Vol.4, No.10, 536-540 (2013)
http://dx.doi.org/10.4236/as.2013.410072 Agricultural Sciences

Technical efficiency analysis of hybrid maize production using translog model case study in District Chiniot, Punjab (Pakistan)

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Received 9 January 2013; revised 10 February 2013; accepted 15 March 2013

ABSTRACT

In Pakistan, maize accounts for 5.93 percent of the total cropped area and 4.82 percent of the value of agricultural production. Given high cost of the production, there is a belief that it is difficult to boost profitability without enhancing use of pricey inputs. Maximum likelihood estimates of stochastic frontier model were estimated and determinants of technical efficiency were calculated. Using Cobb Douglas model estimated maximum likelihood coefficients for all inputs were significant and showed signs according to expectations. The evaluation with the different models gives different technical efficiencies, which shows that technical efficiency estimations are extremely sensitive to the functional form specified.

Keywords: Maize; Translog Model; Maximum Likelihood Coefficients

1. INTRODUCTION

Maize (*Zea mays* L.) is the third cereal for Pakistan after wheat and rice and it accounts for 5.93 percent of the total cropped area and 4.82 percent of the value of agricultural production. Maize being the highest yielding cereal crop in the world is of significant importance for countries like Pakistan, where rapidly increasing population has already out stripped the available food supplies output. Area under maize occupies the third position after wheat and rice, 98% of which is grown in Punjab and N.W.F.P. It is intensely grown on worldwide bases and often referred as “king of grain crops” [1]. It is grown on an area of 1083 thousand hectares with a yearly production of 4271 thousand tones and it has 3944 kg/hectare yield per hectare [2].

Mostly the farms with the same resources are producing different per acre output, because of management inefficiency. The scanty or no role of extension services, poor right of entry to credit, tenant cultivation, low literacy rate, poor communications facilities, and long distance from markets [3] characterize inefficient farms. At present yield level is still up to some extent lower than the potential of our existing varieties. Main constraints to enhance maize productivity are unfavorable weather conditions, unavailability of input at proper time, suboptimal plant density, late sowing, inadequate fertilizer use, inadequate water supply, weed infestation, insect pest attack and the selection of unsuitable cultivars under a given set of environments. Consequently, a farmer’s ability to increase his income and productivity level is constrained by a number of factors of which many fall out of his control. Pakistani maize farmers are constrained with many such factors as acquisition of inputs with limited resources.

Normally, the efficiency levels are low when compared to the international per acre productivity: no doubt, some of the factors contributing towards the low productivity are out of control. This inefficiency is also termed as technical inefficiency and Farrel [4] developed its concept. Broadly speaking, technical inefficiency is the failure to produce maximum output from a given level of inputs.

This efficiency has two components: technical and allocative. Technical efficiency is the ability of a firm to produce a maximal output from a given set of inputs or it is the ability of a firm to use as modest inputs as possible for a given level of output. The former is called input oriented measures and the latter is known as output-oriented measures of technical efficiency. Productivity can be increased through more efficient utilization of resources of farmers and inputs with current technology. In this study, efficiency of maize producers of District Chiniot is evaluated. Interrelationship between efficiency level and various firm specific factors provides useful policy related information. Main objective of the study is to calculate the technical efficiency and determinants of inefficiency of maize growers. A particular objective of the study is to identify the factors causing technical inefficiency by examining the relationship between efficiency level and various firm specific factors.

2. MATERIALS AND METHODS

The primary data was used in this study, which was collected from District Chiniot during the year 2010-11. In order to collect data, random sampling technique was used. The sampling procedure involved the three stages: selection of tehsils, selection of villages, and selection of farmers (respondents). Three tehsils were selected for collecting data and three villages were selected from each selected Tehsil. A sample of 120 farmers was taken as total by dividing equally into three groups (large, medium and small) by farm size. A farm was considered small if farm size is less than or equal to 12.5 acres, medium if farm size was more than 12.5 acres and less than 25 acres, and large if farm size is equal to or greater than 25 acres. Three sampling frames were designed at village level by making strata of small, medium and large farmers. Five farmers were selected from each stratum randomly.

2.1. Statistical Analyses

The Cobb-Douglas and Translog production frontier functions defined and the inefficiency model were jointly projected by the maximum-likelihood (ML) method using FRONTIER 4.1 [5]. By taking the same indicators for the both models, it is clear from the results that Translogrithmic function has a more robustness over the Cobb-Douglas because the mean technical efficiency from the of prior was up to 94% while for subsequent model it was 81.06%.

At this juncturevariant of the stochastic function approach proposed by Battese and Coelli [6] and continued by Greene [7], Hassan [8] and Dey *et al.* [9] in which technical inefficiency effects in a stochastic frontier are an explicit function of other farm specific explanatory variables, and all parameters are estimated in a single-stage maximum likelihood (ML) procedure. The stochastic production frontieris,

$$\ln Y_i = \beta_0 + \sum \beta_j \ln\left(X_{ij}\right) + \left(v_i - u_i\right),$$

Here, Y_i is the yield of maize for the *i*-th farm, x_i is a vector of inputs (or cost of inputs), β is a vector of *i*-th unknown parameters, $(v_i - u_i)$ is an error term. The stochastic frontier is also called composed error model, because it shows that the error term $(v_i - u_i)$ is decomposed into two components: a stochastic random error component (random shocks) v_i and a technical inefficiency component u_i. Where V_i is a symmetrical two sided normally distributed random error that contains stochastic effects which are uncontrolled. It is assumed to be independently and identically distributed $N\left(0, \sigma_v^2\right)$. The term μ_i, is one side ($\mu_I \geq 0$) efficiency component. The two error component (v and μ) are also assumed to be independent of each other. The variance parameters of the model are parameterized as:

$$\sigma_s^2 = \sigma_v^2 + \sigma_u^2; \quad \gamma = \frac{\sigma_u^2}{\sigma_s^2} \text{ and } 0 \leq \gamma \leq 1$$

2.2. Cobb-Douglas Function

$$\ln Y_i = \beta_0 + \beta_1 \ln\left(X_1\right) + \beta_2 \ln\left(X_2\right) + \beta_3 \ln\left(X_3\right) + \beta_4 \ln\left(X_4\right) + \beta_5 \ln\left(X_5\right) + V_i - U_i$$

where, Y_i is the quantity of output (Kg): X_1 is the land preparation cost (Rs); X_2 is N, P, and K nutrients applied (Kg); X_3 is the total irrigation (number); X_4 is the total chemical cost counting both weeding and insecticide cost (Rs) and X_5 is thetotal threshing cost (Rs).

Inefficiency regression equation can be written as,

$$u_i = \delta_o + \sum \delta_i Z_i, \; i = 1$$

where, Z_i are farm-specific variables that may cause inefficiency and δ_o and all δ_i are coefficients to be estimated. Z_1 is farming experience (year); Z_2 is the education (year); Z_3 is the credit it is in the form of dummy variable it has value 1 if farmer avails credit otherwise it would be equal to 0; Z_4 is the extension facilities, dummy variable assuming value 1 if farmer avails extension facilities, otherwise 0; Z_5 is the maize cropped area (acre); Z_6 is the dummy variable for sowing time assuming value 1 if farmer sow timely, otherwise 0.

2.3. Translogrithmic Model

$$\ln Y_{it} = \beta + \sum \beta \ln X_{it} + \sum\sum \beta\left(X_{it}\right)\left(\ln X_{jt}\right) + V_{it} - \mu_{it}$$
$$i = 1, 2, 3 \cdots n, \; t = 1, 2, 3 \cdots n$$

Inefficiency model and variables were same as the Cobb-Douglasmodel.

3. RESULTS AND DISCUSSION

The summary statistics related tothe variables used in analysis is given in **Table 1**.

It is clear from the table the mean yield was 3570 kg, farming experience was 22.7 year, up to 15 irrigations

Table 1. Summary statistics for variables in the stochastic frontier production functions.

Variables	Mean	Std. Deviation	Minimum	Maximum
Yield (Kg)	3570	12.79	2600	4800
Farming Experience (Year)	22.47	14.65	2	50
Irrigation No	14.78	3.72	10	23
Maize Area (Acre)	7.07	6.17	1	30
Chemical Cost (Rs.)	1733.58	235.02	1200	2550
Threshing Cost (Rs.)	5368.26	29282.65	1850	324,780
Land Preparation Cost (LPC) (Rs.)	10005.42	1285.73	5250	13,550

were applied on average, and farm area was 7 acre. While for the case of costs, the average chemical, threshing and LPC were 1734, 5368 and 10,005 rupees respectively.

3.1. Results of Cobb-Douglas Function

The OLS as well as ML estimates of the estimated Cobb Douglas model are given in **Table 2**. The estimate of γ is 0.71, which indicates that the vast mass of error variation is due to the inefficiency error u and not due to the random error v_i. This explores that the random component of the inefficiency effects does make a significant contribution in the analysis. The one sided LR test of $\gamma = 0$ provides a statistic of 26.26 which exceeds the chi-square five percent critical value. It indicates that stochastic frontier model has significant progress over an average (OLS) production function. Maximum likelihood coefficient of fertilizer showed a positive value of 0.31, which was significant, it means by escalating use of all fertilizers by 1% would increase maize yield by 0.31 percent, decreasing return to scale. The estimated ML coefficients for all inputs were significant at 1 percent and positive except land preparation cost (LPC) which was negative, means it has inverse relation with output.

In case of inefficiency variables coefficients of education, extension services, maize cropped area, and sowing time showed negative values. The negative coefficient for education suggests that the educated farmers are more efficient than others are. Those farmers were found to be more efficient than others who have enjoyed extension services and completed in time sowing of maize.

3.2. Results of Translog Production Function

A stochastic translog production frontier is employed in order to select best functional form. The model encompasses the Cobb-Douglas form, so test of first choice for one form over the other can bed one by analyzing significance of cross terms in the translog form [10]. To review the economic plausibility of the calculated coefficients of translog form is very difficult job and cumber some due to its multifaceted nature. It is, therefore, more suitable to estimate some more easily interpreted estimates [11], oftenly production elasticities of inputs are used also, but here estimated coefficients of translog form are used for coefficients interpretation as Basnayake and Gunaratne [10].

Table 2. OLS and Maximum likelihood estimates for parameters of the stochastic frontier (Cobb-Douglas) for Hybrid Maize Producers.

Variables	Parameters	Coefficients OLS	Coefficients MLE	t-Ratio OLS	t-Ratio MLE
Intercept	β_0	1.24	0.54	1.68^{***}	0.68^{ns}
Land Preparation Cost (LPC)	β_1	−1.11	−0.09	-2.15^{**}	-1.84^{*}
NPK (Kg)	β_2	0.35	0.31	4.31^{*}	3.48^{*}
Total Irrigation Number	β_3	0.23	0.19	4.97^{*}	4.14^{*}
Total Chemical Cost	β_4	0.16	0.19	2.24^{**}	2.87^{*}
Total Threshing Cost	β_5	0.78	0.71	10.75^{*}	10.03^{*}
Inefficiency Parameters	**Parameters**	**Coefficients**		**t-Ratio**	
Intercept	δ_0	0.11		1.49^{ns}	
Farming Experience (Year)	δ_1	0.0004		0.44^{ns}	
Education (Year)	δ_2	−0.001		-0.32^{ns}	
Credit	δ_3	0.04		1.07^{ns}	
Extension Services	δ_4	−0.03		-0.82^{ns}	
Maize Cropped Area (Acre)	δ_5	−0.01		-2.68^{*}	
Sowing Time	δ_6	−0.01		-0.32^{ns}	

The ML estimates are given in **Table 3**, where coefficient of land preparation cost (LPC), NPK, and total threshing showed significant effect on output. However, the coefficient of NPK Sqr and total threshing cost Sqr were negative.

The mean technical efficiency obtained from the translog function was 94.10 percent. No one of the parameters in the inefficiency model showed significant effect on inefficiency. Outcome for inefficiency parameters are also given in **Table 3**. Technical efficiency estimates by Cobb-Douglas and translog models are at variance immensely. The Translogrithmic function shows more robustness over the Cobb-Douglas because the mean technical efficiency from the Cobb-Douglas model was 81.06 percent while the translog model showed a mean technical efficiency of 94.10 percent.

Table 4 shows distribution of technical efficiencies for various farm groups. Technical efficiency ranges from as low as 0.75 percent to as high as 0.96 percent.

4. CONCLUSION

The primary objective of this study was to evaluate technical efficiency of hybrid maize farmers of District Chiniot and to discover their inefficiency factors. Results obtained showed that from the stochastic frontier estimation, the average technical efficiency given by the Cobb-Douglas

Table 3. Maximum likelihood estimates for parameters of the stochastic frontier (translog) for hybrid maize producers.

Variables	Parameters	Coefficients	t-Ratio
Stochastic Production Function			
Intercept	β_0	13.03	12.67*
Land Preparation Cost (LPC)	β_1	7.03	2.78*
NPK (Kg)	β_2	3.76	3.90*
Total Irrigation Number	β_3	−1.42	−0.88ns
Total Chemical Cost	β_4	3.31	1.32ns
Total Threshing Cost	β_5	5.36	4.53*
LPC Sqr.	β_6	0.14	1.36ns
NPK Sqr.	β_7	−1.38	−3.21*
Total Irrigation Number Sqr.	β_8	0.11	0.11ns
Total Chemical Cost Sqr.	β_9	0.31	0.94ns
Total Threshing Cost Sqr.	β_{10}	−0.32	−0.82ns
LPC * NPK	β_{11}	1.71	4.06*
LPC * Total Irrigation Number	β_{12}	−0.68	−3.21*
LPC * Total Chemical Cost	β_{13}	−0.34	−1.06ns
LPC * Total Threshing Cost	β_{14}	−0.02	−0.05ns
NPK * Total Irrigation Number	β_{15}	1.23	2.85*
NPK * Total Chemical Cost	β_{16}	−1.13	−2.10**
NPK * Total Threshing Cost	β_{17}	1.09	1.34ns
Total Irrigation Number * Total Chemical Cost	β_{18}	1.28	3.87*
Total Irrigation Number * Total Threshing Cost	β_{19}	−1.11	−3.87*
Total Chemical Cost * Total Threshing Cost	β_{20}	−0.28	−3.28*
Technical Inefficiency Function			
Intercept	δ_0	0.069	1.28ns
Farming Experience (Year)	δ_1	0.001	4.93*
Education (Year)	δ_2	0.006	2.31**
Credit	δ_3	0.008	0.24ns
Extension Services	δ_4	0.038	1.11ns
Maize Cropped Area (Acre)	δ_5	−0.012	−4.68*
Sowing Time	δ_6	0.030	0.84ns
Variance Parameters			
σ^2		0.05	7.89
Γ		0.72	2.88

Note: * and ** show significance at 1 and 5 percent.

Table 4. Frequency distribution of technical efficiency range according to small, medium and large farmers.

Efficiency Range	Small Farmers	% age of Farmers	Medium Farmers	% age of Farmers	Large Farmers	% age of Farmers
0.75 - 0.85	5	4.16	2	1.67	1	0.83
0.86 - 0.95	15	12.5	5	4.16	1	0.83
0.96 - 100	20	16.67	33	27.5	38	31.66
Total	40	33.33	40	33.33	40	33.33

model is 81.06 percent which shows that 18.94 percent output can be increased without increasing the levels of inputs, and this is due to input oriented technical inefficiency. According to the results, older farmers appeared to be more efficient than younger farmers. This is perhaps due to their good managerial skills, which they have learnt over time. Hence, it is necessary to increase educational facilities in the area. It was also discovered that the technical efficiency estimates are highly responsive to the functional form specified because the Cobb-Douglas and translog models resulted in dissimilar technical efficiencies. Although Cobb-Douglas specification gives constant returns to scale, it is widely accepted in the literature.

REFERENCES

[1] Tahir, M., Tanveer, A., Ali, A., Abbas, M. and Wasaya, A. (2008) Comparative yield performance of different maize (*Zea mays* L.) hybrids under local conditions of Faisalabad-Pakistan. *Pakistan Journal of Life and Social Sciences*, **6**, 118-120.

[2] Government of Pakistan (GOP) (2012) Pakistan Economic Survey 2011-12. Economic Advisor's Wing, Finance Division, Islamabad.

[3] Parikh, A. and Shah, M.K. (1994) Measurement of technical efficiency in the north-west frontier provinces of Pakistan. *Journal on Agricultural Economics*, **45**, 132-138. http://dx.doi.org/10.1111/j.1477-9552.1994.tb00384.x

[4] Farrell, M. (1957) The measurement of productivity efficiency. *Journal of the Royal Statistical Society*. *Series A* (*General*), **120**, 253-290. http://dx.doi.org/10.2307/2343100

[5] Coelli, T.J. (1996) A guide to frontier version 4.1 a computer program for stochastic frontier production and cost function estimation. CEPA Working Papers, 96/07, University of New England, New England, 135.

[6] Battese, G.E. and Coelli, T.J. (1995) A model for technical efficiency effects in astochastic frontier production function for panel data. *Empirical Economics*, **20**, 325-332. http://dx.doi.org/10.1007/BF01205442

[7] Greene, W.H. (2003) Econometric analysis. 5th Edition, Prentice Hall, Upper Saddle River.

[8] Hassan, S. (2004) An analysis of technical efficiency of wheat farmers in the mixed farming system of the Punjab Pakistan. Ph.D. Thesis, Department of Environmental and Resource Economics (Farm Management), University of Agriculture, Fasialabad.

[9] Dey, M.M., Paraguas, F.J., Kambewa, P. and Pemsl, D.E. (2010) The impact of integrated aquaculture-agriculture on small-scale farms in Southern Malawi. *Agricultural Economics*, **41**, 67-79. http://dx.doi.org/10.1111/j.1574-0862.2009.00426.x

[10] Basnayake, B.M.J.K. and Gunaratne, L.H.P. (2002) Estimation of technical efficiency and it's determinants in the tea small holding sector in the mid country wet zone of Sri Lanka. *Sri Lankan Journal of Agricultural Economics*, **4**, 137-150.

[11] Ngwenya, S.A., Battese, G.E. and Fleming, E.M. (1997) The relationship between farm size and the technical inefficiency of production of wheat farmers in the Eastern Free State. *Agrekon*, **36**, 283-301. http://dx.doi.org/10.1080/03031853.1997.9523466

