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ANALYSIS OF PROFIT EFFICIENCY IN SUGARCANE PRODUCTION IN DISTRICT SARGODHA, PUNJAB, PAKISTAN

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Abstract

The present paper estimates the profit efficiency of Sugarcane farmers in district Sargodha, Punjab, Pakistan. Stochastic production frontier approach (SFA) was applied to estimate the profit efficiency of Sugarcane farmers and for this purpose Primary data was collected by conducting surveys of district Sargodha, Punjab, Pakistan through simple random sampling technique. The analysis revealed that the profit efficiency level was ranged from 61.5 percent to 98.1 percent with mean of 93.0 percent suggesting that 7.0 percent of the profit loss was because of the combination of allocative and technical inefficiency in Sugarcane production. The findings suggested that sugarcane farmers were relatively efficient, but still there are opportunities to increase profit efficiency in their farming activities. The 7.0 percent efficiency gap from optimum 100 percent remains yet to be achieved by sugarcane farmers. The findings exposed that farmers' level of education, farming experience, family size, extension services and mill development activities significantly influenced the efficiency of farmers. Results suggested that efficiency of Sugarcane farmers can be increased through improvements in rural education, effective extension programs and enhancement in mill development activities. The paper describes the application of the stochastic production frontier approach (SFA) to Pakistan.

Keywords: Stochastic Frontier Approach, Allocative, Technical, Sugarcane, Profit Efficiency

INTRODUCTION

Sugarcane is one of the most important cash crops grown in Pakistan. It is also used as a livestock fodder. According to FAO estimates in 2010, sugarcane was cultivated in more than 90 countries and on an area of 23.8 million hectares, with a worldwide harvest of 1.69 billion tonnes. The largest producer of sugarcane in the world is Brazil. In 2010-11, the other leading producers were India, China, Thailand, Mexico, and Pakistan in decreasing amounts of production. The most important motive of sugarcane production is the world demand for sugar. Cane contribution in sugar production is 80 percent, while rest is obtained from sugar beet. Sugarcane is native to the environment of Southeast Asia and South Asia (FAO, 2011). In Pakistan, sugarcane is the major cash crop like rice, wheat and cotton. Its contribution is about 0.7 percent in GDP and 3.4 percent of value added in agriculture (GOP, 2014). For 84 sugar mills it provides raw material. After textiles the sugar industry is the country's second largest agro-industry.

Sugarcane is cultivated under various soils, climatic and hydrological conditions in Pakistan. Pakistan has two major sugarcane-producing provinces, namely Punjab and Sindh. Both provinces account for more than 90 percent of total sugarcane production. It requires huge applications of irrigation water. The crop is sown in February-March in KPK, Punjab and in some parts of Sindh province. This crop requires a minimal growing period of 10 months. The water requirement of this crop is about 6 acre feet. In large parts of Sindh, sugarcane is intercropped with onion and other high value crops.

Sugarcane is largely grown as a cash crop in Pakistan. Production of the crop is therefore motivated by the economic objective of earning a positive economic return. Meeting this objective requires efficient utilization of scarce resources. The measurement of efficiency goes a long way to determine the profitability of an enterprise and agricultural growth is linked to profit (Abdulail and Huffman, 2000).

Thus, it is necessity to examine profit efficiency in sugarcane production and identification of factors affecting inefficiency of sugarcane production. The method that is used for the solution of the problem of efficient utilization of scarce resources focuses on two questions: first, whether farmers are economically (technically and allocativelly) efficient in sugarcane production and second, what factors determine their level of efficiency? Answers to these two questions provide a clue on how we can help farmers for improving their efficiency in utilizing their resources employed in sugarcane production. The capability of a farmer to attain the maximum achievable profit, recognizing the variable input prices and levels of fixed factors of farmer is called profit efficiency. Profit inefficiency is the loss of profit from not operating on the frontier. Productivity and profitability can be increased through efficient utilization of resources and inputs with existing technology in the presence of significant opportunities. Investment in infrastructure, farm management, extension system, input delivery and farmers' skill can improve profit efficiency at the farm level (Ali and Chaudhry, 1990).

Hence the purpose of this research is to analyze the profit efficiency of the sugarcane farmers, recognizing that fixed factors, prices of variable factors which reveal difference in efficiency of individual farmers. Furthermore, socioeconomic characteristics of sugarcane farmers are identified as a source of profit inefficiency.

RESEARCH METHODOLOGY

The Study

The study was conducted in Sargodha district of Punjab Pakistan. The latitude of district is 31^0 norths and longitude is 72^0 easts. The district is agrarian and famous for the production of sugarcane because of favorable climatic conditions. This study is quantitative by nature and descriptive in design

Sampling techniques

The relevant Primary data for the cropping year 2013 was collected for this study from 120 sugarcane farmers of the district. The respondents were selected using simple random sampling technique from two tehsils of the district, 60 respondents from each tehsil. Well structured questionnaire was designed to collect data relating to input and output prices, level of fixed costs and yield. Data were also collected regarding the socioeconomic factors of sugarcane farmers such as level of education, age, farming experience, credit availability, access to mill development activities and extension services.

Stochastic profit frontier model specification

Profit efficiency in this study is defined as profit gain from operating on the frontier, regarding farm-specific variable input prices and level of fixed factors. Profit is measured in terms of Gross Margin (GM) which is the difference between the Total Revenue (TR) and Total Variable Cost (TVC).That is:

$$GM\ (\pi) = \Sigma\ (TR-TVC) = \Sigma\ (PQ-WX_i) \qquad (1)$$

To normalize the profit function, gross margin (π) is divided on both side of the equation above by P which is the market price of the output (sugarcane).That is:

$$\frac{\pi(p,z)}{P} = \frac{\sum(PQ - WX_i)}{P} = \frac{Q - WX_i}{P} = f(X_i, Z) - \sum p_i X_i \qquad (2)$$

Where TR represents total revenue, TVC represents total variable cost, P represents price of output (Q), X represents the quantity of optimized input used, Z represents price of fixed inputs used, P_i = W/P which represents normalized price of input X_i, while $f(X_i, Z)$ represents production function.

Hence for Sugarcane, we have the Cobb-Douglas profit function in implicit form which specifies profit efficiency of the farmers is expressed as follows:

$$\pi_i = f(P_{ij}, Z_{ik}).\ Exp\ (e_i) \qquad (3)$$

Where:

π_i = Normalized profit of firm $_i$ which is gross revenue minus total variable cost divided by the price of output.

P_{ij} = Prices of variable input j of firm i divided by the price of output.

Z_{ik} = Level of fixed input of firm i where k are a number of fixed inputs.

i = 1, 2… n number of farmers in the sample.

e_i = error term consistent with the frontier concept (Ali and Flinn, 1989).

Where

$$e_i = v_i - u_i \quad (4)$$

The error term μ_i measures profit inefficiency and v_i measures random factors. When $\mu_i = 0$, maximum profit is obtained by the firm and operate on the frontier regarding the prices and fixed factors. If $\mu_i > 0$ the firm is economically inefficient and the profit is lower than the maximum.

The profit efficiency is also defined as the ratio of predicted actual profit to the predicted maximum profit for a best-practiced Sugarcane farmer and this is represented as follows:

Profit Efficiency (Eπ) = $$\pi = \frac{\exp[\pi(p,z)]\exp(\ln V)\exp(-\ln U)-\theta}{\exp[\pi(p,z)]\exp(\ln V)-\theta} \quad (5)$$

Firms specific profit efficiency is the mean of the conditional distribution of Ui given by Eπ and is defined as:

$$E\pi = E\,[\exp(-U_i)/Ei] \quad (6)$$

Eπ takes the value between 0 and 1. If $U_i = 0$ i.e. on the frontier, obtaining potential maximum profit given the price it faces and the level of fixed factors. If $U_i > 0$, the firm is inefficient and results in profit loss.

The variance of the random errors, σ_v^2 and that of the profit inefficiency effect σ_u^2 and overall variance of the model σ^2 are related thus: $\sigma^2 = \sigma_v^2 + \sigma_u^2$, measure the total variation of profit from the frontier which can be attributed to profit inefficiency (Battese and Corra, 1977). Battese and Coelli (1993) provided log likelihood function after replacing σ_v^2 and σ_u^2 with $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and thus estimating gamma (γ) as: $\gamma = \sigma_u^2 / \sigma_v^2 + \sigma_u^2$

The parameter γ represents the share of inefficiency in the overall residual variance with values in interval 0 and 1. A value of 1 suggests the existence of a deterministic frontier, whereas a value of 0 can be seen as evidence in the favour of OLS estimation. To assess the suitability and significance of the adopted model statistical tests are required. Log likelihood-ratio test is an appropriate testing procedure, which permit the assessment of a restricted model with respect to the adopted model (Bohrnstedt and Knoke, 1994). The test statistic of this test is expressed as:

$$LL = -2[\ln L(H_0)/ L(H_1)] = -2[\ln L(H_0) - L(H_1)] \quad (7)$$

Empirical model

The explicit Cobb-Douglas functional form for the sugarcane farmers in the study area is therefore specified as follows:

$\ln\pi_i = \ln\beta_0 + \ln\beta_1 P_{1i} + \ln\beta_2 P_{2i} + \ln\beta_3 P_{3i} + \ln\beta_4 P_{4i} + \ln\beta_5 P_{5i} + \ln\beta_6 P_{6i} + (V_i - U_i)$ (8)

Where

π_i = normalized profit computed as total revenue less variable cost divided by firm specific sugarcane price

P_1 is the cost of fertilizer, P_2 is the cost of pesticide, P_3 is the cost of irrigation, P_4 is the cost of seed and P_5 is the cost of labour.

Inefficiency Model

The inefficiency model (**U_i**) is defined as

$U_i = \delta_0 + \delta_1 W_{1i} + \delta_2 W_{2i} + \delta_3 W_{3i} + \delta_4 W_{4i} + \delta_5 W_{5i} + \delta_6 W_{6i} + \zeta i$ (9)

Where W_i are the farm-specific managerial and household characteristics. These socio economic variables are included in the model to indicate their possible influence on the profit efficiencies of the rice farmers (determinant of profit efficiency).

Where, W_1, W_2, W_3, W_4, W_5 and W_6 represent family size, farming experience, education level of farmers, Mill development activities, credit access (dummy) and extension services (dummy). The parameters of stochastic frontier profit function and inefficiency model are estimated by using the program Frontier 4.1c (Coelli, 1996).

EMPIRICAL RESULTS AND DISCUSSION

The descriptive statistics of the variables used in this study is given in Table 1. The mean sugarcane yield was 765 maunds (40 kilograms) per acre with a standard deviation of 149 kg per acre. The average price of output was recorded as 132 rupees per maund. The average profit was 91077 rupees per acre with a standard deviation of 29275 rupees per acre. The average area under sugarcane was recorded as 7 acres with a standard deviation of 3.74 acres. The average farming experience is 22.5 years.

Table 1: Descriptive statistics of variables in stochastic frontier model

Variables	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**
Sugarcane yield (maunds)	500	1200	765	149
Profit (Rs.)	17850	161498	91077	29275
Output price (Rs/maund)	100	150	132	17.25
Area under sugarcane (acres)	3	17	7	3.74
Seed price (Rs/marla)	1870	4300	1526.9	789.76

NPK price (Rs/kg)	55	218	120.1	30.61
Hired labour wage (Rs/ Man-days)	124	652	331.58	96.83
Irrigation Cost (Rs)	840	1260	1015.7	123.25
Pesticide cost (Rs/litre)	132	574	314.8	96.75
Education (years)	5	14	8	1.29
Farming experience (years)	5	40	22.5	9.52
Family size	3	13	7	2.14

Presence of profit inefficiency effects among sugarcane farmers in the study area as confirmed by a test of hypothesis. Null hypothesis given cited in Table 2 is Ho: γ = 0, which specifies that the inefficiency effects in the stochastic profit frontier are not stochastic. Log likelihood ratio test is used to test the hypothesis:

$LL = -2[\ln L\ (H_0)/\ L\ (H_1)] = -2[\ln L\ (H_0) - L\ (H_1)]$

$= -2(91.04-118.54) = 55.00$

The generalized likelihood ratio test which is defined by the Chi-square (χ2) distribution shows that the computed Chi-square is 55.00 while the critical value of the Chi-square at 5 percent level of significant with 5 degree of freedom χ2 (5 percent, 5) is 11.02 . The null hypothesis is rejected. This implies that the traditional response function (OLS) is not an adequate representation of the data.

Table 2: Generalized likelihood ratio test of hypothesis

Null Hypothesis	**χ^2 statistics**	**Critical value (5%)**	**Decision**
Ho: γ = 0	55.00	11.02	Rejected

The estimated parameters of the stochastic profit frontier function are given in Table 3. The results demonstrate that estimated coefficients of the parameters of normalized profit function are positive and significant except the cost of irrigation. This explains that a unit increase in input prices will increase the profit of sugarcane farmers.

Furthermore, the coefficient of gamma parameter (γ) of 0.75 in Table 3 was significant at 1 percent level of significance. This implies that one-sided random inefficiency component strongly dominates the measurements error and other random disturbance indicate that about 75 percent variation in actual profit from maximum profit between farms was contributed from differences in farmers' practices and 25 percent due to stochastic random error. The estimated value of σ^2 is highly significant at 1 percent which confirm with Hjalmarsson *et al.,* (1996) and Sharma *et al.,* (1997). This suggests that a traditional response function OLS does not adequately represent data which does not include random error produced due to inefficiency.

Table 3: Maximum likelihood estimates of stochastic profit frontier function

Variables	Parameters	Coefficients	T-ratio
Profit Function			
Constant	β_0	0.54	28.32*
Cost of Fertilizer per bag (P_1)	β_1	0.39	24.79*
Cost of pesticide per litre (P_2)	β_2	0.89	2.92*
Cost per irrigation (P_3)	β_3	-0.41	0.57^{ns}
Cost of seed (P_4)	β_4	0.26	1.81***
Labour wage per day (P_5)	β_5	0.75	2.19**
Inefficiency Model			
Constant	δ_0	0.39	0.25^{ns}
Family size	δ_1	0.21	2.04 **
Farming experience (years)	δ_2	-0.37	-3.45 *
Educational level	δ_3	-0.19	-3.30 *
Mill Development activities	δ_4	-0.14	-1.92***
Credit access	δ_5	0.43	0.560ns
Extension contact	δ_6	0.24	1.31^{ns}
Variance Parameters			
Sigma-square σ^2	$\sigma^2 = \sigma_v^2 + \sigma_u^2$	0.20	3.87*
Gamma γ	$\gamma = \sigma_u^2 / \sigma^2$	0.75	11.24*
Log likelihood		118.54	

*Note: *, **, *** represent level of significance at 1, 5, and 10 percent respectively*

The estimated parameters of determinants of profit efficiency are also presented in Table 3. The results of inefficiency model shows that estimated coefficients of farming experience, education and mill development activities have negative signs which implies that these variables decrease the profit inefficiency of farmers.

Profit Efficiency Estimates of the Farmers

The distribution of profit efficiencies of sugarcane farmers in the sampled area is presented in Table 4. The Table shows that mean profit efficiency is 93 percent. The maximum efficiency score is 98 and minimum is 61 percent respectively. The average measure of 93 percent of profit efficiency implies that profit can be increased by 7 percent by improving their technical and allocative efficiency. There are only 10 percent farmers who have below efficiency 70 percent.

Table 4: Profit Efficiency Estimates of the Farmers in district Sargodha

Efficiencies	Frequency	Relative frequency
Below 70%	12	10.00
71%-80%	26	21.66
81%-90%	50	41.67
91%-100%	32	26.67
Total	120	100

Overall Efficiency (percent)	
Mean efficiency score	93
Maximum	98
Minimum	61

CONCLUSIONS AND POLICY RECOMMENDATIONS

The purpose of this study was to determine the level of farm specific profit efficiency of sugarcane farmers and to identify the factors associated with profit inefficiency. In this study a stochastic profit function and inefficiency effect model was estimated. The stochastic profit frontier model of Cob-Douglas type was used to obtain maximum likelihood estimates of the parameters of input prices and inefficiency variables. The maximum likelihood results showed that profit efficiency of sugarcane farmers is different due to presence of profit inefficiency in sugarcane production. The results indicated that all inputs had positive sign on the profitability of sugarcane farmers except irrigation cost. The primary reason of this negative sign is that due to recent energy crises the prices of oil and electricity had increased.

The distribution of profit efficiencies of sugarcane farmers in the study area showed that sugarcane farmers were relatively efficient in their resource allocation, assessed by the fact that 42 percent farmers having profit efficiency range of 80-90 percent. The results of inefficiency model shows that estimated coefficients of farming experience, education and mill development activities have negative signs except family size, credit access and extension services which implies that these variables decrease the profit inefficiency of farmers.

In conclusion, there is dire need to invest in rural education, expand mill development activities and effective extension programs which will increase the profit efficiency of sugarcane farmers. The results of this study reveal that using the stochastic profit frontier allows a detailed analysis of farm efficiency. Further work is required to examine the effects of soil and climatic conditions when examining determinants of profit efficiencies. Due to financial constraints and lack of time this study restricted only to one Punjab, Pakistan district.

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