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

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Abstract

The aim of this paper is to analyze the technical efficiency of rice production in Fogera District of Ethiopia. To do so, the stochastic frontier approach was employed on a data collected from 200 sample households in the 2015/16 production year. As a result, it was found out that except for manure, all variables in the Cobb-Douglass stochastic frontier model, which includes land, fertilizer, oxen, seed, and labor, were positively and significantly related to rice production. The average technical efficiency score predicted from the estimated Cobb-Douglas stochastic frontier production function was calculated to be 77.2 percent, implying that there was a room for rice yield increment by improving the resource use efficiency of households. The study also revealed that the provision of extension services, training on rice product improvement, experience on rice farming, agrochemicals, and education tend to be positively and significantly related to technical efficiency while household size was negatively and significantly related. Thus, strengthening the extension service provision and the training on rice yield increment, campaigns to disseminate rice farming experiences, and an increase in the supply of agrochemicals were 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

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1. Introduction

Rice is among the most important food crops grown in Ethiopia (Asmelash, 2012). The county is believed to have a significant potential in the production of this crop (Ministry of Agriculture and Rural Development Office [MoARD], 2010). According to Hagos and Zemedu (2015), Fogera District nowadays is one of the main producers of rice, which contributes around 58 percent of the Amhara National Regional State and 28 percent of the federal level rice production. The product is one of the main crops being produced in the area. According to Gebremedhin and Dirk (2007), 72 percent of farmers in the Fogera District produce rice.

Rice production in Fogera District has been impressive in terms of yield. For instance, the total rice production of the District during the 2011/2012 production period was 827,104 Quintals[2] while in the 2014/2015 production period, it was 943,555.5 Quintals (Fogera District Agricultural and Rural Development Office [FWARoD], 2015). Nonetheless, the productivity in those periods did not show any increase; instead, it fell from 58.5 Quintals to 56.67 Quintals during the above period (FWARoD, 2015). The increase in the production was simply due to a larger land area for rice cultivation. For a food-insecure country like Ethiopia where poverty is the most striking problem (Oxford Poverty and Human Development Initiative [OPHI], 2015), agriculture plays the major role in the economy, employing more than 84 percent of the country's population. Since agriculture contributes the largest share to foreign exchange earnings and leads the livelihood of a large proportion of the population, improving the production and productivity of this sector is the best way to bring about reduced poverty and to achieve food security (Asfaw and Bekele, 2010). Increasing production and productivity is also critical to economic growth and the development of the country in general and that of the study area in particular. However, given limited agricultural resources like arable land, it will be a difficult job to increase production and productivity. Thus, this situation calls for improving yields of major staple crops such as rice for better food security.

[2] A Quintal is equal to 100kg.

One way to bring about increased agricultural production and productivity is the introduction of improved technology and agricultural research (Asfaw and Bekele, 2010). Despite the fact that this policy has been pursued for a long time ago, improvement in agricultural productivity in general and rice productivity in particular has been minimal. This negligible outcome might be due to the difficulty for agricultural researchers to identify when and how new technologies were used by farmers and the inability to finance farm technologies and other farm expenditures owing to the low per capita income of farmers and high prices of those technologies. According to Asefa (2012), if existing inputs and technologies are not efficiently utilized, trying to introduce new technologies will not be cost-effective. That is, under such circumstances, the use of the existing technologies is more cost-effective than applying new technologies. Thus, a technical-efficiency analysis is crucial to find out if farmers are efficient in the use of the existing resources and to decide when to introduce new technologies.

Studies have been undertaken on the issue of technical efficiency. For instance, Abedullah and Khalid (2007) analyzed the technical efficiency of rice production in Punjab (Pakistan) using the stochastic frontier approach and indicated that farmers in the study area were 91 percent efficient, implying limited scope to improve the resource-use efficiency. Abedullah and Khalid (2007) also indicated that education and mechanization had a positive and significant effect on technical efficiency score while age was found to have a negative and significant effect. Idiong (2007) estimated the farm-level technical efficiency in small-scale swamp rice production in the Cross River State of Nigeria using the stochastic frontier approach and found an average technical efficiency score of 77 percent, implying better scope of enhancing the resource-use efficiency. The study also showed that years of schooling, membership to associations, and access to credit were found to be major determinants of technical efficiency. Bamiro and Janet (2012) employed the 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 was possible in the swamp rice production. The study revealed that the volume of credit had a negative effect on technical efficiency of upland rice while females were found to be more efficient compared to males in the swamp rice production. Kadiri *et al*. (2014) revealed that paddy rice production was technically inefficient in the Niger Delta Region of Nigeria. The study further indicated that marital status, educational level, and farm size were major determinants of rice production in the study area.

Studies conducted in Ethiopia emphasized on the efficiency of maize production. For example, Yilma and Ernst (2001) investigated the technical efficiency of maize production in southwestern Ethiopia, Jimma zone; Alemu *et al*. (2008) studied the technical efficiency of farming systems across agroecological zones in Ethiopia; Asefa (2012) looked into the technical efficiency of crop producing smallholder farmers in Tigray; and Geta *et al*. (2013) studied the technical efficiency of smallholder maize producers in southern Ethiopia. Nonetheless, findings of these studies might not be applicable to the case of rice production in Fogera District due to the diversity in climatic condition of Fogera District and the areas outlined, differences in the knowhow of the farmers, differences in the output produced, and differences in technology and means of production. According to Danso-Abbeam *et al*. (2012), farmers in different agroecological zones had different socio-economic backgrounds 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 the 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 the Amhara National Regional State and is one of the 151 Districts found in the region. The capital of the District is Woreta, which 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, which consists of flat lands (76 percent), mountains and hills (11 percent), and valley bottoms (13 percent). The land use pattern of the District can be described as: 48 percent cultivated land, 22 percent grazing land, 21 percent water bodies, 2 percent forest land, and 7 percent for others. The main crops produced in the Fogera District include rice, *tef*, maize, vegetables, and horticultures. The study area has an annual total rainfall which ranges from 1103 to 1336 mm. There are altogether 26 rural Kebele's and 5 urban Kebele's. As per the 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 were collected from 200[3] households belonging to 10 '*got*'s using a structured questionnaire in the 2015/16 production period. The socio-economic data included data on the sex, age, marital status and education status of respondents. Production information data, on the other hand, included the size of farm land, labor used in production, fertilizer application, agrochemical usage, manure, and yield.

2.3 Sampling Technique

To select a representative sample for the study, a multi-stage sampling technique was employed. In the first stage, five Kebele's were purposively selected based on the extent of rice production. The purposive sampling technique was used so that Kebele`s with better potential of growing rice could be selected. From the aforementioned Kebele's, 10 '*got*'s (two from each Kebele) were randomly selected from which 200 households were randomly chosen. Since the population size of '*got*'s was comparable, sample size was taken proportionately.

[3] The sample size is determined by using Israel's (1992) sample size determination formula, which is given as: $n = \frac{z^2pq}{e^2}$. Assuming a 95% degree of confidence, a 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 '*got*' proportionately, the sample size was determined to be about 200 households.

2.4 Analytical Framework

The two most important approaches to estimate efficiency/inefficiency level are the stochastic frontier production function (parametric) and the Data Envelopment Analysis (DEA) or the non-parametric approach. DEA has the power of accommodating multiple outputs and inputs in technical efficiency analysis. Nonetheless, DEA fails to take into consideration the possible impact of random shock like measurement error and other types of noise in the data (Coelli, 1995). On the other hand, the stochastic frontier does not accommodate multiple inputs and outputs and is more likely to be influenced by mis-specification issues. However, the fact that the latter incorporates stochastic components into the model increased its applicability in the analysis of technical efficiency of agricultural productions. Thus, for this study the stochastic frontier production function was employed and was 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 is given by equation (1) below (Kadiri *et al*., 2014):

$$Y_i = f(X, B) + e_i, \qquad \textbf{(1)}$$

where Y_i refers to the total rice output of the i^th farm measured in kg, $f(X, B)$ 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.

$$e_i = V_i + U_i \qquad \textbf{(2)}$$

where V_i and U_i are independent of each other, V_i is an identically and independently normally distributed random error [$V \sim N(0, \delta v^2)$] that captures the stochastic effects outside the farmers control, and U_i is a one-sided efficiency component that captures the technical inefficiency of the farmer. The technical efficiency of the i^th farm is estimated by the ratio of the observed output to maximum possible output, where the latter is provided by the stochastic frontier production function.

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

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

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

2.5 The Empirical Stochastic Frontier Production Function Model[4]

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 was frequently employed in related efficiency studies (Mohammed 2012; Danso-Abbeam *et al*.; 2012). This method enabled comparison of results with previous studies (Danso-Abbeam *et al*. 2012). The log linear Cobb-Douglass production function is given by Equation (6):

$$lnY = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + V - U \quad (6)$$

where Y refers to the rice output, β_0, β_1, β_2, β_3, β_4, β_5, β_6 are parameter estimates, and X_1, X_2, X_3, X_4, X_5, X_6 refer to 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, variables, and the expected relationship of variables with rice output.

[4] 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.

2.6 Factors Affecting Technical Efficiency

To examine the factors affecting the technical efficiency score, the following model was formulated:

$$U = \delta_0 + \delta_1 W_1 + \delta_2 W_2 + \delta_3 W_3 + \delta_4 W_4 + \delta_5 W_5 + \delta_6 W_6 + \delta_7 W_7 + \delta_8 W_8 + \delta_9 W_9 + e \quad (7)$$

where U_i refers to the technical efficiency of rice farmers, δ_i's refer to the parameter to be estimated and W_i's refer to socio-economic characteristics, which include age, sex, family size, education, extension service, experience, training, agrochemicals, and planting system. Below is the description of variables incorporated in the inefficiency model, variable type, and expected signs of explanatory variables.

Table 1: Definition of Variables Incorporated in the Production Function

S. No.	Variable	Description	Variable Type	Expected relationship
		Dependent variable		
1	Rice Output	Log of the total rice output in kg	Continuous	
		Independent variables		
2	Land	Farm size under rice cultivation in hectare	Continuous	+
3	Labor	Total number 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 of 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	Agrochemicals	Application of agrochemicals (1 if applied, and 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 was conducted to analyze the technical efficiency of rice farmers in Fogera District. Table 3 describes the summary statistics of variables involved in the frontier production function. The average rice output was 32.57 kg with a minimum of 6.0 kg and a maximum of 92 kg. To generate this much rice output, on average 25.32 laborers (both family and hired labor) were employed. The number of oxen owned by farmers under study varied from 0 to 4 with a mean value of 2.185. On the average, each farmer applied 40.49 kg of fertilizer and 54.7 kg of seed per hectare. Approximately 77.5 percent of the farmers applied manure on their rice farm.

Table 3: Summary of the Frontier Production Function

Variables	Mean	Std. Dev.	Min	Max
Rice output	32.57	15.07	6.0	92
Oxen	2.185	0.978	0	4
Land	0.833	0.458	0.125	3
Manure	0.775	0.419	0	1
Labor	25.32	6.032	13	60
Fertilizer	40.49	12.900	20	80
Seed	54.7	11.623	25	100
Observation = 200				

Source: Author's computation based on a sample survey data of 200 farmers (2015/16).

3.1 Socio-economic Characteristics of Rice Farmers

Table 4 presents summary statistics of the socio-economic characteristics of rice producers in the study area. As can be seen from the table, the mean age of rice farmers was 47.205 with 21 and 80 being the minimum and maximum ages, respectively. The average household size was 5.46 with the minimum being 1 and the maximum 12. Females who headed households represented only 6 percent of the total number of households under study. Thus, the gender distribution in the study area was 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 depicts that 46 percent of rice farmers applied agrochemicals on their rice farm. The majority of farmers under the study area (75 percent) used the broadcasting system of rice planting while the rest practiced row planting. The table also shows that 55 percent of the respondents were literate.

Table 4: Summary Statistics of the Socio-economic Characteristics of Rice Farmers

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

Source: Author's computation based on a sample survey data of 200 farmers (2015/16)

3.2 Least Squares Estimation

Table 5 presents the ordinary least square estimates of the log linear Cobb-Douglass production function. As shown in the table, rice land size, number of oxen owned and labor force employed in rice farming were found to be positive and significant in the production process at 1 percent level of significance. On the other hand, fertilizer and rice seed applied were found to have a positive and significant effect on rice output at 10 percent level of significance.

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

Rice output	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 observations:	200			

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

The application of manure to rice farming was found to be insignificant in the production process. This might be due to the fact that though 77.5 percent of the households applied manure on their farms, they did so only on small portions of their farms. Thus, it had a negligible role to rice output. Since the manure had an insignificant effect as a variable, it was excluded from the frontier model estimation. With a higher value of R^2 and Adjusted R^2 (73.67 percent and 72.85 percent, respectively), the inputs employed in the model were able to explain more than 72 percent of the variation in rice output, implying better goodness of fit of the model.

3.3 Estimation of the Frontier Model

To estimate the frontier model, the half-normal, the exponential, and the truncated-normal distributions were assumed as a distribution for the efficiency/inefficiency term. As shown in Table 6, the results under all assumptions were consistent. The estimated values for the variance parameters were found to be significant. This implied that technical efficiency had an effect on rice yield. As shown in Table 6, the estimated lambda and sigma2 were found to be significant, suggesting that the model was characterized by better goodness of fit, and the distributional assumption of the efficiency/inefficiency term was correct. On the other hand, the higher value of lambda, which was 2.633 for the half-normal model, indicated that the one-sided error term "U" dominated the random term, implying that variation in rice yield in the study area was due to the difference in farm-specific characteristics discussed above. The likelihood ratio test for the inefficiency term was found to be significant at 1 percent level of significant, suggesting the inefficiency component present in the model. Thus, the model will not reduce to ordinary least square.

Table 6: Parameter Estimates of the Stochastic Frontier Model

Variables	**frontier normal/half-normal model**				**frontier normal/exponential model**				**frontier normal/truncated-normal model**				
Rice 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, respectively. Source: Author's computation based on survey data (2015/16)

3.4 Input Elasticities of Rice Production

The elasticities of the independent variables are provided in Table 7. As can be seen from the table, the elasticity of labor was found to be higher, implying that rice yield was more responsive to the amount of labor employed in the production process. The response of rice yield was significant to the rest of the 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)

3.5 Frequency Distribution of the Technical Efficiency Scores

Technical efficiency scores[16] derived from the stochastic frontier model are presented in Table 7. It was evident from the results that total technical efficiency scores ranged from 29.89 percent to 95.17 percent with a mean score of 77.2 percent. Thus, based on the efficiency theory, a farm operating at full efficiency level could reduce its input use, on average, by 22.8 percent to produce the same level of output.

[16]Technical efficiency scores are predicted from the half-normal model. This is because the half-normal model results in a moderate technical efficiency score while the exponential and the truncated-normal models underestimate and over estimate 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 1 indicates a higher level of technical efficiency.
Source: Author's computation based on survey data (2015/16)

3.6 Determinants of Technical Efficiency

To examine determinants of technical efficiency of rice farm in the study area, both the ordinary least square and a Tobit model were used. Both models indicated consistent results. Estimation results are presented in Table 9. As shown in the table, age was found to have a positive but insignificant effect on technical efficiency. Gender was positive and not significantly related to technical efficiency. This indicated that being male or female as a household head did not have a role on rice farm technical efficiency, a finding which was in line with the study conducted by Kadiri *et al*. (2014). The provision of extension service and participation in rice yield improvement trainings showed a positive and significant relationship with technical efficiency. The use of agrochemicals was positively and significantly related to technical efficiency.

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

Variables	**Ordinary Least Square Estimates**				**Tobit Estimates**			
Rive output	**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 syste	-0.001	0.0165	-0.08	0.940	-0.002	0.0163	-0.11	0.909
R squared	0.533							
Adjusted R	0.511							
squared	24.13***							
F					125.98***			
χ^2								

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

The household size was found to have a negative and significant effect on technical efficiency. This might be due to the fact that households with large family sizes tend to spend more on consumption goods. Thus, expenditure on rice yield improvement like agrochemicals would be minimal. The result was in line with that of Kadiri *et al*. (2014). Planting system was not significantly related to technical efficiency. This indicated that there was no significant technical efficiency difference between farmers that practice broadcasting planting system and those that practice row planting. Education was significant at 10 percent level of significance, which implied that farmers with better education were more efficient compared to those with lesser educated. This result was in line with studies conducted by Chi and Yamada (2005), Abedullah and Khalid (2007) and Kadiri *et al*. (2014).

4. Conclusion and Policy Implications

This study analyzed the technical efficiency of rice production in Fogera District. The result showed that the average technical efficiency score was around 77.2 percent with a minimum score of 29.89 percent and a maximum of 95.17 percent. This proved that there was substantial possibility to increase rice yield in the study area by improving resource use efficiency. The main factors affecting the technical efficiency of rice farmers in the study area included extension of service, training, experience, use of agrochemicals, household size, and education. To improve the technical efficiency of rice farming in the study area, the following policy implications should be considered. The provision of extension services and trainings on rice yield improvement by the government and non-governmental organizations was found to be significant. Thus, it is essential to further strengthen efforts in these areas. Since experience is significantly related to technical efficiency, the district agricultural development office should create opportunities for farmers with lower technical efficiency to have experience and best practices sharing with those that scored efficiency scores close to one. It is also essential to further improve the supply of agrochemicals and trainings on how to apply agrochemicals on rice fields. The study also revealed that education was positively related to technical efficiency. Thus, it is quite essential to provide adult and vocational education for the farmers in the study area.

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