International Journal of Agriculture Innovations and Research
Volume 8, Issue 2, ISSN (Online) 2319-1473
Manuscript Processing Details (dd/mm/yyyy):
Received: 09/09/2019 | Accepted on: 03/10/2019 | Published: 19/10/2019

Economic Efficiency of Smallholder Farmers in Rice Production: The Case of Guraferda Woreda, Southern Nations Nationalities People's Region, Ethiopia

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Abstract – **Rice is one of the major staple cereal crops in Ethiopia. High productivity and efficacy in its production is vital to improve food security, reduce the level of poverty and to maintain agricultural growth. Thus, the aim of this study was to measure the level of economic efficiency and to identify factors affecting economic efficiency level in Guraferda woreda. Two-stage random sampling technique was used to select 148 household heads and interviewed using a structured questionnaire during 2017/18 production year. Cobb-Douglas production function was fitted using stochastic production frontier approach to estimate the efficiencies level, whereas Tobit model was used to identify determinants that affect efficiency levels of sample farmers. As a result, the mean technical and allocative efficiencies were 78.5 and 80.56%, respectively. While the mean economic efficiency was 63.18%. The average technical and allocative efficiencies implies that there exists a possibility to increase rice production by 21.5% without using extra inputs and decrease cost of inputs by 19.44%, respectively. Cobb-Douglas production function result indicated that, rice output was positively and significantly influenced by land, labor. Seed, oxen power, herbicide and DAP. Likewise, a two-limit Tobit model revealed that economic efficiency was positively and significantly affected by education, frequency of extension contact and cooperatives membership and variables like, proximity to market and non-farm income affected it negatively. The results showed that there is an opportunity to increase efficiency of rice production in the study area. Finally, policies target to motivate and invest in the provision of basic education, strengthen the existing agricultural extension system, organize non-member farmers in cooperative association and development of market and road infrastructures needs to improve economic efficiency of smallholder rice producers.**

Keywords – **Cobb-Douglas, Economic-Efficiency, Ethiopia, Smallholder, Stochastic Frontier, Tobit.**

I. Introduction

Rice (Oryza Sativa Linu) is the staple food over half of the world's population and at least 3.5 billion people are consuming rice [1]. In the world, the largest volume of rice production is concentrated in countries China, India, Indonesia, Vietnam, Thailand, Bangladesh, Burma, Philippines, Brazil and Japan. The percentage share of the above top ten rice producing countries accounts for about 32.9, 24.4, 11.0, 7.0, 6.0, 5.4, 5.3 2.9 and 1.8 % of the world production, respectively [2].

Rice, become a commodity of strategic significance in Ethiopia for domestic consumption as well as export market for economic development [1]. Besides, it is among the target commodities that have received due emphasis in the promotion of agricultural production, as a result it is considered as the "*millennium crop"* to ensuring food security in Ethiopia [4].

In the study area rice is one of the most important crops grown in terms of area coverage and the volume of production. For instance, the total rice yield of the woreda during the 2015/2016 production period was

56,595.21Qt, while in the 2016/2017 production period it was 61,025.22Qt. However, the productivity did not record any increase. Instead, it fell from 19.15 Qt per ha to 18.99 Qt per ha during the above period [5]. The increase in the production was simply because increment of land under rice cultivation from 2,864.13ha to 3,213.55 ha in these similar production years.

Therefore, knowledge on the level of economic efficiency of smallholder rice production and the underlying socio-economic and institutional factors causing economic inefficiency may help to assess the opportunities for increasing rice production and productivity. Thus, this study would try to measure the economic efficiency level and identify the major factors that affect efficiency level of rice production in smallholder farmers in Guraferda Woreda.

Many studies have provided evidences that rice production and productivity is often associated with several problems in Ethiopia. Since rice has a recent history in Ethiopia, its research status is at infant stage, almost much of the works are constrained on adoption and marketing [6-9]. There is only one rice technical efficiency study in Amhara Region [10]. However, focusing only on technical efficiency (TE) understates the benefits that could be derived by producers from improvements in overall performance.

II. Research Methodology

2.1. *Description of the Study Area*

Guraferda woreda, is located in SNNPR, in Bench Maji zone. The woreda center is Biftu, which is at about 561 km away from south west of Addis Ababa and 42 km from the zonal capital Mizan. It covers a total area of 228,281.25ha. From these, 15160, 1500,500,126000, 85061.25 and 60 ha are farming land, grazing land, residential area, forestland, others/bushes and nonfarm and swampy areas, respectively. The worada is bordered on the south by Bero, on the west and north by Gambela region, on the northeast by Sheko, on the east by Debub Bench and on the southeast by Meinit Shasha. There are 27 *Kebeles* in the Woreda [11].

The total population of the woreda in the year 2014 was estimated to be 43,137. Out of the total population, 54.42% and 45.58% are male and female, respectively [12]. Geographically, it is positioned between 6049‟33”-6058‟06”N latitude and 35007‟03”-35025‟02”E longitude [13]. The agro-climatic zones Guraferda are lowland (Moist Qolla) and (Waynadaga), which constitute 78.25% and 21.75%, respectively. The altitude ranges from 700 to 1995 meters above sea level [13]. The mean annual rainfall of the study area is between 1500-2400mm. The area receives highest rainfall in October and the lowest in February. In the area, the peak monthly temperature is maintained in months of March and October. Average monthly temperature of this woreda is 29.5^{o}C [11].

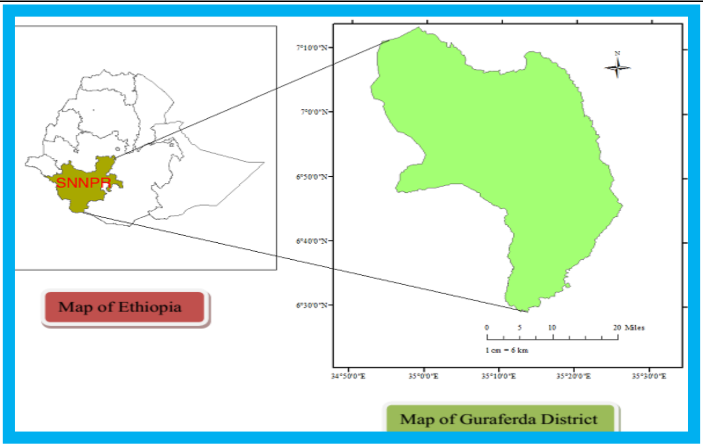

Fig. 1. Geographical location of the study area.

2.2. *Sampling Technique and Sample Size Determination*

Combinations of two stage random and purposive sampling techniques were employed to draw an appropriate sample. Guraferda woreda was selected purposively due to its volume of production, area coverage and number of rice producers. Because of this study focused on efficiency of rice production, rice producer *kebeles* were the major targets in sample selection. In this Woreda from 27, only 18 rural *kebeles* were rice producers out of which six *kebeles* were selected randomly in the first stage. In the second stage, 148 sample rice producer household heads (HHs) were selected randomly using probability proportional to size. The sample size for this study was determined using this formula.

$$n = \frac{N}{1 + N(e)^2} \tag{1}$$

Where

n = Sample size

N = Total number of rice producer household heads

e = Level of precision (8%)

2.3. *Method of Data Analysis*

To address the objectives of the study, both descriptive statistics and econometric models were used to analyze the data. Descriptive statistics such as mean, standard deviation, frequency and percentage values were used to support econometric model result and to describe the farming practice in the study area. From the econometric analysis SFA, specifically Cobb-Douglass production function was used based on the result of GLR test, to estimate the level of TE, AE and EE and Two-limit Tobit model was used to identify factors that affecting the efficiency level of smallholder rice producer farmers.

Specification of Econometric Models:

Stochastic frontiers model was used in this study. Originally this model was proposed by Aigner, Lovell [15], and Meeusen and Van den Broeck [16]. The general functional form of this model was specified as follows.

$$Y_i = f(X_{i,} B) + \varepsilon_i \tag{2}$$

Where: - y_i = The output for the i[th] sample farmer = 1, 2, 3… n, X_i = vector whose values are functions of inputs and explanatory variables for the i[th] farmer, $f(\,)$ is the appropriate functional form and β vector of unknown production parameters to be estimated ε_i is the composed error term (V_i and U_i) and n = number of farmers involved in the survey.

Selection and Estimation of Empirical Model:

Cobb-Douglas and Translog functions have been the most widely used functional forms in most empirical production analysis studies. Each functional form has its own advantage and limitations. Some researchers argue that Cobb-Douglas functional form has advantages over the other functional forms in that it provides a comparison between adequate fit of the data and computational feasibility. It is also convenient in interpreting elasticity of production and it is very parsimonious with respect to degrees of freedom. It is widely used in the frontier production function studies [17].

Moreover, several studies specifically farm efficiency studies used Cobb-Douglas functional form despite its limitations [10, 18, 19,20,21,22 and 23]. Based on the result of generalized log-likelihood ratio test Cobb-Douglas production function was selected for this study. The specific Cobb-Douglas production model estimated was given by:

$$\gamma_i = \beta_o * \prod_{i=1}^{n} \chi_i^{\beta_i} * \ell^{(\nu_i - \upsilon_i)} \qquad (3)$$

The method of estimating a stochastic frontier production function (SFPF), with a Cobb-Douglas production function type by transforming (question 3) it into double log-linear form to 'estimate the efficiency level in rice production of smallholder farmers in the study area, was specified as follow.

$$\ln y_i = \ln \beta_o + \sum_{j=1}^{7} \beta_j \ln x_{ij} + \nu_i - \upsilon_i, i = 1,2...n. \qquad (4)$$

Where: ln = the natural logarithm (in base e); Y = rice output in Qt; X_1= area covered with rice in ha; X_2 = family and hired labor input used in man-days; X_3 = seed input applied in Kg; X_4= fertilizers (Dap and Urea) applied in Kg; X_6 = oxen inputs used by the i[th] farmer in pair of oxen-days and X_7 = chemical (herbicide) in litter. β_0 = level of rice output from ha of land at natural state (the intercept) and the other β_j = constitutes a vector of parameters to be estimated V_i, is a symmetric error term accounting for the deviation from the frontier because of factors which are beyond the control of the farmer and u_i, is a one sided error term accounting for the deviation because of inefficiency effects.

Using the above estimated Cobb-Douglas production function in equation 4, estimation of TE for individual farms was predicted by obtaining the ratio of the observed production values to the corresponding estimated frontier values. The value achieves its maximum feasible value if and only if $TE_i = 1$ otherwise, $TE_i < 1$. The TE for the i[th] farms can be computed as,

$$TE = \frac{\log y_i = \beta_o + \sum_{j=i}^{5} \beta_j l \log_{ij} + \nu_i - \upsilon_i}{\log y_i = \beta_o + \sum_{j=i}^{5} \beta_j \log x_{ij} + \nu_i} \qquad (5)$$

According to Sharma [24] suggests that the corresponding dual cost frontier of the Cobb-Douglas production functional from equation (3) can be rewritten as:

$$c_i = C(w_i, y_i^*; \alpha) \quad (6)$$

Where i refers to the i[th] sample household; C_i is the minimum cost of production; $W_{i,}$ denotes input prices; Y_i^* refers to farm output which is adjusted for noise and α's are parameters to be estimated. The economically efficient input vector of the i[th] household X_{ie} is derived by applying Shepards' lemma [25] and substituting the firms input prices and adjusted output level, a system of minimum cost input demand equation can be written below in question (7) as a derivation form as follow:

$$\frac{\partial c_i}{\partial w_n} = \chi_e(w_i \gamma_i^*; \alpha) \quad (7)$$

Where n is the number of inputs used. The minimum cost is derived analytically from the production function, using the methodology used in (2). Given input oriented function, the efficient cost function can be specified as,

$$Min \sum\nolimits_x c = \sum_{j=i}^{7} \chi_j w_j \quad (8)$$

Subject to $Y =_i^* = \hat{A} \prod \chi_i^{\hat{\beta}_j}$

Where,

$\hat{A} = \exp\ (\hat{\beta}_o)$

ω_i = Input price.

$\hat{\beta}_o$ = Parameter estimates of the stochastic production function and

Y_i^* = Input oriented adjusted output level.

The following dual cost function is found by substituting the cost minimizing input quantities into equation 9.

$$c(\gamma_{k,}^{i^*} w) = HY_k^{i^* \mu} \prod_n w_n^{\alpha n} \quad (9)$$

$$\alpha_n = \mu \hat{\beta}_n, \mu = (\sum\nolimits_n \hat{\beta}_n)^{-1} H = \frac{1}{\mu}(\hat{A} \prod\nolimits_n \hat{\beta}_n^{\beta_{n-k}} \quad (10)$$

EE for the i[th] farmer is derived by applying Shepard's Lemma and substituting the firms input price and adjusted output level into the resulting system of input demand equations.

$$\frac{\alpha c_i}{\alpha \omega_n} = \chi_i^{\beta}(\omega_i \gamma_i^{i^*}; \theta) \quad (11)$$

Where: Ɵ is the vector of parameters and n = 1, 2, 3…, N inputs. The observed, technically and economically efficient costs of production of the i[th] farm are then equal to $\omega_i' X_i$, $\omega_i' X_i^t$ and $\omega_i' X_i^t$; respectively. Those cost measures was used to compute technically and economically efficient indices of the i[th] farmer as follows:

$$TY = \frac{\omega_i' \chi_i^t}{\omega_i' \chi_i} = \frac{\gamma_i}{\gamma_i^*} \quad (12)$$

The farm specific economic efficiency is defined as the ratio of minimum observed total production cost (C*) to actual total production cost (C).

$$EE = \frac{C^*}{C} \tag{13}$$

According to Farrell [26], the AE index can be derived from equations (12) and (13) as follows:

$$AE = \frac{EE}{TE} \tag{14}$$

Determinants of Efficiency:

To analyze the effect of demographic, socioeconomic, farm attributes and institutional variables on technical, allocative and economic efficiencies a second stage procedure was used, where the efficiency scores were regressed on selected explanatory variables using two-limit Tobit model. This model is best suited for such analysis because of the nature of the dependent variable (efficiency scores), which takes values between 0 and 1 and yield the consistent estimates for unknown parameter vector [27].

According to Maddala [28]) the two-limit Tobit model can be specified as,

$$\gamma^*_{i,TE,AE,EE} = \delta_o + \sum_{j=1}^{13} \delta_j \chi_{jk} + \mu_i \tag{15}$$

Where Y_i^* is the latent variable representing the efficiency scores, δ_0, $\delta_1, \ldots, \delta_{13}$ are parameters to be estimated, X_j represent the demographic, socio economic farm and institutional factors that affect efficiency level and μ_i= an error term that is independently and normally distributed with mean zero and variance (δ^2 ~IN (0, δ^2)). Farm-specific efficiency scores for the smallholder rice producers range between zero and one. As a result, two-limit Tobit model can be presented as follow,

$$Y_i = \left\{ \begin{array}{l} 1, if \; y_i^* \geq 1 \\ Y_i^* \; if \; 0 \angle y_i^* \angle 1 \\ 0, if \; y_i^* \leq 0 \end{array} \right. \tag{16}$$

Following Maddala [29], the likelihood function of this model is specified as

$$L(\beta, \delta \perp y_{j,} L_{lj} L_{2i}) = \prod_{yj-L1j} \phi(\frac{L_{1j} - \beta x_j'}{\delta}) \prod_{yj-2j} \phi(\frac{y_i - \beta' x_j}{\delta}) \prod_{j-yj'} \phi(\frac{L_{2j} - \beta x_j'}{\delta}) \tag{17}$$

Where l_{1j} = 0 (lower limit) and l_{2j} = 1 (upper limit) and are normal and standard density functions.

In a two-limit Tobit model, each marginal effect includes both the influence of explanatory variables on the probability of the dependent variable to fall in the uncensored part of the distribution and on the expected value of the dependent variable conditional on it being larger than the lower bound. Thus, the total marginal effect takes into account that a change in explanatory variable had a simultaneous effect on the probability of being efficient in rice production and value of efficiency scores in rice production.

Next to McDonald and Moffitt, Greene and Gould cited in Bealu, Endrias and Tadesse [20], from the likelihood function decomposition of marginal effects was proposed as follows two-limit Tobit model:

The unconditional expected value of the dependent variable

$$\frac{\partial E(Y)}{\partial \chi_J} = [\phi(Z_u) - \phi(Z_L)]\frac{\partial E(Y^*)}{\partial X_J} + \frac{\partial[\varphi(Z_u) - \varphi(Z_L)]}{\partial \chi_J} + \frac{\partial[1 - \varphi(Z_U)]}{\partial \chi_J} \quad (18)$$

The expected value of the dependent variable conditional upon being between the limits

$$\frac{\partial E(Y^*)}{\partial \chi_J} = \beta_{m..}\left[1 + \frac{\{Z_{L\phi}(Z_L) - Z_u\phi(Z_u)\}}{\{\phi(z_u) - \phi(Z_L)\}}\right) - \left[\frac{\{\phi(Z_L) - \phi(Z_u)\}2}{\{\phi(Z_U) - \phi(Z_L)\}2}\right) \quad (19)$$

The probability of being between the limits

$$\frac{\partial[\varphi(Z_U) - \varphi(Z_L)]}{\partial \chi_j} = \frac{\beta_m}{\delta}[\varphi(z_l) - \phi(Z_u)] \quad (20)$$

Where, φ . = the cumulative normal distribution, ∅ . = the normal density function $Z_L = -\frac{X_j\beta}{\sigma}=$ and $Z_U = \frac{(1-X_j\beta)}{1}$ are standardized variables that came from the likelihood function given the limits of y* and σ = standard deviation of the model.

2.4. *Descriptions of Variables and Working Hypothesis*

Based on literature reviewed, a number of factors influencing the level of efficiency of rice production. These factors are summarized as follow.

Table 1. Summary statistics of variables used in the two-limit Tobit model.

Variable	Mean	Std. Dev	Percentage of the mean with Dummy = 1	Percentage of the mean with Dummy = 0	Expected sign
Age of HH (years)	40.54	9.34	-	-	+/-
Education (year)	1.11	1.41	-	-	+
HHsize (man-equivalent)	4.66	2.498	-	-	+/-
Frequency of extension visit (No)	5	2.65	-	-	+
Land fragmentation (Number)	1.40	0.52	-	-	+
Proximity to market (hour)	0.28	0.38	-	-	+
Distance from plot to home(hour)	0.399	0.31	-	-	-
Livestock ownership (TLU)	3.58	2.38	-	-	+
Total cultivated land (ha)	2.53	1.10	-	-	-
Non- farm income	-	-	41.22	58.78	+/-
Credit utilization	-	-	33.78	66.22	+,if user
Sex of household head	-	-	71.62	28.38	+,if male
Membership to coop	-	-	77.70	22.30	+/-

Source: Own review (2018)

III. Results and Discussion

The production function was estimated using seven input variables. The mean and standard deviation of input variables is summarized and described in Table 2. On average, sample households produced 26.11Qt of rice, which is dependent variable in the production function. Similarly, to the production function, the mean and standard deviation of each variable used in the cost function along with their contribution to the total cost of cultivation are summarized and presented in table 2. The total cost of Birr 18542.70 was required to produce 26.11Qt of rice. The land allocated for rice production, by sample households during the survey period, ranged from 0.25 to 3.00 ha with an average of 1.24 ha.

Table 2. Summary statistics of variables used to estimate the production and cost function.

Variables	Unit	Mean	Std. Deviation
Output	Quintal	26.11	14.77
Labor	Man-day	133.77	52.57
Land	Hectare	1.24	0.53
DAP	Kilogram	46.12	31.10
Urea	Kilogram	65.54	54.33
Seed	Kilogram	128.61	56.54
Chemical	Liter	2.42	1.37
Oxen power	Pair of oxen days	9.02	5.28
Cost of output	Birr	18542.70	-
Cost of land	Birr	4051.24	24.28
Cost of labor	Birr	7867.16	47.15
Cost of oxen power	Birr	2098.92	12.58
Cost of DAP	Birr	551.32	3.30
Cost of urea	Birr	709.05	4.25
Cost of seed	Birr	842.41	5.05
Cost of herbicide	Birr	564.66	3.38

Source: Own computation (2018)

3.1. *Econometric Results*

Test of hypothesis: Two hypotheses were tested. The first test was to identify the appropriate functional form between restrictive Cobb Douglas versus non-restrictive Translog production function that best fits the data set. And the other hypothesis tested was that, all coefficients of the inefficiency effect model were simultaneously equal to zero (i.e. Ho: = $\delta_0 = \delta_1 = \delta_2 \ldots = \delta_{13} = 0$). In other words, it was to check whether the explanatory variables in the inefficiency effect model contribute significantly to inefficiency variations among rice growing farmers. The hypotheses for the parameters of the frontier model were conducted using the generalized likelihood (GLR) ratio statistics, λ form can be defined as:

$$LR = \lambda = -2\{Ln[L(H_o)] - Ln[L(H_1)]\} \tag{21}$$

Where, L (Ho) and L (Ha) are the values of the log-likelihood function under the ull and alternative hypotheses, Ho and Ha, respectively. In the cause of the first hypothesis λ or LR value less than critical X^2 value, this implied we accept Ho (Cobb Douglas production function fit the data) and in the second hypothesis λ or LR value greater than critical X^2 value as a result Ho is rejected. Hence, it showed that there exists considerable inefficiency and efficiency variation among rice growing farmers in the study area.

Table 3. GLR tests of hypothesis for the parameters of the SPF

Null hypothesis	LH_O	LH_1	Calculated X^2 (LR)	Critical value (χ2,	Decision
H0: = β_{ij} = 0	29.69	10.23	38.92	41.34	Accept
H0: = $\delta_1 = \delta_2 \ldots = \delta_{13} = 0$	10.23	67.20	113.94	22.36	Reject Ho

Source: model output (2018)

Estimation of production and cost functions: The stochastic production frontier was applied using the maximum likelihood estimation procedure. The frontier model analysis result indicated that, all the input variables in the production function except Urea, had a positive and significant effect on the level of rice output. The coefficients of the production function are interpreted as elasticity. Hence, land has high elasticity of output (0.464) suggests that rice production was relatively sensitive to land. As a result, 1 % increase in number of land in ha was result in 0.464% increase in the rice production, keeping other factors constant. Alternatively, this indicates rice production was responsive to land, followed by oxen power, labor, seed, herbicide and Dap by 0.201, 0.185, 0.171, 0.129 and 0.052%, respectively.

Table 4. Estimation of the Cobb-Douglas frontier production function.

Maximum likelihood estimate			
Variables	Parameter	Coefficients	Std. Err
Cons	β_0	5.522***	0.381
LN Labor	β_1	0.185***	0.056
LN Land	β_2	0.464***	0.066
LN DAP	β_3	0.052***	0.007
LN Urea	β_4	0.010	0.007
LN Seed	β_5	0.171***	0.066
LN Chemical (herbicide)	β_6	0.129***	0.039
LNOxen power	β_7	0.201***	0.044
Sigma square (σ^2)		0.125***	0.023
Lambda		2.729	0.062
Log likelihood function		10.230	
Gamma (γ)		0.882	
Return to scale		1.041	

**** represents significance at 1%, Source*: Model output (2018)

In this study the gamma (γ) calculated as $\gamma = \frac{\delta_U^2}{\delta_S^2} = \frac{\lambda^2}{1+\lambda^2}, \delta_S^2 = \delta_V^2 + \delta_U^2$ alternatively and the output of this model indicate that, ratio of the standard error of u (δ_u) to standard error (δ_v), known as lambda (λ), was 2.729 which is, significantly different from zero. The null hypothesis that there is no inefficiency effect was rejected at 5% level of significance, suggesting the existence of inefficiency effects for farmers in Guraferda woreda.

Based on λ value, gamma (γ) which measures the effect of technical inefficiency in the variation of observed output can be derived ($\gamma = \lambda^2/(1+\lambda^2)$). The estimated value of gamma was 0.882 which indicated that 88.2% of total variation in rice farm output was due to technical inefficiency. This indicates that using stochastic frontier production function model is more appropriate.

According to the model result of SPF the diagnostic statistics of inefficiency component reveals that sigma squared (δ^2) was statistically significant at 1 percent, which indicates goodness of fit and the correctness of the distributional form assumed for the composite error term (table 4).

The coefficients of production variables were calculated to be 1.041, indicating increasing returns to scale. This implies that there is potential for rice producer farmers to continue to expand their production because they are in the I[st] stage of production, where resources use and production is believed to be inefficient. In other words, a percent increase in all inputs proportionally was increase the total production by1.041% (more than1%). This result is consistent with Mustefa who estimated the returns to scale to be 1.039% in his study of EE of barely production in Chole District [29]. But a study by Bealu, Endrias and Tadesse on maize production in Boricha Woreda in Sidama zone found returns to scale to be 0.9588, which falls in stage II of production surface [20].

The dual cost function, which is specified in equation (6) and derived analytically from the stochastic frontier production function, in table 4, was given as follows:

$$\ln_I = 1.394 + 0.001\phi_1 \ln c_{land} + 0.346\phi_2 \ln c_{labor} + 0.019\phi_3 \ln c_{inorganicfertilizer} + 0.054\phi_4 \ln c_{seed} + 0.122\phi_5 \ln c_{chemicals} + 0.133\phi_6 \ln c_{oxenpower} + 0.357 \ln y^* \quad (22)$$

Where C is the minimum cost of production of the i[th] farmer, Y* refers to the index of output adjusted for any statistical noise and scale effects and ω stands for input prices. The model result indicated that 1% increase in the cost of labor, oxen, dap and herbicide would increase total cost of production by 0.346%, 0.133%, 0.016% and 0.122%, respectively.

Efficiency scores of sample households: The results of the efficiency scores indicate that there were wide ranges of differences in TE, AE and EE among rice producer households. The mean of TE was found to be 78.50%. Which reveals that farmers on average could decrease inputs (land, DAP, Urea oxen, labor, herbicide and seed) by 21.5% to get the output they are currently getting, if they use inputs efficiently and the mean AE of rice producer household was 80.56%, this showed that, rice producer households can save 19.44% of their current cost of inputs if they use the right mix of inputs given their prices.

Table 5. Summary of descriptive statistics of efficiency measures.

Type of efficiency	Mean	Std. Deviation	Minimum	Maximum
TE	78.50	0.1235	35.61	96.04
AE	80.56	0.1223	41.87	99.20
EE	63.18	0.1379	29.17	91.28

Source: model output (2018)

In a further form of analysis, the mean allocative efficiency of 80.56% (Table 5) means that there is a need to improve the present level of allocative efficiency. Moreover, the estimates indicated that the farmers have an opportunity to increase their allocative efficiency. For example, farmer with average level of allocative efficiency would enjoy a cost saving of about 18.79% derived from (1 – 0.8056/ 0.9920) * 100 to attain the level of the most efficient farmer.

The mean economic efficiency (63.18) also showed that there was a significant level of inefficiency in the production process. That is the producer with an average economic efficiency level could reduce current average cost of production by 36.82%. To achieve the potential minimum cost level without reducing output levels. It can be inferred that if farmers in the study area were to achieve 100% economic efficiency, they would experience substantial production cost saving of 36.82%.

The frequency distribution of TE result in figure 2 showed that the majority of the sample households have TE score of 81% to 90%. But there are also sample households whose TE levels were limited to the range of 31 to 80 were 45.9 % only. Sample households in this group have a room to enhance their rice production at least by 20%, on average.

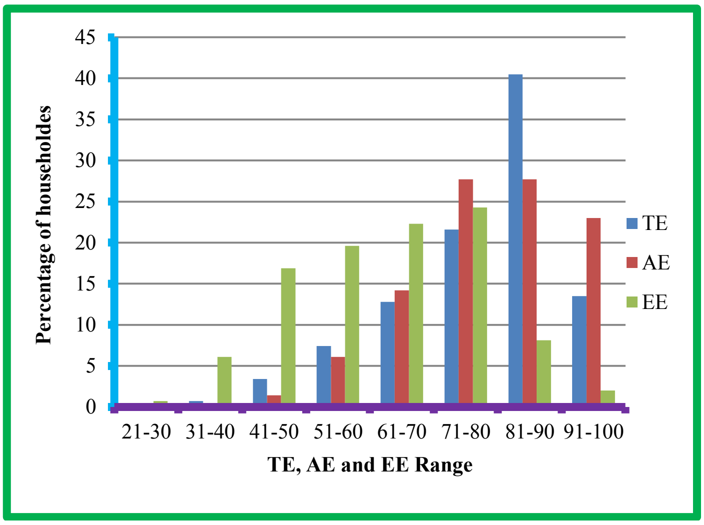

Fig. 2. Percentage distribution of TE, AE and EE scores.

According to the result of AE scores distribution (figure 2), the largest efficiency group of rice producers 27.7 and 27.7% operated between 71-80 and 81-90%, respectively. Households in this group can save at least 20 and 10% of their current cost of inputs by behaving in a cost minimizing way, respectively. Only 23% of the total sample households had an AE score that ranged between 91and 100%.This shows that almost 77 % rice producing households can at least save 10% of their current input cost by reallocation of resources in cost minimizing way.

The distribution of EE scores implies that about 43.3% of the farmers were performing below average efficiency level (figure 2). The majority (24.3%) of rice producers in the study area were operated between 71% and 80%. Households in this group can save at least 20% of their current cost of inputs by behaving in a cost minimizing way.

After determining the existence of efficiency differential among farmers by measuring the levels of their efficiencies, the second key objective of this study was finding out factors causing economic efficiency differentials among farmers. To observe this, the technical, allocative and economic efficiency estimates derived from the model were regressed on socio-economic, demographic, farm and institutional variables that explain the variations in efficiency across farm households using two-limit Tobit regression model. Table 6, illustrates these factors that affect efficiencies in rice production.

Table 6. Two-limit to bit model estimates result for TE, AE and EE measures.

Technical efficiency Allocative efficiency Economic efficiency									
Variables	Coef. (Std. Err.)	ME		Coef. (Std. Err)	ME		Coef. (Std. Er	ME	
		$\partial E(y^*))$	$\partial E(y)\,\partial[\varphi(Z_U) - \varphi(Z_L)]$		$\partial E(y^*))$	$\partial E(y)\,[\partial(\varphi(Z_U) - \varphi(Z_L)]$		$\partial E(y)[\partial(\varphi(Z_U) - \varphi(Z_L)]$	$\partial E(y^*)$
Age	0.002** (0.001)	0.0019	0.0019 (0.0009)	0.000	0.0001	0.0001 (0.0001)	0.001 (0.001)	0.0014 0.0001	0.0013
Sex	-0.058*** (0.018)	-0.0580	-0.0571 (-0.0271)	0.031 (0.025)	0.0249	0 .0292 (0.0268)	-0.025 (0.025)	-0.0253 -0.0026	-0.0243
EDHH	0.002 (0.007)	0.0021	0.0021 (0.001)	0.024** (0.010)	0.0195	0.0228 (0.0209)	0.022** (0.010)	0.0215 0.0022	0.0206
HH size	0.013*** (0.003)	0.0132	0.0130 (0.0062)	-0.004 (0.005)	-0.0033	-0.0039 (-0.0035)	0.007 (0.005)	0.0067 0.0007	0.0065
NONFIC	-0.027* (0.015)	-0.0273	-0.027 (-0.0122)	-0.031 (0.021)	-0.0251	-0.0293 (-0.0259)	-0.049** (0.021)	-0.0491 -0.0044	-0.0471
FEXCT	0.016*** (0.003)	0.0157	0.0155 (0.0073)	-0.005 (0.004)	-0.0041	-0.0048 (-0.0044)	0.008** (0.004)	0.0083 0.0008	0.0080
LFG	-0.005 (0.016)	-0.0048	-0.0048 (-0.0023)	0.003 (0.022)	0.0026	0.0031 (0.0028)	-0.003 (0.022)	-0.0029 -0.0003	-0.0028
CRDUT	0.004 (0.019)	0.0036	0.0036 (0.0017)	-0.031 (0.026)	-0.0252	-0.0293 (-0.0249)	-0.024 (0.025)	-0.0235 -0.0021	-0.0226
TCVLD	0.011 (0.015)	0.0112	0.0052 (0.0110)	-0.008 (0.021)	-0.0062	-0.0073 (-0.0067)	-0.003 (0.020)	-0.0029 -0.0003	-0.0028
PROXMKT	0.030 (0.044)	0.0304	0.0299 (0.0142)	-0.206*** 0.062	-0.1674	-0.1961 (-0.1799)	-0.163***	-0.1623 -0.0165	-0.1558
PDH	-0.017 (0.030)	-0.0171	-0.0168 (-0.0080)	0.013 0.041	0.0108	0.0127 (0.0117)	-0.006 (0.040)	-0.0055 -0.0006	-0.0053
MCOOP	0.025 (0.024)	0.0247	0.0244 (0.0088)	0.090*** 0.033	0.0782	0.0873 (0.0436)	0.093*** (0.032)	0.0922 0.0030	0.0885
Livestock	0.007* (0.004)	0.0071	0.007 (0.0033)	0.002 0.005	0.0016	0.0019 (0.0017)	0.006 (0.005)	0.0059 0.0006	0.0057

***, ** and * refers to 1%, 5% and 10% significance level, respectively.

(Expected change) $\frac{\partial E(y^*)}{\partial x_j}$, (change in probabliy) $\frac{\partial[\varphi(Z_U)-\varphi(Z_L)]}{\partial x_j}$ & (Total change) $\frac{\partial E(Y)}{\partial x_j}$ were used to compute the marginal effect.

Source: Model results.

The estimated coefficient of age for TE in table 6 had positive and significant at 5% significant level. This result indicates, as age household head increase their farming experience increase as a result their technical efficiency also rise. Moreover, the marginal effect of age for technical efficiency shows that, for sample period, an increase age of household head by one-year lead, increase the probability of the farmer being technically efficient by 0.09%

and the mean level and an overall increase in the probability and the level technical efficiency by 0.19 and 0.19%, respectively. The result was similar with [24] and contradict among [20, 30 and 31].

Sex of household head had positive and significant effect on TE at 1%, which is corresponding to the hypothesis made. The result indicated that male household head was more efficient than female. The possible explanation is that male households were carried out most of the activities on the farm, especially on land preparation and had more frequent follow up and supervision of their farm and they might accomplished the farming activities on time and efficiently than female smallholder farmers. In addition the two-limit Tobit model marginal effect result indicate that a unite increase the dummy variables representing male and female household head order with 1 and 0, result increased the probability, expected value and overall increase the probability and level of technical efficiency by 2.71, 5.8 and 5.71%, respectively. This result is also similar with the finding of [30] and it is in contrast with [32].

Education had positive and significant effect on both allocative and economic efficiency with expected sign at 5% significance level. Education enhances the acquisition and utilization of information on improved technology by the farmers. The results showed that farmers with more years of formal schooling were more efficient than their counterparts (table, 6). The significant effect of education on allocative and economic efficiency confirms the importance of education in increasing the efficiency of rice production. This result indicates that, allocative and economic efficiency require better knowledge and managerial skill than technical efficiency. In other words, educated households have relatively better capacity for optimal allocation of inputs. The computed marginal effect result also indicate that, a one year increase in educational attainment level of the household head would increases the probability of a farmer being allocatively efficient by 2.09% and the mean value of allocative and economic efficiency category by about 1.95 and 2.06% with an overall increase in the probability and levels of AE and EE by 2.28 and 2.15%, respectively. The result is in line with [22 and 18].

Family size was hypothesized to have either positive or negative effect. However, number of family size in the household has a positive and significant impact on TE at 1% level of significance. This might be, due to the fact that, a larger household size guarantees availability of family labor for farm operations to be accomplished in time. At the time of peak season, there is a shortage of labor and hence household with large family size would deploy more labor to undertake the necessary farming activities like ploughing, weeding and harvesting on time than their counterparts and for this reason they are efficient in rice production. furthermore, the computed value of ME result of household size showed that, a one-person increase in the number of household size would increase the probability of the farmer being technically efficient by about 0.62% and the expected value and overall the probability and level of TE of smallholder farmers by about 1.32 and 1.3%, respectively. The result is similar with [21] and dissimilar [10].

Non-farm income has negative effect on TE and EE and statistically significant at 10 and 5% significant level, respectively (Table 6). This negative and significant effect of non-farm income on TE and EE indicates that farmers engaged in non-farm income earning activities tend to exhibit lower level of TE and EE. This might be because farmers may allocate more of their time to non-farm income generating activities and thus may lag in agricultural activities. On the other hand, incomes from non-farm activities may be used as extra cash to buy agricultural inputs and can improve risk management capacity of farmers. However, the result shows that agricultural lag effect of non-farm activity has dominated its income effect. Furthermore, the two-limit Tobit model ME result indicates that, a one percent increase in participating in non-farm income generating actives would result in, decrease probability fall under TE and EE category by 1.22 and 0.44%, expected value by about 2.27 and 4.71% and with an overall decrease in the probability and the level of TE and EE by 2.7 and 4.91%, respectively. This result was consistence with the findings of [33 and 34].

The coefficient of frequency of extension contacts had significant and positive relationship with TE and EE at 1 and 5% significance level, respectively. This result indicates that, farmers who had more number of extension contact during the cropping period were technically and economically more efficient than those who had less number of extension contact during 2017/18 production period. This implies that a frequent contact facilitates the flow of new ideas between the extension agent and the farmer thereby giving a room for improvement in rice efficiency. Moreover the ME result revealed that, a unit increase the frequency of extension contact leads to increase the probability fall under TE and EE category by 0.73 and 0.08%, expected value by about 1.57 and 0.8% and with an overall increase in the probability and the level of TE and EE by 1.55 and 0.83%, respectively. This result is in line with the results of [10, 19 and 35] and opposing to [35].

Proximity to market was another important explanatory variable, in line the hypothesis, the coefficient of AE and EE is found to be negative and statistically significant at 1% level of significance. This result showed that as distance increase from market farmer's allocative and economic efficiency reduced. This might due to present of areas that transport access not reached. As a result, farmers face difficulties to reach improved technology, transport inputs and farm product easily. Moreover, the marginal effect indicates that a unit increase distance to the market would decrease probability fall under AE and EE group by 17.99 and 1.65%, reduce the expected value by about by 16.74 and 15.58% and with an overall decrease in the probability and the level of AE and EE by 19.61%, and 16.23% respectively. This finding was agreed with [20, 36 and 37].

The coefficients of AE and EE of rice production were positively and significantly influenced by cooperative membership at 1% significant level. This result indicates that information effect of cooperatives dominated than time loses effect for rice production process. That means farmers who were members of farmer cooperatives received viable information on production technologies than their counterparts. This could help the farmer to improving the level of productive efficiency. In addition, a unit increase in dummy variable representing member and non-member to cooperatives ordered with 1 to 0 would result in, increase the probability of the farmers to fall under AE and EE category by 4.36 and 0.3 % and increase the expected value of AE and EE by about 7.82 and 8.85% with an overall increase in the probability and the level of AE and EE by 8.73 and 9.22%, respectively. The result is agreed with [21 and 30].

The last, but not least, explanatory variable that explains variation in TE was livestock ownership, measured in TLU. The coefficient of livestock ownership for TE was positive and significant at 10%. Positive and significant impact of livestock ownership on TE might be due to the importance of livestock in the crop production system as source of draft power, income and manure that may help to maintain soil fertility and result in maximization of output. Moreover the ME result (0.0033, 0.0007 and 0.0070) showed that, each unit increase in livestock ownership (TLU) would increase the probability, expected value and overall the probability and level of TE by about 0.33, 0.71 and 0.7%, respectively. This outcome is similar with [18, 30 and 38]. However, it contrasts with [33].

IV. Conclusion

In this study, there exists a considerable room to improve the level of TE, AE and EE of smallholder rice producers. The result of Cobb-Douglas production function indicated that land and oxen power were limiting constraints, with positive sign as expected. The positive coefficients of these variables indicate that, increased use of these inputs was increase the production level to better amount.

The average TE, AE and EE values of the sample households were 78.5, 80.56 and 63.18%, respectively. These implies that farmers can increase their rice production on average by 21.5% without increasing inputs if they were technically efficient, reduce current cost of inputs by 19.44% with cost minimization way and there was a room to improve EE by 36.82% when these farmers operate at full efficiency levels.

The key factors that affect the level of efficiencies were identified, to help different stakeholders to increase the current level of efficiency in rice production. Accordingly, age of household head, sex, household size, frequency of extension contact and livestock holding had positive and significant effect as expected on TE. This implies that farmers with older age, male sex, large number of household size (man-equivalent), more number of extension contact and more number of livestock were technically efficient than their counterparts. However, non-farm income had negative effect on TE. Therefore, we can conclude that, farm households who spent more of the time in non-farm income generating activities were technically less efficient than others.

Education level of household head and membership to cooperative had positive and significant effect on AE as expected. This implies households with better education level and cooperative members were more allocatively efficient than others. However, proximity to market had negative effect on AE. From this it can be conclude that farmers who far away from the nearest market center allocatively less efficient than these close to nearest market.

Lastly, education level of household head, frequency of extension contact and cooperative membership had positive and significant effect on EE as expected. From this, we can conclude that household heads with better level of education, more number of extension contacts and cooperative members were economically more efficient than their counterparts. Nevertheless, distance from market and non-farm income had negative and significant effect on EE. It can also conclude that farmers who far away from nearest market and spent most of their time on non-farm income generating activities were economically less effacement than their opposed.

Acknowledgments

The authors would like to thank Ethiopian Ministry of Education, for their support in providing logistics and finance to conduct this study.

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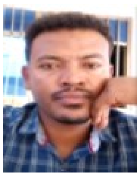

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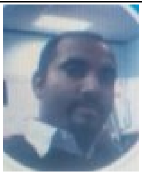

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