Quality of Inputs and Technical Efficiency Nexus of Citrus Farmers: A Case Study of Sargodha District, Punjab (Pakistan)

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Abstract

This study reports the results of an investigation into the technical efficiency of citrus farmers of Sargodha District of Punjab Province. The method employed was the stochastic frontier production function approach suggested by Battese and Coelli (1995) for cross sectional data. The model was estimated by using the data on 82 citrus farmers for the period 2008. The coefficients of the production function revealed that the use of more water and nitrogen by the farmers involved in intercropping reduced citrus output. The estimates of technical efficiencies of the farmers range from 0.53 to 0.98 while the mean technical efficiency was 0.88. This suggests that 12 % of citrus output forgoes because of inefficiency. Quality of inputs like water and land were found to be significant determinants of technical efficiency of the citrus farmers.

Keywords: Stochastic frontier, inefficient inputs, technical efficiency, citrus farmers

1. INTRODUCTION

Attempts by researchers to measure the efficiency of citrus formers in the Pakistan are relatively few and very little research efforts have been directed for the issue of technical efficiency (i.e. the ability to convert inputs into output) of the sector.

Efficiency score of firm or farmer is usually estimated by stochastic frontier approach. This approach is based on the seminal work of Aigner et al. (1977). The basic idea of stochastic frontier analysis lies in the additive error term which consists of a noise and an inefficiency term. The stochastic frontier production function provides a satisfactory, but not the perfect, mean of estimating the degree/extent of technical inefficiency. The stochastic frontier approach recognizes that a farmer or firm`s inability to produce exactly which would be expected from the firm or farmer, may not be only due to technical inefficiency but also due to the random effects outside firm`s control.

The critical importance of efficiency gains has been recognized by researchers as well as policy makers. A sizeable work has been done for the measurement of productive efficiency since the Farrel`s (1957) work. In the last two decades, a variety of models has been developed for the measurement of technical efficiency for example Meeusen and Brock (1977), Kumbhakar (1990, 1991), Greene (1993), Battese and Coelli (1992, 1993, 1995), Battese et. al. (1993), Battese and Broca, (1997), Rao and Coelli (1998) but still there is a little attention for citrus sector in this regard, in Pakistan.

This study seeks to utilize stochastic frontier method for the measurement of technical efficiency of citrus farmers. This model has the advantage that we can, simultaneously estimate the parameters of production frontier and farmer efficiency score, given that the assumptions about the distributions of errors terms.

Following are the central reasons to measure the technical efficiency of citrus farmers. First, this sector contributes a valuable share of agriculture output of Pakistan`s economy. Moreover, it is source of foreign exchange earnings. Second, after the implementation of world trade order (WTO), like the other sectors, citrus sector has come under international competition. It alarms that only competent and proficient sectors will stand in the global market/economy. Third, policy issues, for making citrus sector more aggressive, are incredibly essential. Information on productive use of inputs and technical efficiency is indispensable to provide help to the policy makers for drawing the policy measures.

The study`s objectives are: to measure the technical efficiency scores of the citrus farmers and to look over the sources of technical inefficiency of the sector. In the present study, the analysis of the data of citrus farmers focuses on the estimation of stochastic frontier production function for which the technical inefficiency is presumed to be function of total operational land and quality of inputs like land and water.

The paper is prepared as follows. In section 2 we have outlined the source of data for study and explained the methodology and model specification. Section 3 presents empirical results and discussion. Finally, section 4 provides conclusion and policy recommendations.

2. DATA AND METHOD OF ANALYSIS

The primary data used for study were obtained from 82 citrus farmers of district Sargodha in 2009. Sargodha is the Pakistan`s best citrus producing area. For this study, the Cobb-Douglas stochastic frontier production function was found to be an adequate model for the data. The model to be estimated is defined as:

$$\ln Y_i = \beta_0 + \sum_{j=1}^{5} \beta_j \ln X_j + V_i - U_i \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

i=1,2,………………82

Where i indicates ith farmer in the sample.

Y_i is total value of output of ith farmer

X_1 is total amount of the land (in acres) used for citrus production

X_2 is total labor measured in working days

X_3 is amount of nitrogen (in kg) applied to the land

X_4 is amount of phosphorus (in kg) applied to the land

X_5 is number of irrigations applied to land

V_i`s are random errors which are associated with measurement error in production and those stochastic factors which are not in control of farmer. $V_i$`s are assumed i.i.d and N $(0, \sigma_v^2)$ and independent of U_i.

U_i`s capture technical inefficiency of production and are non-negative random variables. $U_i$`s are assumed to be independently distributed, such that U_i is obtained by truncation at zero of normal distribution with variance σ^2 and mean μ_i, where the mean is define as:

$$\mu_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 \ldots\ldots\ldots\ldots\ldots (2)$$

Where

Z_1 is farmer`s experience in years

Z_2 is farmer`s education in years

Z_3 is total area of land operated by citrus farmer

Z_4 is a dummy variable for quality of water(if quality of water is not good then Z_4 = 1 and Z_4 = 0 if quality of water is good)

Z_5 is a dummy variable for quality of land (if quality of land is not good then Z_5 = 1 and Z_5 = 0 if quality of land is good)

The model defined by (1) and (2) is a special case of the model for panel data proposed by Battese and Coelli (1995). In which, they modeled the inefficiency effects (U_i`s) in terms of other explanatory variables (i.e age, education etc.) in the stochastic frontier and estimated all the parameters of the model by using the maximum likelihood method. Given the specification of (1) and (2), the technical efficiency of ith farmer is defined as;

$$TE_i=\exp(-U_i)$$

All the parameters of (1) and (2) and the technical efficiencies of farmers are obtained by using computer software FRONTIER 4.1, written by Coelli (1996). FRONTIER 4.1estimates the parameters of stochastic frontier model together with variance parameters expressed as:

$$\sigma_s^{\,2}=\sigma_v^{\,2}+\sigma^2 \qquad \gamma=\frac{\sigma^2}{\sigma_s^{\,2}}$$

3. RESULTS AND DISCUSSION

The maximum likelihood estimates of the parameters of the Cobb-Douglas stochastic frontier production function are given in Table 1. These estimates have been obtained by using computer program FRONTIER 4.1. The coefficients of the inputs are output elasticities with respect to the inputs.

Table 1: Maximum Likelihood Estimates for the Parameters Cobb Douglas Stochastic Frontier Model

Variables	**Coefficients**	**S.E**	**t-ratio**
Constant	5.35	0.108	49.5*
X_1	-0.055	0.049	-0.12
X_2	0.063	0.008	7.80*

X_3	-0.232	0.115	-2.02*
X_4	0.071	0.008	8.87*
X_5	-0.089	0.080	-1.12

***Significant at 5%**

The coefficients of stochastic frontier are according to expectations, with the exception of negative sign of land but it is insignificant. The sign of coefficient of labor variable shows expected positive relationship of labor and value of the output. The coefficients for Nitrogen and number of irrigations are -0.232 and -0.089 respectively. The negative sign of coefficient of Nitrogen shows that the use of more Nitrogen decreases the total output of citrus and a similar picture can be observed from the negative sign of number of irrigations.

In order to investigate the determinants of inefficiency, the technical inefficiency model was evaluated; results are presented in Table 2. The coefficients of the variables included in technical inefficiency model, are of particular interest for us, in the present study.

Table 2: Results of Technical Inefficiency

In-efficiency Model			
Variables	**Coefficients**	**S.E**	**t-ratio**
Constant	-8.13	16.71	-0.49
Z_1	0.66	0.13	5.07*
Z_2	0.262	0.485	0.540
Z_3	-0.03	0.007	-4.28*
Z_4	0.122	0.036	3.38*
Z_5	0.315	0.059	5.33*
Variance Parameters			
Sigma-squared	0.558	1.162	0.48
Gamma	0.994	0.012	83.6*

***Significant at 1%**

In the inefficiency model, the coefficient of education is positive but it is not significant. The coefficient of operated land is negative which shows that citrus farmers who operate smaller farms are more inefficient than those with larger farms in Sargodha district or effect of increasing operated land reduces inefficiency of production of citrus farmers in Sargodha district. Moreover, the coefficient of quality water is positive which shows that technical efficiency of citrus farmers will increase if quality of water is good, in other words, the technical inefficiency of farmers increases as quality of water becomes bad. The same is the true for quality of land because its coefficient is also positive; both the coefficients are highly significant.

The value of estimate of variance parameter γ (Gamma), which is associated with the variability of the technical inefficiency effects, is very close one , this shows that technical inefficiency effects are highly significant in analysis of the of production of citrus in Sargodha district. However, the estimate of variance of random error term σ_s^2 (Sigma-squared) is not significant.

TECHNICAL EFFICIENCIES

The estimated technical efficiencies of the citrus farmers in percentage are reported in Table 3. The estimates of technical efficiencies of the farmers range from 0.53 to 0.98 while the mean technical efficiency is 0.88. Which shows that on average approximately 12 % of citrus output is lost due to technical inefficiency. This also indicates that there exist a potential to increase citrus production, with available resources and technology.

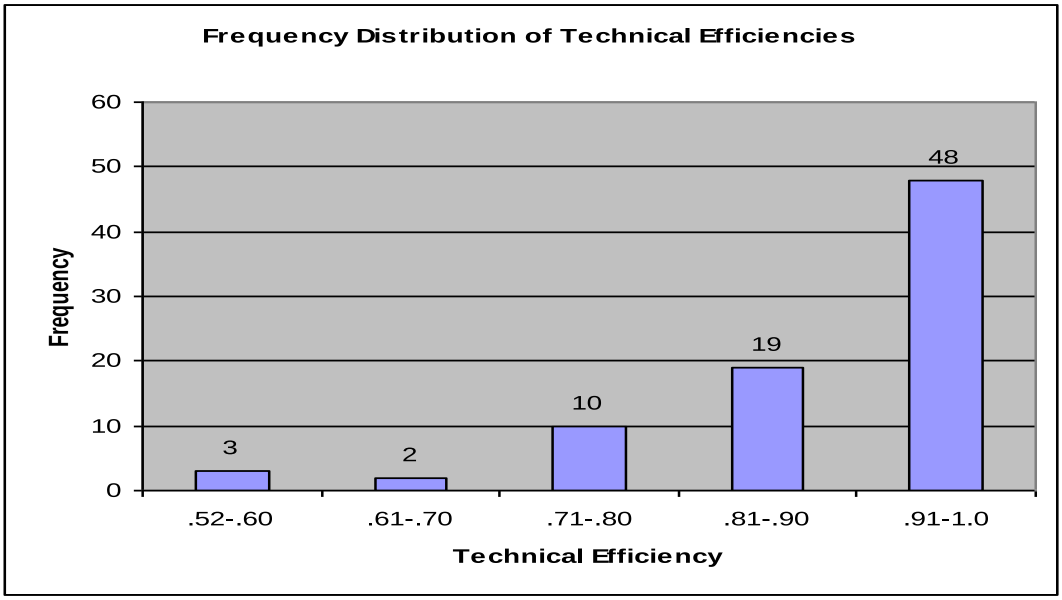
Table 3: Technical Efficiencies of Citrus Farmers (in percentage)

Farmer No.	Technical Efficiency	Farmer No.	Technical Efficiency	Farmer No.	Technical Efficiency
1	0.90	29	0.84	57	0.75
2	0.98	30	0.97	58	0.89
3	0.91	31	0.98	59	0.95
4	0.97	32	0.93	60	0.93
5	0.91	33	0.90	61	0.97
6	0.97	34	0.95	62	0.93

7	0.86	35	0.95	63	0.91
8	0.72	36	0.90	64	0.94
9	0.96	37	0.93	65	0.83
10	0.96	38	0.92	66	0.95
11	0.94	39	0.75	67	0.93
12	0.91	40	0.85	68	0.81
13	0.94	41	0.74	69	0.96
14	0.96	42	0.96	70	0.79
15	0.94	43	0.82	71	0.96
16	0.92	44	0.84	72	0.97
17	0.67	45	0.92	73	0.90
18	0.85	46	0.91	74	0.78
19	0.97	47	0.97	75	0.93
20	0.95	48	0.83	76	0.94
21	0.60	49	0.92	77	0.91
22	0.96	50	0.95	78	0.90
23	0.97	51	0.73	79	0.87
24	0.57	52	0.95	80	0.97
25	0.52	53	0.61	81	0.91
26	0.94	54	0.79	82	0.89
27	0.85	55	0.76		
28	0.71	56	0.92		
Mean Technical Efficiency = 0.88					

The graph of frequency distribution of the estimates of technical efficiencies is given in Figure 1. The figure shows that distribution of technical efficiencies is negatively skewed in shape, with a relatively large number of farmers have a technical efficiency greater than 0.90.

Figure 1: Frequency Distribution of Technical Efficiencies of Citrus Farmers in Sargodha District



4. CONCLUSION AND POLICY RECOMENDATIONS

In present study, nexus between quality of inputs and technical efficiency of citrus farmers was investigated by using the data of 82 citrus farms situated in the major citrus production district of the Pakistan. The empirical analysis shows that the technical inefficiency affects for the citrus farmers are highly significant. Moreover, technical efficiency was found positively related with good quality of inputs like water and land. Our results also confirmed the inverse relationship of operated land size and technical inefficiency. It implies that decreases in operated land size are related with increases in technical inefficiency of citrus farmers. Findings of the study suggest that government should provide quality water to citrus farmers. Irrigation department can play important role in this regard. For improvement of land, modern techniques should be used by the farmers and government should support the farmers for this.

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