STOCHASTIC FRONTIER ANALYSIS OF MAIZE FARMERS IN AZAD JAMMU AND KASHMIR, PAKISTAN

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ABSTRACT:- The research study was carried out to analyze the technical efficiency of maize growers through Cobb-Douglas type Stochastic Frontier Analysis in four villages of Muzaffarabad district, Azad Jammu and Kashmir (AJK), Pakistan. The proportional sampling allocation sampling technique was adopted to collect primary data from 80 sampled respondents in 2013-14. The maximum likelihood estimates of major inputs showed that seed, tractor hours, FYM and labor days have contributed significantly to increase the maize yield. However, the DAP and urea have shown no effect on maize yield. The mean technical efficiency was estimated at 83%, implying that the farmers can still enhance their technical efficiency by 11% within the given inputs and technology. The results have demonstrated that maize crop is lucrative crop in the study area as maize growers have received increasing return to scale i.e., 1.90 (Ep>1), hence economies of scale exists. The variance parameter lambda (λ) and gamma (Γ) both were significant indicating the good fitness of model and inefficiency impact, respectively. The estimated value for Γ was 0.77 underscores that 77% variation in the production frontier was explained by technical inefficiency effect. The inefficiency indices showed that farmers with more schooling years and more number of contacts with extension agents were more efficient. Contrarily, age of the farmer and large farm size have inverse relation to technical efficiency of the farmers. This research study concludes that the use of more labor and application of farm yard manure is contributing significantly. It is recommended that the high input prices may be levelled off by the regulatory authorities so that farmers can apply the required crop inputs such as DAP and urea in study area.

Key Words: Maize; Technical Efficiency; Stochastic Production Frontier; Cobb-Douglas; Production; Pakistan.

INTRODUCTION

Maize is one of the most common cereal crops grown globally and ranked at third most common crop in the total food grain production after wheat and rice worldwide (Anupama et al., 2005). The global world production of maize was estimated to be 950 mt for 2012-2013 which is an increase of about 9% from 2011-2012. The US is the leading producer with the production of about 40% of total maize output followed by China, which is contributing 192.7 mt to total world production. Brazil, European Union and Argentina produced 67, 65.5 and 25 mt, respectively.

Pakistan's agriculture sector employed 43.7% of labour force that fulfills their own food requirements and ensures availability of food for the rest of nation and value-added

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activities (GoP, 2014). In Pakistan, maize is third important cereal after wheat and rice and contributes 0.4% to overall Gross Domestic Product (GDP) and 2.1% to value added of agricultural output. Maize was planted on about 1.08 mha with production of 3.3 mt (GoP, 2013). Maize is a significant cereal crop of Azad Jammu and Kashmir (AJK), Pakistan and remained the single largest cereal crop in AJK for many decades. It was the staple food among *Kashmiries* (local resident of Kashmir) before the availability of substitute crops such as wheat and rice. Maize is still grown in a wide range of agro-ecological zones and growing altitude ranges from 1,828 m to 3,656 m. This research study has made an effort to address the maize production frontier and technical efficiency aspect of the maize growers.

The objectives of present study are to estimate the technical efficiency of maize growers, analyze the factors (if any) causing inefficiency in maize yield and suggest policy guidelines for maize growers.

MATERIALS AND METHOD

Study Area

The study was undertaken in the four villages of district Muzaffarabad of AJK, Pakistan, namely Kommi, Majhoi, Garhi Dupatta and Nowshehra. The rationale of selection of these four villages was that maize production is relatively higher as compared to rest of the villages of district Muzaffarabad.

Sampling Design

The proportional allocation sampling technique was utilized to select the 80 sampled respondents (maize growers) in the study area as previously used by Chaudhry (1998). The formula used for proportional allocation technique is as follow:

$$ni = Ni/N*n \quad \text{................I}$$

where,

ni = No. of sampled respondents in i^{th} village
n = Total sample size
N = Total number of farmers in research area
Ni = Total number of farmers in each village

The estimation of proportional allocation formula was made to obtain the required sample for each village. The list of all the maize growers of aforesaid villages was taken from agriculture department of AJK and desired sample size of 80 respondents were derived by employing Proportional Allocation technique as follows:

n_1(Majhoi) = 205/865 *80= 19
n_2(Kommi) = 240/865 *80 = 22
n_3(Garhi Dupatta) = 255/865*80 = 24
n_4(Nowshehra) =165/865*80 = 15

Data Type and Analysis Procedure

The primary data were collected from the selected farmers through interview schedule for 2013-14. The collected data was analyzed by using computer software STATA and Frontier 4.1.

Conceptual Modeling

The Cobb-Douglas type Stochastic Frontier Production Model is utilized for this study. This model was demonstrated by Farrell (1957) followed by Aigner et al. (1977) and Meeusen and Broeck (1977) who amalgamate the further basis for this model. The general form of this model can be mathematically expressed as follows:

$$\ln qi = \beta_o + \beta_1 \ln x_i + v_i - u_i$$

qi = $\exp(\beta_0 + \beta_1 \ln x_i + v_i - u_i)$

qi = $\exp(\beta_0 + \beta_1 \ln x_i) \times \exp(v_i) \times \exp(-u_i)$

$\exp(\beta_0 + \beta_1 \ln x_i)$ = Deterministic Component

$\exp(v_i)$ = Noise

$\exp(-u_i)$ = inefficiency

where,

i = 1, 2, … N (Number of i^{th} farmer)

$f(x_i ; \beta)$ = Suitable functional form

y_i = Output level of i^{th} sampled farm

x_i = Inputs used for the i^{th} farm

β_i = Parameters to be estimated

v_i = Accounts for random variation that are not in the control of farmers having normal distribution that is $Vi \sim N(0, \sigma^2 v)$.

u_i = A non-negative technical inefficiency effect which is assumed to have half normal distribution.

Model Specification

The model specification of this research study is as follow:

lnY = $\beta_0 + \beta_1 lnS + \beta_2 lnTH + \beta_3 lnDAP + \beta_4 lnUrea + \beta_5 lnFYM + \beta_6 LAB + D_1 MAJ + D_2 Kommi + D_3 Nowsh + (V_i - U_i)$

In = Natural Logarithm

Y = Log transformed yield in m ha^{-1}

β_i = Parameters to be estimated

S = Log transformed seed in kg ha^{-1}

TH = Log transformed tractor ploughing hours ha^{-1}

DAP = Log transformed DAP Fertilizer in bags ha^{-1}

UREA = Log transformed Urea Fertilizer used in bags ha^{-1}

FYM = Log transformed farm yard manure in trolleys ha^{-1}

LAB = Log transformed labor in person days per acre for hoeing/weeding/harvesting

DMAJ = Dummy variable = 1 if farmer of the village Majhoi and 0 otherwise

DKommi = Dummy variable = 1 if farmer of village Kommi and 0 otherwise

DNowsh = Dummy variable = 1 if farmer of village Nowshehra and 0 otherwise

V_i = A random variable which is assumed to be independently and normally distributed with 0 mean and constant variance $\sigma^2 v$

U_i = A non-negative technical inefficiency effect which is assumed to have half normal distribution

Estimation of Technical Inefficiency Level of Maize Producers

The following model was used to estimate the technical inefficiency in maize production

$U_i = \delta_0 + \delta_1 EDU + \delta_2 AGE + \delta_3 CONT + \delta_4 FSZ$

where,

μ_i = Inefficiency effect

δ_i = Coefficients to be estimated

EDU = Educational level of the farmer (years of schooling)

AGE = Age of the farmer (years)

CONT = No. of farmers contacts with extension agents (include farmers visits either to extension agent office for improved knowledge, demonstration plot or other extension events).

FSZ = Farm size in ha

RESULTS AND DISCUSSION

Descriptive Statistics of Major Variables

Maize yield can be affected by many factors such as seed, tractor hours, DAP, urea, FYM and labor days. In the present study these explanatory variables were considered as a reason for variation in maize yield. The results revealed that the mean value of seed used was 52.78 kg with a standard deviation of 7.48 (Table 1). The minimum amount of seed used by the respondents was 29.65 $kgha^{-1}$ and the maximum was reported as 61.24 $kgha^{-1}$. Seed had the highest standard deviation among all the other independent variables which showed the high variability of seed usage among the respondents. Quantity of tractor hours ranges between 2.47 h as minimum and 13.50 h as maximum ha^{-1} with mean value 5.28. The fertilizers such as DAP and urea had the mean of 0.57 and 1.20, respectively. The maximum amount of the DAP and urea applied by the farmers was 2.50 and 3.70 bags ha^{-1}, respectively. The results illustrated that the use of both these fertilizers was very low in the study area and the respondents had more reliability on FYM. All of the sampled respondents were using FYM in different amounts.

Table 1. Descriptive statistics of major inputs of maize crop

Crop inputs	Obs.	Min.	Max.	Mean
Seed (kg h^{-1})	80	29.65	61.24	52.78
Tractor (h^{-1})	80	02.47	13.50	05.29
DAP (bags h^{-1})	80	0.012	02.50	00.57
Urea (bags h^{-1})	80	0.012	03.70	01.20
FYM(tractor trolleys)**	80	03.47	11.00	07.00
Labor Days (N)	80	24.71	86.42	54.08

*Source: Primary Data, 2013-14, *1 bag = 50kg, **1 tractor trolley = 500 kg*

The minimum amount of FYM was 3.47 tractor trolley and the maximum was 11 tractor trolleys with a mean value of 7.00 tractor trolley. In the study area the number of labor days range from 24.71 to 86.42 with a mean of 54.08. The results further revealed that labor days had the major contribution towards maize productivity.

Stochastic Frontier Production Analysis

The maximum likelihood estimates of Cobb-Douglas production function revealed that majority of the explanatory variables had contributed significantly to the maize production. It is evident that the coefficients of all the explanatory variables had positive sign and are according to economic theory (Table 2). However the results for chemical fertilizers i.e., DAP and urea had shown insignificant contribution. The insignificant effect of both fertilizers might be because of their low use in the study area. This result is consistent with the previous research study of Sadiq et al. (2009). The results further revealed that among the independent variables seed is significant at 5% level of significance ($P \leq 0.05$). Maize output showed the greatest elasticity to labor among all the explanatory variables. This situation underscores that the maize crop is labor intensive and had the maximum response to the use of labor followed by FYM and tractor hours. All the other independent variables except DAP and urea were significant at 1% level of significance (P<0.01). The elasticity sum of all inputs was 1.90 (Ep>1) which suggests that the growers in the study area had the increasing returns to scale. These results are consistent with those reported by Bozulu and Cehan (2007), and Zalkuwi et al. (2010). The four villages of the study area were assigned as dummy variable to compare the maize production level among these villages. The village Ghari Dupatta was taken as reference village while villages Majhoi, Kommi and Nowshehra were compared with the reference village. It is evident from the estimated data that maize production of Majhoi and Kommi is significantly different from referenced village. However, Nowshera is insignificant implying that maize production of Nowshehra is almost same as to corresponding village. The computed value of λ was 1.843 which is significantly different from zero suggests that the employed stochastic

Table 2. Maximum likelihood estimates for technical efficiency

Independent variables	Coefficient	S.E	t-ratio	P-Value
Constant	1.457	0.701	2.08	0.030
ln Seed	0.274	0.153	1.79	0.050*
ln Tractor hours	0.230	0.081	2.82	0.005**
In DAP	0.057	0.060	0.94	0.346
In Urea	0.001	0.060	0.02	0.984
ln FYM	0.459	0.079	5.81	0.000**
ln Labor	0.879	0.198	4.43	0.000**
Sum of elasticity of inputs	1.900	----	----	
Dummy for Majhoi	0.221	0.084	2.61	0.009**
Dummy for Kommi	0.255	0.095	2.68	0.007**
Dummy for Nowshehra	0.083	0.082	1.02	0.308
Variance parameters				
Sigma-v	0.210	0.048		
Sigma-u	0.205	0.137		
Sigma2	0.086	0.039		
Lambda (λ)	1.856	------		
Gamma (Γ)	0.770	0.185		
Maximum likelihood value	-0.460			

*Source: Primary Data, 2013-14, * and ** = Significant at 5% and 1% level, respectively.*

production model was good fit and it correctly measured the composite error term. The gamma parameter was estimated at 0.77 which underscores that 77% variation in the stochastic production function was due to the inefficiency factors, the factors that are unexplained by the production function.

Inefficiency Estimates

The results of inefficiency model illustrated that the negative sign with two variables i.e., education and contact with extension agents depicts that higher level of education and more number of contacts of farmers with extension agent had an inverse relation with inefficiency (Table 3). This implies that an increase in education of farmer can decrease the inefficiency by 0.08%. The results are consistent with the previous study by Battese et al. (1996) and Owens et al. (2001). The results further illustrate that the age of the farmers was positively related with the inefficiency implying that if the age of the farmers increased by 1% it will increase the inefficiency by 0.15%. The reason can be that aged farmers can't look after their field properly than the young energetic farmer. The results are consistent with the previous findings (Battese and Coelli, 1995; Mathijs and Vranken, 2000). The coefficient of farm size was found significant and had direct relation with technical inefficiency. The reason for this inverse relation might be that it is easier to manage the operations for small farm size as compared to the large farm size. This finding is consistent with the results of Laura and Langemeier (1999) and Bozulu and Cehan (2007).

The descriptive statistics of the estimated technical efficiency score for maize growers revealed that the technical efficiency estimates ranges between 62% and 94% (mean = 83% $\pm$ 0.068). The average technical efficiency of 83% showed that the farmers in the study area were about 1% below the production frontier. This confirms that the farmers in the study area were not completely technical efficient and the maize output could be increased by 11% with the given resources and technology.

CONCLUSION AND RECOMMENDATION

The stochastic production frontier analysis illustrated that labor was the major contributing input for maize production. The mean technical efficiency in study area was 83% which revealed that still there is potential to improve the production by 11% within given inputs and technology. The computed gamma was 0.77 underscores that 77% variations in the maize output was explained by technical

Table 3. Major factors affecting technical inefficiency

Variables	Coefficient	S.E	t-ratio	P-value
Contact	2.330	0.276	8.46	0.000
Education (schooling year)	-0.088	0.029	-2.98	0.003
Age (years)	0.152	0.062	2.42	0.001
Farm size (acres)	0.325	0.041	7.81	0.000
Extension agent contacts (No.)	-0.235	0.028	-8.28	0.000

Source: Author's Own Estimates

inefficiency factors. Education and contacts with extension department showed negative impact towards the inefficiency. To overcome these issues extension agents should train the farmers regarding maize crop management practices to enhance the production. Moreover, Government should take steps to keep the reasonable prices of maize inputs.

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AUTHORSHIP AND CONTRIBUTION DECLARATION

S. No	Author Name	Contribution to the paper
1.	Dr. Khurram Nawaz Saddozai	Results and their interpretation, Supervised data analysis, Overall management of article
2.	Ms. Umme Rubab	Introduction, Data collection, Data entry, Review of literature and model development
3.	Mr. Abass Ullah Jan	Results and discussion, Conclusion and recommendation

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