Economic Efficiency Analysis of Smallholder Sorghum Producers in West Hararghe Zone, Ethiopia

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The study was aimed at analyzing the economic efficiency of sorghum producing smallholders in West Hararghe zone. It was based on cross-sectional data of 200 sample sorghum producing households randomly selected. The estimation of stochastic frontier production function indicated that labor, DAP fertilizer, area, seed and oxen power affects sorghum yield positively. The estimated results showed that the mean technical, allocative and economic efficiencies were 78.9%, 38.6% and 33.6% respectively which indicates the presence of inefficiency in sorghum production in the study area. Among factors hypothesized to determine the level of efficiencies, frequency of extension contact had positive relationship with technical efficiency and it was negatively related to both allocative and economic efficiencies, while soil fertility was also found to significantly influence technical efficiencies positively and experience has positive relationships with technical efficiency and allocative efficiency and slope significantly affects technical efficiency negatively. The result also indicated that cultivated land was among significant variables in determining technical efficiency and economic efficiency of farmers in the study area. Education was found to significantly determine allocative and economic efficiencies of farmers positively. The result indicated that there is a room to increase the efficiency of sorghum producers in the study area. Therefore, emphasis should be given to improve the efficiency level of those less efficient farmers by adopting and using the best practices of relatively efficient farmers.

Keywords: Sorghum, Economic efficiency, Cobb-Douglass, Stochastic frontier.

INTRODUCTION

Ethiopia, the country with an area of about 1.12 million square kilometers, is one of the most populous countries in Africa with the population of 112 million in 2019 with annual growth rate of 2.6% this growing population requires better economic performance than ever before at least to ensure food security. However, the agricultural sector in the country is characterized by small-scale, subsistence-oriented, an adverse combination of agro climatic, demographic, economic and institutional constraints, and heavily dependent on rainfall. Ethiopian agricultural sector contributes 46.4% of the country’s GDP, employs 83% of total labor force and contributes 90% of exports.

Even though Ethiopia is the country with largest grain producers in Africa it is characterized by large pockets of food insecurity and a net importer of grains. Despite agricultural dominance, there were more than seven million peoples in need of food assistance in the country. The country is food insecure mainly due to lack of improved technology and economic inefficiency in production. The smallholder farmers, who are providing the major share of the agricultural output in the country, commonly employ backward production technology and limited modern inputs. Hence, being an agriculturally dependent country with a food deficit, increasing crop production and productivity is not a matter of choice rather a must to attain food self-sufficiency (World Food Programe, 2015).

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According to CSA (2017) within the category of grain crops, cereals are the major food crops both in terms of the area they are planted and volume of production obtained. They are produced in larger volume compared with other crops because they are the principal staple crops. Cereals are grown in all regions with varying quantity as shown in the CSA survey results. Out of the total grain crop area, 79.3% (9,588,923.7 ha) was under cereals. The proportion of the crop grain areas for teff, maize, sorghum and wheat took up 22.6% (about 2,731,111.7 ha), 17% (about 2,054,723.69 ha), 15.9% (1,923,717.5 ha and 11.9% (1,437,484.7 ha), respectively. Sorghum accounts for an average ten percent of daily caloric intake of households living in the eastern and northwestern areas of the country. About three-quarters of the sorghum grain in Ethiopia is used for making injera (the traditional bread, made from teff in more productive areas of the country). Another 20 percent is used for feed and for local beer production, with the remainder held for seed. The entire plant is utilized, with sorghum stalks used for house construction and cooking fuel and leaves used for animal fodder (GAIN, 2017).

Research institutions claim that it is possible to produce 50-60 qt per ha if improved technologies and practices are used appropriately. Yet, the average productivity level of sorghum in the study areas is about 22 qt/ha, which is below minimum potential yield level. Despite increase in the use of improved inputs especially fertilizers, the productivity level is so low. This is an indication that farmers are not using inputs efficiently. If the existing production system is not efficient, introduction of new technology could not bring the expected improvements in the productivity of sorghum and other crops. Given the existing technology, improvements in the level of technical efficiency will enable farmers to produce the maximum possible output from a given level of inputs. Hence, improvement in the level of technical efficiency will increase productivity. Theoretically introducing modern technologies can increase agricultural output. However, according to Tarkamani and Hardarkar (1996), cited in Mustefa (2014) in areas where there is inefficiency, trying to introduce a new technology may not have the expected impact and "there is a danger of trying to rediscover the wheel" if the existing knowledge is not efficient.

**MATERIAL AND METHODS**

**Description of the Study Area**

The study was conducted in West Hararghe zone, Oromia National Regional State of Ethiopia and the capital city of the Zone is located about 326 km east of the capital city of Addis Ababa along the main road. Based on the population projection value (2018) report, West Hararghe has a population of 1,951,706, an increase of 47.16% over the 1994 census, of whom 989,861 are men and 961,845 women; with an area of 15,065.86 square kilometers, the zone has a population density of 124.23. While 160,895 or 9.36% are urban inhabitants, a further 10,567 or 0.56% are pastoralists. The topography of West Hararghe is characterized by steep slopes in the highlands and mid-highlands and large plains in the lowland areas. The highlands and mid-highlands are normally extensively cultivated but only partially protected by soil conservation structures and practices such as grass strips, alley cropping and bench terraces. The Zone is characterized by crop-livestock mixed farming system where livestock in general and dairy production in particular contribute significantly to farmer livelihoods used as cash income generating purpose. The major crops grown in the area are sorghum barley, wheat, and pulses production and sorghum are primarily produced followed by maize. Khat and Coffee is an important cash crop of this Zone. Over 50 square kilometers is planted with this crop of coffee and the climatic condition is conducive to livestock production.

**Data Source and Sampling Procedure**

Both primary and secondary data were used for this study. Primary data were collected using semi structured questionnaires in two stages. First a preliminary survey was conducted through focus group discussion (using checklist) to obtain general information about the study area. Then formal survey data collection was undertaken with the sampled households and secondary data are collected from different published and unpublished materials.

So, the study followed the formal survey procedure where data collection for quantitative information is gathered using semi-structured questionnaire and selecting a representative sample from a given population. Since the sample selected from a given population is expected to represent the population as a whole, homogeneity of the population is very important. As far as the agro-ecology and farming system of the study area is concerned, it is more or less homogenous. Hence, multi stage random sampling technique was implemented to draw a representative sample. In the first stage among twelve sorghum producing districts two districts are selected, in the second stage five kebeles from the districts were selected randomly based on probability proportional to size of kebeles in the districts, finally following the establishment of a sample frame for sorghum growing farmers in each of the five kebeles, the sample households were selected using simple random sampling with probability proportional to size. The sample size was determined by the formula given by (Yemane, 1967).

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

Where: \(n\) = Sample size, \(N\) = Population size and \(e\) = level of precision by taking* \(e^2\) as 7.5%, total number of household head 10277the sample size would be 200. Accordingly, a total of 200 sorghum producing households were randomly drawn in 2019 production year.
Econometric model analysis

The Stochastic Frontier Model will be used to estimate the level of technical, allocative and economic efficiencies of sorghum producers. The model was simultaneously developed by Aigner et al. (1977) and Meeusen and Van Den Broeck (1977).

The model is defined as: $Y_i = F(X_i; \beta) + \epsilon_i$

Where $Y_i$ is measures the quantity of output of the $i^{th}$ firm, $X_i$ is a vector of inputs used by $i^{th}$ firm, $f(X_i; \beta)$ is a suitable production function, $\beta$ is vector of unknown parameters to be estimated. $\epsilon_i$ is the composed disturbance term which equals $(\epsilon_i - u_i)$. The random disturbance term $u_i$ is intended to capture the effects of the stochastic noise and assumed to be independently and identically distributed $[N(0, \sigma^2)]$ while $\epsilon_i$ captures technical inefficiency and assumed to be independent of $u_i$. It also assumed to be independently and identically distributed as half-normal, $u_i = N(0, \sigma^2)$. The variance parameters are expressed as $\sigma^2 = \sigma^2_{\lambda} + \sigma^2_{\alpha}$ and $\lambda = \alpha/\sigma$ where, it is the ratio of the standard error of the non-symmetric to symmetric error term. Battese and Corra (1977) proposed $\gamma = \sigma^2_{\lambda} / (\sigma^2_{\lambda} + \sigma^2_{\alpha})$, instead of $\lambda$. However, there is an association between $\gamma$ and $\lambda$. According to Bravo and Pinheiro (1997) gamma can symmetrize $\lambda$. The reason is that $\alpha$ could be any non-negative value while $\gamma$ ranges from 0 to 1, such that the value zero is associated with the traditional response for which $u_i$ is absent from the model, i.e. perfect efficiency in production. The value one indicating that all the deviations from the frontier are due to entirely technical inefficiency i.e. the random error on production is zero. A Stochastic Frontier model requires a prior specification of the functional form, for this study, Cobb-Douglas production function will be used. Thus, to estimate a Cobb-Douglas production function, we must log all of input and output data before analyzing the data (Coelli 1995). The linear form is specified as:

\[
\ln(\text{output}) = \beta_0 + \beta_1 \ln(\text{land}) + \beta_2 \ln(\text{labor}) + \beta_3 \ln(\text{seed}) \\
+ \beta_4 \ln(\text{Urea}) + \beta_5 \ln(\text{oxen}) + \beta_6 \ln(\text{Dap}) + \epsilon_i
\]

Technical efficiency (TE) of an individual firm is estimated as the ratio of the observed output to the corresponding frontier output. The measure is given as:

\[
\text{TE}_i = \frac{Y_i}{Y*} = \frac{f(X_i; \beta) \exp(v_i - u_i)}{f(X; \beta) \exp(v_i)} = \exp(-u)
\]

Following Bravo-Ureta and Rieger (1991) adjusted output $Y^*$ is used to derive the technically efficient input vector, $X^*$. The technically efficient input vector for $i^{th}$ firm, is derived by simultaneously solving equation and the observed input ratio $X_i \cdot X^* (i>1)$ where $K_i$ is equal to the observed ratio of the two inputs in the production of $Y^*$. Sharma et al. (1999) suggests that the corresponding parameter of the dual cost frontier can be derived algebraically and written in a general form as:

\[
C_i = C(\omega_i, Y^*; \alpha)
\]

Where $C_i$ is the minimum cost of production; $\omega_i$ is a vector of input prices for the $i^{th}$ firm; $Y^*$ refers to farm output which is adjusted for noise $v_i$ and $\alpha$ is a vector of parameters to be estimated from primal function. To estimate the minimum cost frontier analytically from the production function, the solution for the minimization problem is given as:

\[
\min \sum_i C_i = \sum_{i=1}^{6} X_i \omega_i
\]

Subject to $Y_i^* = \bar{A} \prod_j X_{ij}^\beta$

Where $\bar{A} = \exp(\bar{\beta}_i)$, $\omega_i$ is input prices, $\bar{\beta}_i$ is parameter estimate of the stochastic production function and $Y_i^*$ is input oriented adjusted output level. Then, substituting the input demand equations derived using shepherds’s lemma and output adjusted for stochastic noise in the minimization problem above, the dual cost function can be written as follows:

\[
C_i(Y^*_i, \omega, \omega) = H Y_i^* \prod_j \omega_i^\alpha
\]

Where; $\alpha_i = \mu \bar{\beta}_i$, $\mu = (\Sigma \bar{\beta}_i)^{-1}$ and $H = \frac{1}{\mu} (\bar{A} \prod \bar{\beta}_i) \mu$

The economically efficient input vector for the $i^{th}$ firm, $X_{ie}$ derived by applying Shepard’s Lemma and substituting the firms input price and adjusted output level into the resulting system of input demand equations.

\[
\frac{\partial C_i}{\partial \omega_i} = X_{ie} = (\omega_i, Y_i^*; \alpha)
\]

Where $n = 1, 2, 3,...n$ are inputs used. The observed, technically and economically efficient costs of production of the $i^{th}$ firm are then equal to $\omega_i X_{i}, \omega_i X_{i}, \omega_i X_{i}$ respectively. Those cost measures are used to compute TE, AE and EE induces for the $i^{th}$ firm as follows:

\[
\text{TE}_i = \frac{\omega_i X_{i}}{\omega_i X_{i}} = Y_i / Y_i^* 
\]

Where, $Y^*$ = frontier output and $Y_i$ = actual yield

$\text{EE}_i = \omega_i X_{i} / \omega_i X_{i} = C/C$

Where, $C^*$ = minimum (efficient) cost

$C = \text{actual cost}$

$\text{AE}_i = \omega_i X_{i} / \omega_i X_{i}$

$\text{AE} = \text{EE}_i / \text{TE}_i$

Each of these efficiency measures takes a value between zero and one inclusive, with a value of one, indicating full efficiency.

Determinants of efficiency

To analyze the effect of demographic, socioeconomic, farm attributes, institutional variables on efficiencies, a second step procedure will be used where the estimated efficiencies scores are regressed on selected explanatory variables using censored 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 $\alpha$ (Maddala, 1999). Estimation
with OLS regression of the efficiency score would lead to a biased parameter estimate since OLS regression assumes normal and homoscedastic distribution of the disturbance and the dependent variable Greene (2003). Following Tobin (1958) the model can be specified as:

$$E_i = \sum_{i=1}^{n} \beta_j X_j + \epsilon_i$$

$$E_i = \left\{ \begin{array}{ll}
i & \text{if } E_i^* \geq 1 \\
0 & \text{if } E_i^* < 1 \\
\end{array} \right.$$

Where \( E_i \) is an efficiency score, representing technical, allocative and economic efficiencies; and \( \epsilon_i \sim N(0, \sigma^2) \) and \( \beta_i \) are the vector of parameters to be estimated. The \( X_j \) represents various farm specific variables and \( E_i^* \) is the latent variable, with \( E_i = E [ E_i^*/X_j ] \) equals \( X_i \beta \).

**RESULTS OF ECONOMETRIC ANALYSIS**

**Hypothesis Test**

Before proceeding to the estimation of the parameters from which individual level of efficiencies are estimated, it is essential to examine various assumptions related to the model specification. To do this, two hypotheses were tested the first one is testing for the existence of the inefficiency component of the total error term of the stochastic production function. The result reveals the existence of inefficiency or one-sided error component in the model. Hence, the hypothesis that sorghum producers in the area are efficient is strongly rejected. As a result, the production behavior of sorghum producers of the study area can better be represented by the stochastic production function than the average response function. The second related hypothesis to be tested was that all coefficients of the inefficiency effect model are simultaneously equal to zero (i.e. \( H_0: \delta_0 = \delta_1 = \delta_2 = \ldots = \delta_{14} = 0 \)) against the null hypothesis, which states that all parameter coefficients of the inefficiency model are different from zero. It is to mean that the explanatory variables in the inefficiency effect model do not contribute significantly to the explanation of the economic inefficiency variation for the sorghum-growing households. So based on the test result, the null hypothesis is rejected in favor of the alternative hypothesis that explanatory variables associated with inefficiency effects model are simultaneously different from zero.

**Table 1.** Generalized Likelihood Ratio test of hypotheses for parameters of SPF

<table>
<thead>
<tr>
<th>Null hypothesis</th>
<th>( \lambda )</th>
<th>Degree of freedom</th>
<th>Critical value (( \chi^2 ), 95%)</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>( H_0: \gamma = 0 )</td>
<td>17.32</td>
<td>1</td>
<td>6.34</td>
<td>Rejected</td>
</tr>
<tr>
<td>( H_0: \delta_0 = \delta_1 = \delta_2 = \ldots = \delta_{14} = 0 )</td>
<td>41.23</td>
<td>14</td>
<td>22.72</td>
<td>Rejected</td>
</tr>
</tbody>
</table>

Source: Model output based on survey data, 2019

**Production function variables**

The relative contribution of both usual noises and the inefficiency component on total variability should be determined. The ratio of the standard error of \( u(\alpha_i) \) to the standard error of \( v(\gamma_i) \), known as lambda (\( \lambda \)), is 2.146. Based on \( \lambda \), gamma (\( \gamma \)) which measures the effect of technical inefficiency in the variation of observed output can be derived (i.e. \( \gamma = \lambda^2 [1+\lambda^2] \)). In this case, the value of this discrepancy ratio (\( \gamma \)) calculated from the maximum likelihood estimation of the full frontier model was 0.822 with standard error of 0.016 and it is much higher than its standard error.

**Table 1.** Parameter Estimates of the Stochastic Production Frontier Model

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour</td>
<td>0.486***</td>
<td>0.171</td>
</tr>
<tr>
<td>DAP</td>
<td>0.121*</td>
<td>0.059</td>
</tr>
<tr>
<td>UREA</td>
<td>0.101</td>
<td>0.187</td>
</tr>
<tr>
<td>Seed</td>
<td>0.036*</td>
<td>0.019</td>
</tr>
<tr>
<td>Area</td>
<td>0.924***</td>
<td>0.167</td>
</tr>
<tr>
<td>Oxen</td>
<td>0.376***</td>
<td>0.182</td>
</tr>
<tr>
<td>Constant</td>
<td>1.095***</td>
<td>0.391</td>
</tr>
<tr>
<td>Gamma</td>
<td>0.822***</td>
<td>0.017</td>
</tr>
<tr>
<td>Lambda</td>
<td>2.146***</td>
<td>0.007</td>
</tr>
<tr>
<td>Sigma square</td>
<td>0.397***</td>
<td>0.052</td>
</tr>
</tbody>
</table>

*and *** Significant at 10% and 1%, significance level respectively.  
**Source:** Model output based on survey data, 2019

The coefficient for the parameter \( \gamma \) can be interpreted in such a way that about 82.2% of the variability in sorghum output in the study area in the year 2019 was attributable to technical inefficiency effect, while the remaining 17.8% variation in output was due to the effect of random noise. This indicates that there is a room for improving output of sorghum by first identifying those institutional, socioeconomic and farm specific factors causing this variation.

The dual frontier cost function derived analytically from the stochastic production is given as:

\( \ln C_i = 5.450 + 0.894 \ln Y_i + 0.35 \ln \text{labor} + 0.346 \ln \text{oxygen} + 0.1010 \ln \text{UREA} + 0.1094 \ln \text{DAP} + 0.4973 \ln \text{Area} + 0.0305 \ln \text{seed} \)

Where \( C \) is the minimum cost of production of the \( j \)th farmer, \( Y^* \) refers to the index of output adjusted for any statistical noise and scale effects and \( \alpha \) stands for input prices.

**Technical, allocative and economic efficiency scores**

The model output indicates that farmers in the study area were relatively good in technical efficiency than allocative efficiency or economic efficiency. The mean level of technical efficiency of sorghum growing sample households was about 78.9%. This means in the short run...
there are opportunities for reducing sorghum production inputs by 21.1% through adopting technologies used by the best practice of sorghum farmers. The mean allocative efficiency of farmers in the study area was 38.6% indicating there is a need to improve the present level of allocative efficiency. The estimates depicted that the farmers have ample opportunities to increase their allocative efficiency. For instance, farmer with average level of allocative efficiency would enjoy a cost saving of about 32.6% derived from (1 – 0.386/0.573)*100 to attain the level of the most efficient farmer. The most allocative inefficient farmer would have an efficiency gain of about 65.6% derived from (1-0.197/0.573)*100 to attain the level of the most technically efficient farmer.

The mean economic efficiency 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 66.4% 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 66.4%. This implies that reduction in cost of production through eliminating resource use inefficiency could add about 66.4% of the minimum annual income. The result also indicated that the farmer with average level of economic efficiency would enjoy a cost saving of about 34.6% derived from (1-0.336/0.514)*100 to attain the level of the most efficient farmer. The most economically inefficient farmer would have an efficiency gain of 66.5% derived from (1-0.173/0.516)*100 to attain the level of the most efficient farmer.

Table 3. Summary of descriptive statistics of efficiency measure

<table>
<thead>
<tr>
<th>Types of Efficiency</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Standard deviations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical Efficiency</td>
<td>0.518</td>
<td>0.943</td>
<td>0.789</td>
<td>0.072</td>
</tr>
<tr>
<td>Allocative Efficiency</td>
<td>0.197</td>
<td>0.573</td>
<td>0.386</td>
<td>0.057</td>
</tr>
<tr>
<td>Economic Efficiency</td>
<td>0.173</td>
<td>0.516</td>
<td>0.336</td>
<td>0.045</td>
</tr>
</tbody>
</table>

Source: Model output based on survey data, 2019

Frequency distribution of efficiency estimates of sample farmers is presented in Table 4. Most of households had a higher technical efficiency levels. About 21% of sorghum farmers in the study area were operating above the efficiency level of 90% and 43.50% of them were operating in the range of 80-90% of technical efficiency levels. On the other hand, none of the farmers was operating below 50% of technical efficiency level. The result indicated that the potential to improve sorghum productivity for individual farmers through improvement in the level of TE is the smallest as compared to that of the AE and EE.

Table 4. Frequency distribution of efficiency estimates of sample farmers

<table>
<thead>
<tr>
<th>Efficiency level</th>
<th>TE N</th>
<th>TE Percent</th>
<th>AE N</th>
<th>AE Percent</th>
<th>EE N</th>
<th>EE Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>00-09.999</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>10-19.999</td>
<td>0</td>
<td>0.00</td>
<td>2</td>
<td>1.00</td>
<td>16</td>
<td>0.00</td>
</tr>
<tr>
<td>20-29.999</td>
<td>0</td>
<td>0.00</td>
<td>15</td>
<td>7.50</td>
<td>77</td>
<td>38.50</td>
</tr>
<tr>
<td>30-39.999</td>
<td>0</td>
<td>0.00</td>
<td>105</td>
<td>52.50</td>
<td>98</td>
<td>49.00</td>
</tr>
<tr>
<td>40-49.999</td>
<td>0</td>
<td>0.00</td>
<td>64</td>
<td>32.00</td>
<td>7</td>
<td>3.500</td>
</tr>
<tr>
<td>50-59.999</td>
<td>16</td>
<td>8.00</td>
<td>14</td>
<td>7.00</td>
<td>2</td>
<td>1.00</td>
</tr>
<tr>
<td>60-69.999</td>
<td>25</td>
<td>12.50</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>70-79.999</td>
<td>30</td>
<td>15.00</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>80-89.999</td>
<td>87</td>
<td>43.50</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>90-99.999</td>
<td>42</td>
<td>21.00</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Source: Model output based on survey data, 2019

Determinants of efficiency differentials among farmers

After measuring levels of farmers’ efficiency and determining the presence of efficiency differences among farmers, finding out factors causing efficiency disparity among farmers was the next most important step of this study. The result of Tobit model showed that; frequency of extension contact, cultivated land and educational level of household head were important factors influencing economic efficiency of farmers in the study area. The model also revealed that three variables were found to significantly influence allocative efficiency of sorghum producers. These variables were frequency of extension contact, experience of household head on sorghum production and educational level of the household. However, the sign for extension contact in allocative and economic efficiencies was not as anticipated. The result also show that frequency of extension contact, soil fertility, experience, slope and cultivated land were found to be statistically significant to affect the level of technical efficiency of farmers.

Frequency of extension contact: Frequency of extension contact had statistically significant positive relationship with technical efficiency at 1% significance level as it was expected. 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 farm efficiency. Advisory service rendered to the farmers in general can help farmers to improve their average performance in the overall farming operation as the service widens the household’s knowledge with regard to the use of improved agricultural inputs and agricultural technologies. This result is also similar to those obtained by Jema, (2008) and Tolosa et al. (2019). However, the negative coefficient of extension contact which is significant at one percent in allocative efficiency and economic efficiency indicates that efficiencies in resource allocation are deteriorating as the frequency of extension contact increases. This may be due to the fact that extension workers are only interested in maximizing output at any cost.
Table 5. Maximum likelihood estimates of the tobit model

<table>
<thead>
<tr>
<th>Variables</th>
<th>TE</th>
<th>AE</th>
<th>EE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef.</td>
<td>Std. Err</td>
<td>Coef.</td>
</tr>
<tr>
<td>Constant</td>
<td>0.5286***</td>
<td>0.0437</td>
<td>0.5682***</td>
</tr>
<tr>
<td>EXTNCON</td>
<td>0.0040***</td>
<td>0.0009</td>
<td>-0.0026***</td>
</tr>
<tr>
<td>Soil fertility</td>
<td>0.0782***</td>
<td>0.0197</td>
<td>0.02416</td>
</tr>
<tr>
<td>Experience</td>
<td>0.0027***</td>
<td>0.0009</td>
<td>0.0018**</td>
</tr>
<tr>
<td>House hold size</td>
<td>0.0002</td>
<td>0.0038</td>
<td>-0.0007</td>
</tr>
<tr>
<td>slope</td>
<td>-0.0398*</td>
<td>0.0216</td>
<td>-0.0167</td>
</tr>
<tr>
<td>Cultivated land</td>
<td>0.0358*</td>
<td>0.0195</td>
<td>-0.0110</td>
</tr>
<tr>
<td>Fragmentation</td>
<td>0.0078</td>
<td>0.0170</td>
<td>-0.0098</td>
</tr>
<tr>
<td>OFNFA</td>
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<td>0.0176</td>
<td>-0.0104</td>
</tr>
<tr>
<td>Livestock</td>
<td>-0.0000</td>
<td>0.0014</td>
<td>-0.0000</td>
</tr>
<tr>
<td>Credit</td>
<td>0.0221</td>
<td>0.0221</td>
<td>-0.0060</td>
</tr>
<tr>
<td>Education</td>
<td>0.0108</td>
<td>0.0187</td>
<td>0.0126*</td>
</tr>
<tr>
<td>Weeding</td>
<td>0.0151</td>
<td>0.0221</td>
<td>0.0034</td>
</tr>
<tr>
<td>Proximity</td>
<td>-0.0007</td>
<td>0.0054</td>
<td>0.0013</td>
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<tr>
<td>Inter cropping</td>
<td>0.02416</td>
<td>0.0145</td>
<td>-0.0041</td>
</tr>
</tbody>
</table>

*, **and ***Significant at 10%, 5% and 1%, significance level respectively.

Source: Model output based on survey data, 2019

Perceived fertility status of soil: It was hypothesized that the fertility status of the soil would have significant impact on the output of sorghum. The result indicates that the coefficient of fertility of soil is positive and statistically significant at one percent level of significance implying that fertility of soil is an important factor in influencing the level of efficiency in the production of sorghum. Therefore, development programs in improving and maintaining the fertility of land will have positive impact in raising efficiency. The study result is similar with Ermiyas et al. (2015) that showed that soil fertility had positive relationship with efficiency.

Experience: The estimated coefficients of experience for technical efficiency was positive signs and significant at one percent. Dawang et al. (2011) and Azeb et al. (2019) which is because of the accumulated experiences that have been gathered over time they become skillful as they get older and may have an interest in the use of new methods of production. The estimated coefficients of experience for allocative efficiencies were also positive and significant at five percent significance level. This may be because allocative efficiency requires greater knowledge and skill gathered over time, which increases the capacity of farmers for optimal allocation of resources and technology. Therefore, experienced the farmers are more technically and allocatively efficient they are.

Slope: The slope of land was hypothesized to determine technical efficiency negatively. The result shows that slope determined efficiency negatively and it is statistically significant at ten percent level of significance. This is because as slope increase soil erosion also increase and the nutrients (fertilizers) applied to the soil also lost through erosion and this can reduce the availability of nutrients to the crop and consequently minimize the yield obtained and efficiency of the farmers. The result is similar to that obtained by Azeb et al. (2019), which slope significantly and negatively determines efficiency of sorghum producer. Cultivated land: Total cultivated or farm land was found to have significant and positive impact on technical efficiency and economic efficiency at ten and one percent respectively, which is in line with the hypothesis made. This might be because of Farmers with larger area of cultivated land have the capacity to use compatible technologies that could increase the efficiency of the farmer, enjoy economies of scale. This result is in line with the argument of Mustefa (2014). Therefore, larger farms are relatively better efficient than small size farms.

Education: The coefficient for educational level was significant and positively related to allocative and economic efficiencies at ten and five percent respectively. The result indicates that, allocative efficiency and economic efficiency require better knowledge and managerial skill. The positive sign indicates that increase in human capital enhances the efficiency of farmers. The sign was as expected because the more educated the farmers are the more will be the likelihood of being efficient in resource allocation. This result is consistent with that of Musa (2013) and Tolosa et al. (2019). Because of their better skills, access to information and good farm planning; literate farmers are better to manage their farm resources and agricultural activities and willing to adopt improved production technologies.

CONCLUSION AND RECOMMENDATIONS

Thus, the results of the study give information to policy makers and extension workers on how to better aim efforts to improve farm efficiency as the level and specific determinant for specific efficiency types are identified. This could contribute to compensation of high production cost,
hence improve farm revenue, welfare and generally help agricultural as well as economic development. These findings stress the need for appropriate policy formulation and implementation to enable farmers reduce their inefficiency in production as this is expected to have multiplier effects ranging from farm productivity growth to economic growth and poverty reduction at macro level.

In the study area, levels of different types of efficiencies and their determinants were found to be different and allocative efficiencies and economic efficiencies were found to be low. Therefore, an intervention aiming to improve efficiency of farmers in the study area has to give due attention for resource allocation in line with output maximization as there is big opportunities to increase output without additional investment.

The result indicated that extension contact has positive and significant contribution to technical efficiency. Since extension services are the main instrument used in the promotion of demand for modern technologies, appropriate and adequate extension services should be provided. This could be done by designing appropriate capacity building program to train additional development agents to reduce the existing higher ratio of farmers to development agents as well as to provide refreshment training for development agents. The study also indicated that extension contact has negative and significant contribution to allocative and economic efficiencies. Therefore, extension agents have to give due attention for appropriate input allocation and cost minimization in addition to their acknowledgeable effort to increase production. This calls for the need to more effective policy support for extension services and additional efforts need to be devoted to upgrade the skills and knowledge of the extension agents.

The result of the study shows that soil fertility is a crucial factor in determining technical efficiency of households. Therefore, households have to work to improve the fertility status of the soil though it is difficult to achieve this in the short run. Households can do this by applying fertilizers that are suitable for the farm and practicing soil conservation practices. Strengthening soil fertility maintenance program is required and extension workers can play a great role in improving the status of the soil by working closely with the farmers in this regard.

Slope significantly reduced the technical efficiency of sorghum producers when lands are vulnerable to erosion damages and their fertility is likely to be poor due to high run-off. If soil conservation measures such as check dam and water way measures are not practiced, it reduces efficiency thereby reducing sorghum production. So, development agents should encourage households to strengthen the soil conservation measures such as check dam and water way to reduce soil erosion.

Total cultivated land was found to be related to technical and allocative efficiencies level positively. This shows that with increased cultivated area, technical and allocative efficiencies of sorghum production would increase. This might be because of farmers with larger area of cultivated land have the capacity to use compatible technologies that could increase the efficiency of the farmer, enjoy economies of scale. Thus, provision of technologies that would help to carry out such operations more efficiently would improve the technical and allocative efficiencies level of the farmers and complementary inputs including employment of labor.

Education was very important determining factor that has positive and significant impact to both allocative efficiency and economic efficiency in the study area. It is central to adopt and use modern agricultural technologies and practices, agricultural information and institutional accessibilities which in turn increase and improve farm household’s efficiencies. Thus, government has to give due attention for training farmers through strengthening and establishing both formal and informal type of framers’ education, farmers’ training centers, technical and vocational schools as farmer education would reduce both allocative and economic inefficiencies.

Finally, it is interesting to note that most efficiency studies in the developing countries have focused mainly on the measurement of technical efficiency, even though it is by improving the overall economic efficiency that major gains in production could be achieved. This means, additional efforts should be devoted to examining the impact of both allocative and economic efficiencies on performance for different types of crops and areas at various points in time.

REFERENCES


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