The coefficient of education variable is negative, but not significant so we can not say that the educated farmers are more efficient than the illiterate farmers. The coefficient of age variable is negative, but not significant too, therefore, we can not say that the older farmers were not less inefficient than the younger farmers. This result is in line with those of Hossain (1999) and Coelli (1996). The estimated variance (2) is large and significantly different from zero which indicated a good fit and correctness of specified assumption.

Technical Efficiency and Its Distribution

It is observed that the mean value of technical efficiency was 0.80 with a ranged from 0.63 to 0.88 (Table 2). This implied that, on average, the sugarcane production in the study areas was about 80 percent of the potential (stochastic) frontier production level, given the levels of their inputs and the technology currently being used at Rajshahi. This also indicated that there existed an average level of technical inefficiency was 20 percent. The technical efficiency of large, medium and small farmers was 88, 78 and 74 percent respectively. The variation in technical efficiency was observed higher with medium and small farmers (ranged 66-82) and (ranged 63-88) and large farmers variation is lower ranged (88-82) (Table 2). It is found that on an average 79 percent technical efficiency level achieved by more than 70 percent farmers (all). On the contrary, 21% number of all farmers achieved technical efficiency level of less than 70 percent, which indicates that technical efficiency level for a few farmers had comparatively low (Table 3).

Table 2. Farm specific technical efficiency of sugarcane production in the study area

Farm category	No. of farms	Technical efficiency			
		Mean	Maximum	Minimum	Standard deviation
Large	10	0.88	0.88	0.82	0.02
Medium	51	0.78	0.82	0.66	0.02
Small	39	0.74	0.79	0.63	0.01
All	100	0.80	0.88	0.63	0.02

Table 3. Frequency distribution of technical efficiency of sugarcane production

Farm category	Number of farmer under different efficiency level (%)				
	61-70	71-80	81-90	91-100	All
Large	-	-	10(100)	-	10(100)
Medium	1(2)	40(78)	10(20)	-	51(100)
Small	20(51)	19(49)	-	-	39(100)
All	21(21)	59(59)	20(20)	-	100(100)

In conclusion, the overall efficiency level is satisfactory. There were some socio economic factors, which were causes about inefficiency. The research findings indicate that there is a scope to increase efficiency of sugarcane farmers of Rajshahi district by reducing the factor of inefficiencies. The farm specific technical efficiency revealed scope for minimizing inefficiency in sugarcane production.

REFERENCES

Ahmad, M. 2001. Agricultural productivity growth differential in Punjab, Pakistan: A District level Data. *The Pakistan Development Review*, **40**: 1-25.

Aigner, D.J.C.; Lovell, A.K. and Schimidt, P.J. 1977. Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, **6**: 21-37.

Alam, M.M; Haque, M.I and Bokhiar, S.M. 2005. Contribution of sugarcane crop to the national economy of Bangladesh, *Bangladesh J. Sugarcane*, **24-27** : 27-32

Bakh, E.M. and Islam, M.S. 2005. Technical and allocative efficiency of growing wheat in north west districts of Bangladesh. *Bangladesh Journal of Agric. Economics*, **XXVIII**, **(1&2)**:73-83.

Battese, G. E.; Malik, S. J. and Broca, S. 1993. Production function for wheat farmers in selected districts of Pakistan: An application of a dtochastic frontier production function with time -varing inefficiency effects. *Pakistan Development Rev.*, **32** : 233-268.

Coelli, T.J.1996. Specification and estimation of stochastic frontier function. An unpublished *Ph. D. Thesis*. School of economic studies, University of New Englaland, Armidale, Australia.

FAO. 2007. Food and Agricultural Organization , Rome.

Hossain, M.S. 1999. An analysis of the efficiency of cotton farmers in the Punjab province in Pakistan. An unpublished Ph. D. Thesis. Graduate school of Agriculture and resource economics, University of New England, Arm idale Australia.

Jamil, M. and Gopang, A.D. 2004 . Sugarcane scenario, constraints and strategies to improve its production in Pakistan. *Pakistan Sugar Journal*, **XIX(6):** 55-65.

Kabir,M.H. and Alam, M.M. 2001. Technical and allocative efficiency of irrigated sugarcane farms in northwest southwest regions of Bangladesh. *Bangladesh J. Sugarcane*, **23** : 74-79.

Kamruzzaman, M. and Islam, H. 2008. Technical efficiency of wheat growers in some selected sites of Dinajpur district of Bangladesh. *Bangladesh J. Agril. Res.*, **33(3)**:363-373.

Khan, M. H.and Maki, D.R. 1979. Effects of farm size on economic efficiency. The case of Pakistan. *American J. Agric. Econ.*, 64-9.

Kaliranjan, K.P. and Shand, R.T. 1994. Economics in disequilibrium: An approach from the frontier, Macmil lan India Ltd., New Delhi.

Meeusen, W. and Van Den Broeck, J. 1977. Efficiency estimation from Cobb-Douglas production function with composed Error. *International Economic Review.*, **18**:435-444.