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December 2016

Analysis of Technical Efficiency of Rice Production in Fogera District of Ethiopia: A stochastic Frontier Approach

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Abstract

The possible way to improve production and productivity with a given input mix and available technology is to improve efficiency of resource use. For this purpose examining the technical efficiency of the production process is very crucial. Thus, the aim of this paper is to analyze the technical efficiency of rice production in Fogera District of Ethiopia. To do so, stochastic frontier approach is employed on a data which is collected from 200 sample households in 2015/16 production year. The sampling techniques used to get those 200 sample households is a multistage sampling where in the first stage five Kebeles[1] were purposively selected, in the second stage two Gotes[2] randomly selected from each Kebeles and in the third stage 200 households were selected using simple random sampling technique. Doing so, it was found that except manure all the variables in the Cobb-Douglass stochastic frontier model which includes; land, fertilizer, oxen, seed and labor are found to be positively and significantly related to rice production. The average technical efficiency score predicted from the estimated Cobb-Douglas stochastic frontier production function is found to be 77.2% implying that there is a room for rice yield increment by improving the resource use efficiency of the households. The study also revealed that; provision of extension service, training on rice product improvement, experience on rice farming; agrochemical and education tend to be positively and significantly related to technical efficiency while household size is negatively and significantly related. Thus, strengthening extension service provision and training on rice yield increment, campaigns to disseminate rice farming experiences and increasing the supply of agrochemicals are crucial to improve the technical efficiency of rice production in the study area.

Keywords

Ethiopia, Fogera District, Technical Efficiency, Cobb-Douglas Production Function, Stochastic Frontier Approach

[1] Kebele is the smallest administrative unit of Ethiopia
[2] Gote is a sub Kebele

1. Introduction

Rice is among the most important food crops grown in different parts of Ethiopia (Asmelash, 2012). The potential for rice production in the country is also estimated to be around thirty million hectares (Ministry of Agriculture and Rural Development office [MoARD], 2010). According to Hagos and Zemedu (2015) now days Fogera District is one of the main producers of rice which contributes around 58 percent of the Amhara national regional state and 28 percent of the national rice production. The product is one of the main crops produced in the area. According to Gebremedhin and Dirk (2007) 72 percent of farmers in the District produce Rice.

Rice production in Fogera District has shown strong performance in terms of yield. For instance, the total rice yield of the District during the 2011/2012 production period was 827, 104 Quintal[3], while in the 2014/2015 production period it is 943, 555.5 Quintal (Fogera District Agricultural and Rural Development office [FWARoD], 2015). Noneth eless, the productivity did not record any increase. Instead, it fell from 58.5 Quintal to 56.67 Quintal during the above period (FWARoD, 2015). The increase in the production was simply because more land under rice cultivation. For a food insecure country like Ethiopia, where poverty is the most striking problem (Oxford Poverty and Human Development Initiative, [OPHI] 2015) and agriculture plays the major role in the economy employing more than 84 percent of the country's population, contributing the largest share to the foreign exchange earnings and leading the livelihood of the dominant population, improving the production and productivity of this sector is the best way to bring about reduced poverty and achieve food security (Asfaw & Bekele, 2010). Increasing production and productivity is also critical to economic growth and development of the country in general and that of the study area in particular. Nonetheless, given limited agricultural resource like arable land, it will be a difficult job to increase production and productivity. This calls for improving yields of major staples crops such as Rice for better food security.

One way to bring about increased agricultural production and productivity is introduction of improved technology and Agricultural research (Asfaw & Bekele, 2010). Despite the fact that the policy rule is pursued so long ago, improvement in agricultural productivity in general and rice productivity in particular is minimal. This might be due to the difficulty for agricultural researchers to identify when and how new technologies are used by farmers, inability to finance farm technologies and other farm expenditure owing to the lower per capita income of farmers and higher prices of those technologies. According to Asefa (2012), if the existing inputs and technologies are not efficiently utilized trying to introduce new technologies is not cost effective. That is, under such circumstances the use of the existing technologies is more cost effective than applying new technologies. Thus, a study on the technical efficiency analysis is crucial to identify if farmers are efficient in the use of the existing resource and for decisions to introduce new technologies.

Studies have been undertaken on the issue of technical efficiency analysis. For instance, Abedullah and Khalid (2007) analyzed the technical efficiency of rice production in Punjab (Pakistan) using stochastic frontier approach and indicated that farmers in the study area were 91% efficient implying limited scope to improve the resource use efficiency. Abedullah and Khalid (2007) also indicated that education and mechanization have positive and significant effect on technical efficiency score while age is

[3] Quintal is equal with 100 kg

found to have negative and significant effect. Idiong (2007) estimated the farm level technical efficiency in small-scale swamp rice production in cross river state of Nigeria using stochastic frontier approach and found an average technical efficiency score of 77% implying better scope to enhancing the resource use efficiency. The study also shown that, years of schooling, membership to associations and access to credit are found to be the major determinants of technical efficiency. Bamiro and Janet (2012) employed stochastic frontier approach to analyze the technical efficiency of swamp rice and upland rice production in Osune Sate, Nigeria and estimated an average technical efficiency of 56% and 91% respectively, which showed that efficiency improvement is possible in the swamp rice production. The study revealed that volume of credit have negative effect on technical efficiency of upland rice while females are found to be more efficient compared to males in the swamp rice production. Kadiri *et al.* (2014) revealed that paddy rice production is technically inefficient in the Niger Delta Region of Nigeria. The study further indicated that, marital status, educational level and farm size are the major determinants of rice production in the study area.

Studies conducted in Ethiopia emphasized on the efficiency of maize production. That is, Yilma and Ernst (2001), on the technical efficiency of maize production in Southwestern Ethiopia; Jimma zone, Alemu *et al.* (2008), on the technical efficiency of farming systems across agro ecological zones in Ethiopia, Asefa (2012) on the technical efficiency of crop produci ng smallholder farmers in Tigray, Ethiopia and Geta *et al.* (2013) on technical efficiency of Smallholder Maize Producers in Southern Ethiopia. Nonetheless, findings of those studies might not be applicable for the case of rice production in Fogera District due to the diversity in climatic condition of Fogera District and the aforementioned areas, differences in the knowhow of the farmers, differences in output produced, difference in technology and means of production. According to Danso-Abbeam *et al.* (2012) farmers in different agro ecological zone have different socio-economic background and resource endowment which might impact their resource use efficiency. Thus, the main objective of this study is to analyze the technical efficiency of rice production in Fogera District of Ethiopia.

2. Methodology

The study aimed at analyzing the technical efficiency of rice production in Fogera District in the 2015/16 production period using cross-sectional data. Below is discussion of the data type and sources, model specification and method of analysis.

2.1. Description of the Study area

Fogera District is located in the South Gondar Zone of Amhara national regional state and it is one of the 151 Districts found in the region. The capital of the District is Woreta and is located 625 km northwest of Addis Ababa and 55 km from the regional capital, Bahir Dar. It is situated at 11º46 to 11º59 latitude North and 37º33 to 37º52 longitude East. It has a total land area of 117,405 hectare of which flat lands account for 76% while the rest are mountains and hills and valley bottoms account for 11% and 13%, respectively. The land use pattern of the District is characterized by 48 % cultivated land, 22 % grazing land, 21% water bodies, 2 % forest land and 7 % for others. The main crops produced in the District include Rice, Teff, Maize, Vegetables and Horticultures. The study area has an annual total rainfall which ranges from1103 to 1336 mm. There are altogether 26 rural Keeble's and 5 urban Keeble's. As per population census dated 2005, the population of this district was 224,884 (Central Statistical Authority [CSA] 2005).

2.2. Data Type and Sources

Primary data on socio economic and production information is collected from 200[4] households belonging to 10 Gotes using structured questionnaire in the 2015/16 production period. The socio-economic data includes data on sex of respondents, age, marital status and education status. Production information data on the other hand includes size of farm land, labor used in production, fertilizer application, agrochemical usage, manure and yield.

2.3. Sampling Technique

To select representative sample for the study a multistage sampling technique is employed. In the first stage five Keeble's are purposively selected based on the extent of rice production. The purposive sampling technique is used due to the fact that it enables to choose Kebele`s with better potential of growing rice. From the aforementioned Keeble's 10 Gotes (two Gotes from each Kebele) are randomly selected from which 200 households are randomly chosen. Given the fact that the population size of Gotes is comparable, sample size is taken proportionately.

2.4. Analytical Framework

The two most important approaches to estimate efficiency/inefficiency level is the stochastic frontier production function (parametric) and the Data Envelopment Analysis (DEA) or nonparametric approach. DEA has the power of accommodating multiple output and inputs in technical efficiency analysis. Nonetheless, it fails to take into consideration the possible impact of random shock like measurement error and other noise in the data (Coelli, 1995). On the other hand, the stochastic frontier does not accommodate multiple input and output. It is also more likely to be influenced by misspecification issues. However, the fact that it incorporates stochastic component into a model increased its applicability in the analysis of technical efficiency of agricultural productions. Thus, for this study the stochastic frontier production function is employed and is adapted from Addai and Victor (2014) and Salau *et al.* (2012).

2.4.1 Stochastic Frontier Production Function

As indicated above DEA assumes the absence of random shocks, while farmers always operate under uncertainty. As a result this study employed the stochastic frontier approach. The stochastic frontier production function with multiplicative error term is given by equation 1 (Kadiri *et al.*, 2014):

$$\mathrm{Y}_i = f(X, B) + e_i - - - - - - -(1)$$

Where, Y_i refers to the total value of Rice output of the i[th] farm measured in Birr, $f(X, B)$ is suitable functional form (like Cobb-Douglass, translog) of the Vector of inputs X, B refers to vector of parameters to be estimated and e_i refers to an error term. The error term in the stochastic frontier production function has two components. i.e.

$$e_i = V_i + U_i - - - - - - - - (2)$$

Where V_i and U_i are independent of each other, V_i is identically and independently normally distributed random error $[\mathrm{V}{\sim}\mathrm{N}(0, \delta \mathrm{v}^2)]$ that captures the stochastic effects outside the farmers control and U_i is a one sided efficiency

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4 The sample size is determined by using Israel (1992) sample size determination formula which is given as: $n = \frac{z^2 pq}{e^2}$. Assuming a 95% degree of confidence, 50% proportion of an attribute that is present in the population and a 7% desired level of precision the sample size is determined at 196. For ease of distributing the sample size to each Gotes proportionately the sample size approximated to 200 households.

component that capture the technical inefficiency of the farmer. The technical efficiency of the ith firm is estimated by the ratio of the observed output to maximum possible output, where the latter is provided by the stochastic frontier production function.

$$TE = \frac{Y_i}{{Y_i}^*} - - - - - - - - - - - -(3)$$

$$\mathrm{TE} = \frac{\exp(X_i B)\exp(V-U)}{\exp(X_i B) exp(V)} - - - - - - (4)$$

$$\mathrm{TE} = \exp(-U) - - - - - - -(5)$$

2.5 The Empirical Stochastic Frontier Production Function Model[5]

The empirical stochastic frontier model used the Cobb-Douglass specification for the analysis of the technical efficiency of rice farms in Fogera District. The Cobb-Douglass functional form is frequently employed in related efficiency studies (Mohammed 2012; Danso-Abbeam *et al.*, 2012). This enables comparison of results with previous studies (Danso-Abbeam *et al.* 2012). The log linear Cobb-Douglass production function is given by equation 6:

$$LnY_i = \beta_0 + \beta_1 X_{1ij} \ldots + \beta_6 X_{6ij} + V - U - - - (6)$$

Where, ij refers to the jth observation of the ith farm, $Y_i$refers to the total value of Rice output, $\beta_0, \beta_1 \ldots.\beta_6$ are parameters to be estimated, X_{1ij}, $X_{2ij} \ldots X_{6ij}$ refers Land, Labor, Oxen, Fertilizer used in kg, Seed input in kg and Manure use respectively and V and U are as defined before. Table 1 presents the list of explanatory variables in the frontier model, variable and expected relationship of the variables with rice output which proxy is rice income.

2.6 Factors Affecting Technical Efficiency

To examine the factors affecting technical efficiency score, the following model is established.

$$\mathrm{U}_i = \delta_0 + \delta_1 W_1 + \delta_2 W_2 - \delta_9 \mathrm{W}_9 + e - -(7)$$

Where U_i refers to the technical efficiency of rice farmers,δ_i`s are parameters to be estimated and $W_i$`s refers to the socio economic characteristics which includes, age, sex, family size, education, extension service, experience, training, agrochemical and planting system. Below is given the description of the variables incorporated in the inefficiency model, the variables type and expected signs of the explanatory variables

[5] The variables in the Cobb Douglass production function and the inefficiency model are selected based on previous literature and pilot survey conducted prior to data collection.

Table 1: Definition of Variables Incorporated in the Production Function

S. No	Variable	Description	Variable Type	Expected relationship
Dependent variable				
1	Rice Income	Log of the total income from rice production	Continuous	
Independent variables				
2	Land	Farm size under rice cultivation in hectare	Continuous	+
3	Labor	Total numbers of (family and employed) labor employed	Continuous	+
4	Oxen	Total number of Oxen owned or available for farming	Continuous	+
5	Fertilizer	Log of Fertilizer used in rice farm per hectare in kg	Continuous	+
6	Seed	Log of Seed input applied per hectare rice farm in kg	Continuous	+
7	Manure	Manure usage (1 if used 0 otherwise)	Dummy	+

Table 2: Variable Choice and Definition for the Efficiency/Inefficiency Model

S.No.	Variable	Description	Variable Type	Expected relationship
Dependent variable				
1	Technical Efficiency	Technical efficiency score of each household	Continuous	
Independent Variables				
2	Age	Age of the household head in years	Continuous	+
3	Sex	Sex of the household head (1 if male and 0 otherwise)	Dummy	-/+
4	Family Size	Number of persons in the household	Continuous	-
5	Education	Level of education of the household head in years	Dummy	+
6	Extension service	Number of extension visits during farming /production period	Dummy	+
7	Experience	years in rice farming of the household head	Continuous	+
8	Training	Training on farm management (1 if received training any 0 otherwise)	Dummy	+
9	Agrochemical	Application of agrochemical (1 if applied 0 otherwise)	Dummy	-
10	Planting System	Planting system(1 if broadcasting and 0 if row planting)	Dummy	+

3. Result and Discussion

3.1 Summary Statistics for Variables in the Stochastic Frontier Production Function

The study is conducted to analyze the technical efficiency of rice farmers in Fogera District. Table 3 describes a summary statistics of the variables involved in the frontier production function. In the table sample mean, standard deviation, minimum and maximum values are given. The proxy of rice output which is, the total income from rice production yields a mean of 39088.5 Birr[6] with a minimum of 7700 Birr and maximum of 110000 Birr. To generate this much income on average 25.32 number of labor (both family and hired labor) are employed. The number of oxen owned by farmers under study varies from 0 to 4 with a mean value of 2.185. On average each farmer applied 40.49 kg of fertilizer and 54.7 kg of seed per hectare. Approximately 77.5% of farmers applied manure on their rice farm.

[6] Birr is the unit of currency in Ethiopia

Table 3: Summary of the Frontier Production Function

Variables	Observation	Mean	Std. Dev.	Min	Max
Rice Income	200	39088.5	18083.21	7700	110000
Oxen	200	2.185	0.978	0	4
Land	200	0.833	0.458	0.125	3
Manure	200	0.775	0.419	0	1
Labor	200	25.32	6.032	13	60
Fertilizer	200	40.49	12.900	20	80
Seed	200	54.7	11.623	25	100

Source: Author's computation based on survey data (2015/16)

3.2 Socio Economic Characteristics of Rice Farmers

Table 4 presents summary statistics of the socio economic characteristics of rice producing farmers in the study area. As it can be seen from the table, the mean age of rice farmers is 47.205 with 21 and 80 the minimum and maximum age respectively. The average household size is 5.46 with minimum 1 and maximum 12. Female household head represents only 6 percent of the total household under study. Thus, the gender distribution in the study area is characterized by male dominance. On the other hand 79 percent of the respondents received extension service while 41.5 percent have participated in rice output improvement trainings. Table 4 also indicates that 46 percent of rice farmers applied agrochemical on their rice farm. Majority of the farmers in the study area (75 percent) use broadcasting system of rice planting while, the rest practice row planting. It is also indicated that 55 percent of the respondents are literate.

Table 4: Summary Statistics of the Socio Economic Characteristics of Rice Farmers

Variable	Obs	Mean	Std. Dev.	Min	Max
Age	200	47.20	12.83	21	80
Gender	200	0.06	0.25	0	1
Extension	200	0.79	0.41	0	1
Training	200	0.42	0.49	0	1
Experience	200	18.44	5.41	2	27
Agrochemical	200	0.46	0.50	0	1
Household size	200	5.46	1.98	1	12
education	200	0.55	0.49	0	1
Planning system	200	0.75	0.44	0	1

Source: Author's computation based on survey data (2015/16)

3.3 Least Square Estimation

Table 5 presents the ordinary least square estimates of the log linear Cobb-Douglass production function. As it is shown in the table 5; Rice land size, number of oxen owned and labor force employed in rice framing are found to be positive and significant in the production process at one percent level of significance. On the other hand, fertilizer and rice seed applied are found to have positive and significant effect on rice output at ten percent level of significance.

Table 5: Ordinary Least Square Estimates of the Cobb-Douglass Production Function

Rive Income	Coef.	Std. Err.	t	P>|t|
Intercept	5.268***	0.432	12.18	0.000
Land	0.169***	0.049	3.43	0.001
Fertilizer	0.104*	0.061	1.71	0.089
Oxen	0.156***	0.023	6.70	0.000
Seed	0.173*	0.089	1.94	0.053
Labor	1.139***	0.097	11.70	0.000
Manure	0.058	0.045	1.27	0.205
R squared :	0.737			
Adjusted R squared:	0.729			
Number of observation:	200			

Note: The asterisks (*, **, ***) indicate significance at the 10%, 5% and 1% levels
Source: Author's computation based on survey data (2015/16)

Manure application is found to be insignificant in the production process. This might be due to the fact that manure is not widely practiced in the study area and thus it has negligible role to rice output. Due to the fact that the variable manure is insignificant it is excluded from the frontier model estimation. With a higher value of R^2 and Adjusted R^2 (73.67% and 72.85% respectively), the inputs employed in the model were able to explain more than seventy two percent of the variation in rice out and thus implying better goodness of fit of the model.

3.4 Estimation of the Frontier Model

To estimate the frontier model the half-normal, the exponential and the truncated-normal distribution is assumed as a distribution for the efficiency/inefficiency term.

Table 6: Parameter Estimates of the Stochastic Frontier Model

Variables	frontier normal/half-normal model				frontier normal/exponential model				frontier normal/truncated-normal model				
Rive output	Coef.	Std. Err.	z	P>|z|	Coef.	Std. Err.	z	P>|z|		Coef.	Std. Err.	z	P>|z|
Intercept	5.849***	0.401	14.5	0.000	5.970***	0.396	15.1	0.000		5.970***	0.396	15.1	0.000
Land	0.190***	0.050	3.80	0.000	0.196***	0.046	4.21	0.000		0.196***	0.047	4.21	0.000
Fertilizer	0.119**	0.056	2.12	0.034	0.106**	0.053	2.01	0.044		0.106**	0.053	2.01	0.044
Oxen	0.135***	0.021	6.28	0.000	0.138***	0.020	6.76	0.000		0.138***	0.020	6.76	0.000
Seed	0.163**	0.079	2.06	0.039	0.149*	0.076	1.94	0.052		0.149*	0.077	1.94	0.052
Labor	1.045***	0.083	12.5	0.000	1.011***	0.084	11.9	0.000		1.011***	0.085	11.9	0.000
/lnsig2v	-3.989	0.307	-12.9	0.000	-3.698	0.221	-16.7	0.000	/mu	-286.89	481.608	-0.60	0.551
/lnsig2u	-2.052	0.195	-10.5	0.000	-3.185	0.267	-11.9	0.000	/lnsigma2	4.069	1.669	2.44	0.015
									/ilgtgamma	7.768	1.685	4.61	0.000
sigma_v	0.136	0.020			0.157	0.017			sigma2	58.496	97.670		
sigma_u	0.358	0.034			0.203	0.027			gamma	0.999	0.0007		
sigma2	0.146	0.021			0.066	0.009			sigma_u2	58.47	97.670		
lambda	2.633	0.050			1.292	0.039			sigma_v2	0.0247	0.0055		
LR test of sigma_u=0:					LR test of sigma_u=0:								
chibar2(01) = 26.43					chibar2(01) = 19.48								
Prob>=chibar2 = 0.000					Prob>=chibar2 = 0.000								

Note: The asterisks (*, **, ***) indicate significance at the 10%, 5% and 1% levels
Source: Author's computation based on survey data (2015/16)

As it is indicated in table 6 the result under all assumptions is consistent. The estimated values for the variance parameters are found to be significant. This implies that technical efficiency had an effect on rice yield. As shown in table 6 the estimated lambda and sigma2 are found to be significant. This implies that the model is characterized by better goodness of fit and also the distributional assumption of the efficiency/inefficiency term is correct. On the other hand the higher value of lambda which is 2.633[7] for the half-normal model indicates that the one sided error term "U" dominates the random term and thus implying that variation in rice yield in the study area is due to the difference in farm specific characteristics discussed above. The likelihood ratio test for the inefficiency term is found to be significant at one percent level of significant implying that inefficiency component presents in the model and thus the model will not reduce to ordinary least square.

3.5 Input Elasticities of Rice Production

The Elasticities of the independent variables are provided in table 7. As it can be seen from the table the elasticity of labor is found to be higher implying that rice yield is more responsive to the amount of labor employed in the production process. The response of rice yield is significant to the rest of covariates involved in the Cobb-Douglass stochastic frontier model.

Table 7: Elasticities of Independent Variables

Variables	Elasticity	Std. Err.	z	P>|z|
Land	0.015	0.004	3.80	0.00
Fertilizer	0.041	0.019	2.13	0.03
Oxen	0.027	0.004	6.25	0.00
Seed	0.060	0.029	2.06	0.04
Labor	0.312	0.025	12.47	0.00

Source: Author's computation based on survey data (2015/16)

3.6 Frequency Distribution of the Technical Efficiency Scores

The technical efficiency score[8] derived from the stochastic frontier model is presented in table 3.6. It is evident from the result that the total technical efficiency score ranges from 29.89% to 95.17% with a mean score of 77.2%. Thus, based on the efficiency theory a farm operating at full efficiency level could reduce its input use on average by 22.8% so as to produce the same level of output.

[7] Lambda ($\hat{\lambda}$) is the ratio of the standard deviation of the two error components. i.e. $\lambda = \frac{\sigma_u}{\sigma_v}$. The fact that the estimated λ is greater than 1 and significantly different from zero implies the presence of inefficiency effect within the model.

[8] The technical efficiency scores are predicted from the half normal model. This is because, the half normal model produces moderate technical efficiency score while the exponential and the truncated-normal models, underestimates and over estimates the technical efficiency score respectively (Kebede, 2001).

Table 8: Technical Efficiency Distribution of Rice Farmers

TE Rating (%)	No. of Farmers	%age of Farmers
0<TE<20	0	0
20<TE<30	1	0.5
30<TE<40	2	1
40<TE<50	6	3
50<TE<60	14	7
60<TE<70	25	12.5
70<TE<80	55	27.5
80<TE<90	71	35.5
90<TE<100	26	13
Total	100	
Mean TE	77.2%	
Standard deviation	12.67%	
Minimum	29.89%	
Maximum	95.167%	

Note: A TE value close to one indicates higher level of technical efficiency
Source: Author's computation based on survey data (2015/16)

3.7 Determinants of Technical Efficiency

To examine the determinants of technical efficiency of rice farm in the study area both the ordinary least square and a Tobit model are used. The result indicates that both models are consistent. The estimation result is presented in table 9. As shown in the table, age is found to have positive but insignificant effect on technical efficiency. Gender is positive and not significantly related to technical efficiency. This indicates that being male or female as a household head does not have a role on rice farm technical efficiency. This finding is in line with a study by Kadiri *et al.* (2014). Provision of extension service and participation in rice yield improvement trainings show positive and significant relationship with technical efficiency. Agrochemical is positively and significantly related to technical efficiency. Household size is found to have negative and significant effect on technical efficiency.

Table 9: Estimates of Parameters of the Efficiency/Inefficiency Model

Variables	**Ordinary Least Square Estimates**				**Tobit Estimates**			
Rive Income	**Coef.**	**Std. Err.**	**t**	**P>|t|**	**Coef.**	**Std. Err.**	**t**	**P>|t|**
Intercept	0.537***	0.0371	14.47	0.000	0.536***	0.0365	14.72	0.000
Age	-0.0001	0.0006	-0.23	0.820	-0.0001	0.0005	-0.24	0.808
Gender	0.031	0.0259	1.22	0.224	0.031	0.0255	1.22	0.224
Extension	0.092***	0.0170	5.45	0.000	0.093***	0.0167	5.57	0.000
Training	0.039***	0.0140	2.86	0.005	0.039***	0.0137	2.89	0.004
Experience	0.008***	0.0014	6.36	0.000	0.009***	0.0014	6.53	0.000
Agrochemical	0.049***	0.0143	3.49	0.001	0.050***	0.0141	3.56	0.000
HH size	-0.009***	0.0034	-2.72	0.007	-0.009***	0.0034	-2.81	0.005
Education	0.029**	0.0142	2.09	0.038	0.030**	0.0140	2.15	0.033
Planting system	-0.001	0.0165	-0.08	0.940	-0.002	0.0163	-0.11	0.909
R squared	0.533							
Adjusted R squared	0.511							
F	24.13***							
χ^2					125.98***			

Note: The asterisks (*, **, ***) indicate significance at the 10%, 5% and 1% levels
Source: Author's computation based on survey data (2015/16)

This might be due to the fact that households with large family size tend to spend more on consumption goods and thus expenditure on rice yield improvement like agrochemical will be minimal. The result is in line with that of Kadiri *et al.* (2014). Planting system is not significantly related to technical efficiency. This indicates that there is no significant technical efficiency difference between farmers that practi ce broadcasting planting system and those that p ractice row planting. Education is significant at 10% level of significance which implies that farmers with better education are more efficient compared to those with less educated. This result is in line with that of Chi and Yamada (2005), Abedullah and Khalid (2007 and Kadiri *et al.* (2014).

Conclusion and Policy Implications

This study analyzed the technical efficiency of rice production in Fogera District. The results have shown that the average technical efficiency score is around 77.2 percent with a minimum score of 29.89% and a maximum of 95.17%. This proves that there is substantial possibility to increase rice yield in the study area by improving the resource use efficiency. The main factors affecting the technical efficiency of rice farmers in the study area includes; Extension, Training, Experience, Agrochemical, Household size and Education. To improve the technical efficiency of rice farming in the study area the following policy implications should be considered. That is, provision of extension service and trainings on rice yield improvement provided by the government and non-governmental organization are found to be significant. Thus, it is essential to further strengthen these efforts. As experience is significantly related to technical efficiency, the District agricultural development office should create an opportunity for those farmers with lower technical efficiency to share an experience from those that scored an efficiency score close to one. It is also essential to further improve the supply of Agrochemicals and the trainings on how to apply agrochemicals on rice filed. The study also revealed that education is positively related to technical efficiency and thus it is quite essential to provide adult education and vocational education for the farmers in the study area.

References

Abedullah, Shahzad Kouser, and Khalid Mushtaq. (2007). Analysis of technical efficiency of rice production in Punjab (Pakistan): Implications for future investment strategies. *Pakistan Economic and Social Review*, 231-244.

Addai, Kwabena Nyarko, and Victor Owusu. (2014). Technical efficiency of maize farmers across various agro ecological zones of Ghana. *Journal of Agriculture and Environmental Sciences*, 3(1), 149-172.

Alemu, Bamlaku A., E. A. Nuppenau, and H. Boland. (2008). Technical efficiency of farming systems across agro-ecological zones in Ethiopia: An application of stochastic frontier analysis.

Asefa, Shumet. (2012). Analysis of technical efficiency of crop producing smallholder farmers in Tigray. *Ethiopia.'Munich Personal RePEc Archive (MPRA), Paper*, (40461).

Asfaw, Solomon, and Bekele Shiferaw. (2010). Agricultural technology adoption and rural poverty: Application of an endogenous switching regression for selected East African Countries. Poster Presented at the Joint 3rd African Association of Agricultural Economists (AAAE), 19-23.

Asmelash, Yemane. (2012). Farmers' evaluation of upland rice varieties in Fogera District, South Gondar, Ethiopia. *Asian Journal of Agriculture and Rural Development*, *2*(4), 604-608.

Bamiro, Olasunkanmi M., and Janet O. Aloro. (2013). Technical efficiency in swamp and upland rice production in Osun State. *Scholarly Journal of Agricultural Science*, *3*(1), 31-37.

Coelli, T. J. (1995). Recent developments in frontier modelling and efficiency measurement. *Australian Journal of agricultural economics*, *39*(3), 219-245.

Chi, Truong Thi Ngoc and Ryuichi Yamada. (2005). Assessing the technical efficiency of input in

rice production in Thoi Lai Commune, Co Do District, Can Tho City. *Omonrice* 13 (-): 116-120
Danso-Abbeam, G., R. Aidoo, K. O. Agyemang, and K. Ohene-Yankyera. (2012). Technical efficiency in Ghana's cocoa industry: Evidence from Bibiani-Anhwiaso-Bekwai District. *Journal of Development and Agricultural Economics*,*4*(10), 287-294.
FDARoD (Fogera District Agricultural and Rural Development Office), (2015). Annual report. Ethiopia, Woreta.
Gebremedhin, Berhanu, and Dirk Hoekstra. (2007). Cereal marketing and household market participation in Ethiopia: The case of teff, wheat and rice. In *AAAE Conference Proceedings (2007)* (pp. 243-252).
Geta, Endrias, Ayalneh Bogale, Belay Kassa, and Eyasu Elias. (2013). Productivity and efficiency analysis of smallholder maize producers in Southern Ethiopia. *Journal of Human Ecology*, *41*(1), 67-75.
Hagos, A., & Zemedu, L. (2015). Determinants of Improved Rice Varieties Adoption in Fogera District of Ethiopia. *Science, Technology and Arts Research Journal*, 4(1), 221-228.
Idiong, I. C. (2007). Estimation of farm level technical efficiency in smallscale swamp rice production in cross river state of Nigeria: a stochastic frontier approach. *World Journal of Agricultural Sciences*, *3*(5), 653-658.
Israel, G. D. (1992). *Determining sample size*. University of Florida Cooperative Extension Service, Institute of Food and Agriculture Sciences, EDIS.
Kadiri, F. A., C. C. Eze, J. S. Orebiyi, J. I. Lemchi, D. O. Ohajianya, and I. U. Nwaiwu. (2014). Technical efficiency in paddy rice production in Niger Delta Region of Nigeria. *Global Journal of Agricultural Research*, *2*(2), 33-43.
Kebede, T. A. (2001). Farm household technical efficiency: A stochastic frontier analysis. A study of rice producers in Mardi watershed in the western development region of Nepal. *Departemen of Economics and Social Sciences, Agricultural University of Norway*.
MoARD (Ministry of Agriculture and Rural Development), (2010). Annual report. Ethiopia, Addis abeba.
Mohammed, Wakili Abba. (2012). Technical efficiency of sorghum production in hong local government area of Adamawa state, Nigeria. *Russian Journal of Agricultural and Socio-Economic Sciences*, *6*(6).
Salau, S. A., Adewumi, M. O., & Omotesho, O. A. (2012). Technical efficiency and its determinants at different levels of intensification among maize-based farming households in Southern Guinea Savanna of Nigeria. *Ethiopian Journal of Environmental Studies and Management*, 5(2), 195-206.
Yilma, Tsegaye, and Ernst Berg. (2001). Technical efficiency of maize production in Southwestern Ethiopia: a case of Jimma zone. In *Proceedings of Deutscher Tropentag Conference on International Agricultural Research for Development, October* (9-11).

Acknowledgements

Acknowledgements go to Fogera District Agricultural development office for facilitating the data collection process and providing the necessary information needed to conduct this study and Mr. Debebe Aklog, Mr. Hailu Desalegn for their support in the data collection process and Dr. KN Reddy for sparring some time to go through the language part.