Technical, Allocative and Economic Efficiency of Soya bean Production: The Case of Smallholder Farmers in Pawe District, Ethiopia[1]

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Abstract

This study was undertaken with the objective of assessing technical, allocative and economic efficiency of soya bean production and to identify factors affecting them in Pawe district. The data were collected from 203 randomly selected sampled households in Pawe district Northwestern Ethiopia. Both descriptive and econometrics model were employed to analyze the collected data. A stochastic frontier approach was applied to measure technical, allocative and economic efficiency of soya bean production. The estimated SPF model showed that amount of land, labor and DAP were found to explain the frontier function. The result found that the mean technical, allocative and economic efficiency was 72.72%, 35.378% and 25.05%, respectively. The estimated value of gamma was 0.7384 which indicates that 73.84% of the variation in soya bean output was due to technical inefficiency. This indicates there is a big opportunity to increase soya bean production in the study area through improving efficiency. For example, given fixed level of input and technology, there is opportunity to increase soybean yield by 27.28% in Pawe district. In addition, the Tobit model result showed that age, level of education, extension service, access for credit, farming experience, off/nonfarm income participation and training affected technical, allocative and economic efficiency of soya bean producer farmers in the study area. Depending on the findings the following recommendations are forwarded. Government or any stakeholder should facilitate timely access to DAP with reasonable price,

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reduction in interest rate of the lending institutions and increase training to farmers using farmer training centers.

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1. Introduction

The economic development of Africa, more than any other continents, depends on the improvement of the agricultural and agro-industry sectors, which are mainly affected by the productivity of resources so that the inappropriate use of resources in these nations matter significantly. This is in particular true for Sub-Saharan Africa where agriculture is the fundamental contributor to the majority of their gross domestic product (GDP) and it is the major source of earnings and employment (Henao and Baanante, 2006). Consequently, one of the foremost policy concerns of the governments in these countries nowadays is to reap sustainable development that fulfill economic objective (Girmay, 2006).

Like to most of African countries, agriculture plays a central role to achieve economic growth in Ethiopia. The sector contributes 36.3% of the country Gross Domestic Product (GDP) and it additionally function a source of employment opportunities to more than 73% of total population that is involved in agriculture, generates about 70% of the foreign exchange earning of the country and 70% raw materials for the industry in the country (UNDP, 2018). This indicates that the overall economy of the country and the food security of the majority of the population rely on agriculture. However, the sector is explained by low performance, caused by a combination of natural calamities, demographic factors, socio-economic factors, backward and poor technologies and lack of knowledge on the efficient utilization of limited resources particularly on land and capital (WFP, 2012). Hence, being agriculture dependent country with a food deficit gap, increasing crop production and productivity is not a matter of choice rather a must to attain food self-sufficiency.

Soya bean is gaining ground globally due to its multipurpose use as human food, livestock feed, industrial purposes, and more recently, as a supply of bio energy (Myaka et al., 2005). Producing and consuming more soya bean would enhance the circumstance (Food Security) as soy gives a nutritious mix of each calorie and protein consumption. In addition, this crop is the most nutritionally wealthy crop, it contains 40% of protein compared to 18% from meat and 11% from eggs (Chianu et al., 2008).

In Ethiopia, the volume of soya bean production during the last sixteen years has been increased (CSA, 2001-2017). Despite the increased volume of soya bean production, its national average yield (22.71quintal per ha) remains low as compared to the world average yield (27.6 quintal per ha) (CSA, 2018). Besides, spatial variability in soya bean productivity is another concern for soybean productivity enhancement in Ethiopia. For instance, in 2018/19, the average soya bean productivity in Ethiopia varied from 23.20 quintals per ha (Oromiya region) to 21.38 quintals per hectare (Benishangul-Gumuz region). Similarly, the average soya bean productivity varied in other regions too (CSA, 2018). Therefore, increasing production levels and reducing its variability are both essential aspects to improved food security and well-being of the people of Ethiopia.

On the other hand, Ethiopia recorded a huge trade volume deficit in soya bean in recent years. The trade deficit which is the difference between the imported and exported volume of soya bean is about 138 million Kg on average (CSA, 2001-2017), which indicates there is a higher demand in the domestic market for soybean. However, there are many factors hindering soya bean production in Ethiopia. The problems are not only limited to market access but also to low productivity and production, lack of processing facilities, lack of capital to increase production and limited market information system for effective agricultural marketing (Bezabih, 2010).

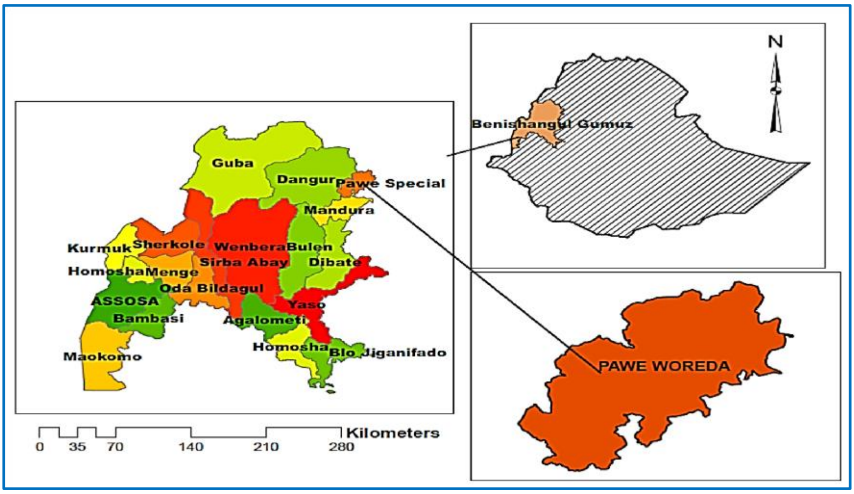
The future demand for soya bean can be met by increasing farm productivity (Masuda and Goldsmith, 2009). Basically, production and productivity can be boosted using two ways. The first method is through increased use of inputs or improvement in technology given some level of input. The second option of increasing productivity is through improving the efficiency of smallholder farmers, given fixed level of inputs and technology. However, rather than just evaluating the technical potential of the crop, it is advantageous to take a serious look at the economic considerations in terms of farmers‟ ability in the efficient allocation of a given inputs and at the same time the chance they stand in improving their livelihoods through soybean production. As a result, this study is mainly concerned about assessing economic efficiency of smallholder farmers on soya bean production.

There are many of researchers in Ethiopia who have done efficiency analysis on various crop production (for example, Kinde, 2005; Assefa, 2016; Hassen, 2016 and Moges, 2017). However, soya bean which have a great contribution for the country export in Ethiopia are scanty in this regard. There is only one study related to measuring efficiency of soya bean production in Ethiopia (Regasa et al., 2019) with some methodological problems. In this study, the method used to measure efficiency are to some extent vague and some very important variables (for instance age, offarm income, membership to cooperative and slope) are omitted from the tobit model. In addition, empirical study on measuring farm efficiency of soya bean production in Pawe district are untouched. Consequently, technical, allocative and efficiency of soya bean production under smallholder farmers and the factors that might be cause to farm inefficiency remain unidentified in the study area. Therefore, this study aimed to fill the existing knowledge gap in measuring technical, allocative and economic efficiency of soya bean production and identifying determinant factors that causes to farmers' technical, allocative and economic efficiency in soya bean production.

2. Methodology

2.1 Study Area

Figure 1: Geographical location of Pawe district



Source: Fitsum (2016)

Pawe is one of the 20 districts in the Benishangul-Gumuz regional state of Ethiopia Located at the Northwestern of Ethiopia. It is located about 570 km away from the capital city, Addis Ababa. Pawe is bordered on the south by Mandura district, on the west by Dangur district and on the northeast by Jawi district. The administrative center of this district is Almu. This district has a total of 20 kebele administration. The total population is estimated at 45,552 of whom 23,265 were men and 22,287 were women. From this 22.1% of population are urban inhabitants. The majority of the inhabitants (63.49%) practiced Ethiopian Orthodox Christianity (CSA, 2007). The farming system of the district is characterized as mixed crop-livestock farming system dominated by cereal and pulses crops. From the pulses, soya bean takes a big share in terms of production and area coverage. Despite the fact that the area is potential for crop production, agricultural productivity is generally low and it is subsistence oriented.

2.2 Sampling Techniques and Sample Size

This study employed combinations of multi-stage, purposive and random sampling techniques to draw the appropriate sample households. In the first stage, from the total seven districts in Metekel Zone, Pawe district is selected purposively for its long year experience in soya bean production. In the second stage, from the total of 20 soya bean producer kebeles in the district, three kebeles were selected by using simple random sampling method. Consequently, the three selected kebeles are village 26, village 24, and village 23/45. Finally, sample size was determined by using a formula developed by Yamane (1967).

$$\mathrm{n} = \frac{N}{1+N\,(e)^2} = \frac{49{,}578}{1+49{,}578\,(0.07)^2} = 203 \tag{1}$$

Where n = required sample size N= size of population e = desired level of precision (7%).

2.3 Data Type and Method of Collection

Both primary and secondary data were used for this study. The primary data were obtained from sample households using structured questionnaire via face-to-face interview with the heads of the households. Degree holder enumerators from the Pawe woreda were recruited and one day training was given to them by the researcher. Secondary data were obtained from Pawe district agricultural office (PDAO) report.

2.4 Analytical Methods

The analysis of production efficiency was carried out following the Aigner et al. (1977) method of the estimating the Stochastic Frontier Production Functions (SFPF). The study specified the SFPF using a Cobb-Douglas and Translog production function for smallholder soya bean producing farmers in the Pawe district, Metekel zone, Benishangul – Gumuz Regional state, Ethiopia. The linear form of Cobb-Douglas production function is represented in Equation 2.

$$lnY_i = \beta_0 + ln\sum\beta_j X_{ij} + \mathcal{E}_i \qquad \textbf{(2)}$$

$$\mathcal{E}_i = v_i + u_i$$

Where ln denotes the natural logarithm; j represents the number of inputs used; i represents the ith farmer in the sample; Y represents the observed soya bean production of the ith farmer; Xij denotes jth farmer input variables used in soya bean production of the ith farmer; β stands for the vector of unknown parameters to be estimated; εi is a composed disturbance term made up of two elements (v_i and u_i); νi accounts for the stochastic effects beyond the farmer's control, measurement errors as well as other statistical noises and ui captures the technical inefficiency.

The Trans log stochastic frontier production function initially developed by Aigner et al. (1977) and Meeusen and Van den Broeck (1977) specified as:

$$lnY_i = \sum_{k=1}^{7}\beta_k \; lnX_{ik} + \frac{1}{2}\sum_{k=0}^{7}\sum_{j=0}^{7}\beta_{jk} \; lnX_{ij}lnX_{ij} + v_i - u_i \qquad \textbf{(3)}$$

Here ln denotes the natural logarithm, Y_i represents output of the ith producer, k represents the number of inputs used, X_{ij}represents a set of 7 input variables (land, labor, seed, oxen power, chemicals, dap, and urea) used by the ith farmer, and β is a vector that collects unknown parameters to be estimated.

The random error v_i accounts for the stochastic effects beyond the farmers control, measurement errors as well as other statistical noise, and u_i captures production inefficiency due to factors that are in the control of the farmer. Both of the Cobb-Douglas and Trans log production function have their own advantage and limitation. However, in this study, the appropriate functional form which best fit the data was selected by using likelihood ratio test.

The solution to the cost minimization problem is the basis for deriving the dual cost frontier, given the input price (ω_j), parameter estimates of the stochastic frontier production function ($\hat{\beta}$) and adjusted output level Y_k^{i*}.

$$MinC = \sum_n \omega_n x_n$$

Subject to 1RE

$$Y_k^{i*} = \hat{A} \prod_n x_n \hat{\beta}_n \quad \textbf{(4)}$$

Where $\hat{A} = \exp(\hat{\beta}_0)$, ω_n = input price, $\hat{\beta}$= parameter estimates of the stochastic production function and $Y_k^{i}*$ = input oriented adjusted output level from Equation 4.

The following dual cost function will be found by substituting the cost minimizing input quantities into Equation 5.

$$C(Y_k^{i*}, w) = HY_k^{i*\mu} \prod_n \omega_n \alpha_n \quad \textbf{(5)}$$

Where $\alpha_n = \mu\hat{\beta}_n,\ \mu = \left(\sum_n \hat{\beta}_n\right)-^1\ and\ H = \frac{1}{\mu}(\hat{A} \prod_n \hat{\beta}_n \hat{\beta}_n)-^{\mu}$

Therefore, the efficiency indices of the given farmer can be calculated as follows:

$$\mathrm{TE} = \frac{\mathrm{Y}}{\mathrm{Y*}} \quad \textbf{(6)}$$

Where Y* represents frontier output, Y represents actual yield

$$EE = \frac{C}{C*} \quad \textbf{(7)}$$

Where, C* represents minimum (efficient) cost, C represents actual cost. Following Farrell (1957), allocative efficiency index of the ith farmer can be derived from Equations 6 and 7 as follows;

$$AE = \frac{EE}{TE} \qquad \textbf{(8)}$$

After measuring the level of efficiency, a Tobit model employed to identify the hypothesized socioeconomic and institutional factors that affect performance of farmers. 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 (Maddala, 1999).

Following Maddala (1999) the Tobit model can be specified as:

$$Y_i^* = \beta_0 + \sum \beta_{Xim} + \mu_i \qquad \textbf{(9)}$$

Where Y_i^* represents latent variable representing the efficiency scores of farmers i; β represents a vector of unknown parameters; Xim represents a vector of explanatory variables m (m = 1, 2... k) for farm i and μi represents an error term that is independently and normally distributed with mean zero and variance σ2.

Denoting y_i as the observed variables, $y_i = y \begin{cases} 1 & if\ y_i^* \geq 1 \\ y_i^*\ if\ 0 < y_i^* < 1 \\ 0 & if\ \ y_i^* \ \leq 0 \end{cases}$ **(10)**

3. Results and Discussion

This section presents the demographic, socioeconomic and institutional characteristics of the sampled respondents. Understanding the characteristics of respondents is important in order to identify variables that can hinder or increase the production efficiency of sampled soya bean producers. The characteristics of sample households were summarized under each sub-section by descriptive (mean, minimum, maximum, percentage and charts). For this study, data were collected from 203 randomly selected households.

3.1 Descriptive Statistics for Characteristics of Sampled Households

The mean age of sampled respondents was 50.40years with minimum and maximum age of 25 and 88 years, respectively. The average formal years of schooling attend by sampled respondent is approximately three years with a maximum of 12 years (Table 1).

Table 1: Descriptive statistics for characteristics of sampled households

Variables	Mean	Std. Deviation	Minimum	Maximum
AGE	50.40	14.01	25	88
EDUCATION	2.90	2.07	0	12
FRMEXP	27.98	12.21	2	78
FAMSIZ	8.54	2.12	1	12
FARMSIZ	0.625	0.282	.25	1
FQECT	8.97	4.60	4	22
DISTMK	4.98	2.35	1	9
TLU	4.34	1.80	0.065	9.245
HTFDST	4.88	2.42	1	9

Source: Own survey result, 2020

3.2 Soya Bean Production Constraints

The problems faced by smallholder soya bean producers in the study area can disturb their performance and productivity. If the problems need to be identified, programs that might help improve the productivity must be put in place. Respondents were asked to identify major constraints faced regarding to soya bean production. Various constraints were identified and discussed as follow.

From soya bean production constraints, weed infestation was a serious problem that farmers were facing in the study area followed by crop diseases and pest infestation. From the total 203 sampled respondents about 87 (42.86%), 71

(34.98%) and 36 (17.73%) respondents reported that they were facing weed infestation, crop disease and pest infestation, respectively. Moreover, there was also labor shortage in the study area. Sample households also reported that there were animal and seed shortages during peak agricultural production seasons (Table 2).

Table 2: Soya bean production constraints faced by the respondents

Soybean production problems	Numbers of farmers	Percent
Animal Shortage		
Yes	18	8.87
No	185	91.13
Crop Disease		
Yes	71	34.98
No	132	65.02
Labor Shortage		
Yes	27	13.30
No	173	86.70
Pest		
Yes	36	17.73
No	167	82.27
Seed Shortage		
Yes	4	1.97
No	199	98.03
Weed Infestation		
Yes	87	42.86
No	116	57.14

Source: Own survey result, 2020

3.3 Summary of Production Function Variables

The production function in this study was estimated using seven input variables. The input variables used in production function of soya bean were land, labor, DAP, Urea, oxen power, seed and chemical whereas the dependent variable was soybean production. To draw some picture about input and output variables, the minimum, maximum, mean of input and output variables are presented. The sampled households had achieved a mean yield of 13.35quintal per hectare. However, due to unknown reasons too small farmers obtained less than 3 qt of soybean per hectare (Table 3).

Table 3: Descriptive statistics of output and input variables

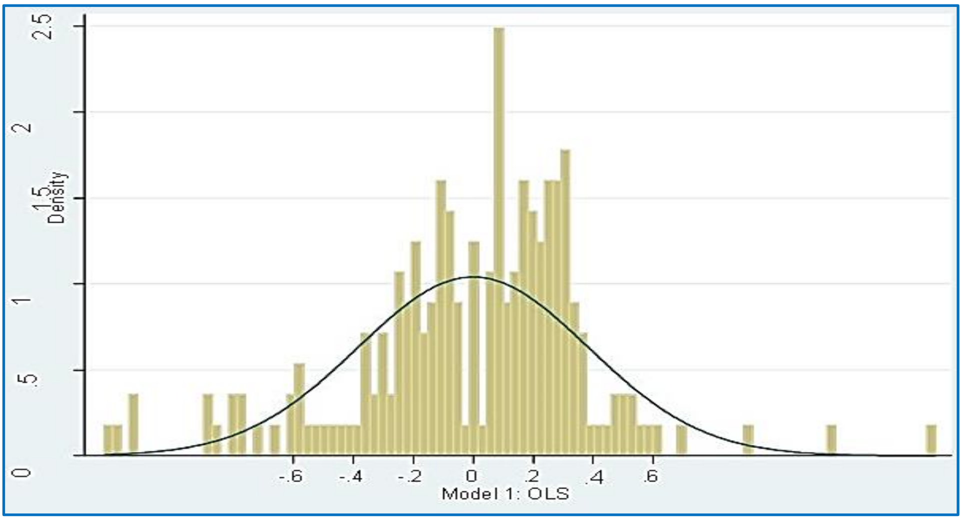
Variable	Mean	Std. Deviation	Minimum	Maximum
Output (quintal/ha)	13.35	6.67	2	37
DAP (kg)	60.53	28.56	0	100
Urea (kg)	64.90	31.02	0	100
Oxen (oxen day)	9.51	5.18	3	24
Seed (kg)	77.56	18.21	43	100
Land (ha)	0.539	0.288	0.25	1.5
Labor (MD)	41.01	19.93	10	101
Chemical (L)	7.83	5.27	1.5	24

Source: Own survey result, 2020

4. Econometrics Results

Before going to the econometric analysis, the collected data from 203 sample households was tested related to stochastic frontier model. In this study, three hypotheses were tested. The likelihood function of a stochastic frontier model is highly nonlinear and estimation can be difficult. Given this potential difficulty, it is desirable to have a simple test on the validity of the stochastic frontier specification prior to undertaking the more expensive maximum likelihood estimation. Schmidt and Lin (1984) proposed an OLS residual test to check for the validity of the stochastic frontier model specification. As a rule of thumb, for a production-type stochastic frontier model with the composed error vi-ui, and distributed symmetrically around zero, the residuals from the corresponding OLS estimation should skew to the left (i.e., negative skewness) and if the estimated skewness has the expected sign, rejection of the null hypothesis provides support for the existence of the one-sided error. Following the OLS estimation of the production function of soya bean farm, this study plots the histogram of the residuals compared to a normal density. The result showed that there was some evidence of negative skewness (Figure 2).

Figure 2: Distribution of OLS Residuals



Source: Own survey result, 2020

To formally examine and test, the study used the skewness statistic. The statistic is labeled as skewness and it had a value equal to -0.372. The negative sign implies that the distribution of the residuals were skews to the left which is consistent with a production frontier specification. As a result, the result confirms the rejection of the null hypothesis of no skewness in the OLS residuals (Table 4). This result was further confirmed by significance of the generalized log-likelihood ratio test for γ presented in Table 6 where results of the stochastic frontier model are presented.

As indicated earlier, to further verified the existence of the inefficiency effect a likelihood ratio test were applied to test the null hypothesis that the inefficiency component of the error term is equal to zero (γ: = 0) and the alternative hypothesis that the inefficiency component different from zero (γ: ≠ 0). The result obtained from Table 5 showed that the computed likelihood ratio test statistic 7.09 is greater than x2 critical value of 2.705, which indicates there was evidence to reject no inefficiency effects in the data. Thus, the null hypothesis that the average response function (OLS specification) is an adequate representation of the data were rejected and the alternative hypothesis that stated there exists considerable inefficiency among sample farmers was accepted. This finding confirms the results of skewness test presented earlier.

Table 4: Skewness statistic

Percentiles		Smallest		
1%	-1143	-1.230		
5%	-.7603	-1.199		
10%	-0.497	-1.143	Obs	203
25%	-0.193	-1.139	Sum of Wgt.	203
50%	0.073		Mean	5.12e-10
		Largest	Std. Dev.	0.383
75%	0.241	0.704		
90%	0.346	0.930	Variance	0.147
95%	0.488	1.1901	Skewness	-0.372
99%	0.930	1.541469	Kurtosis	5.148

Source: Own survey result, 2020

The second test was to select appropriate functional form which best fits the collected data. The Cobb-Douglas and the Trans-log functional forms are the most commonly used stochastic frontier functions in the analysis of efficiency in production. As a rule of thumb, if the likelihood ratio value greater than the x2 critical value we should reject the null hypothesis. Accordingly, a likelihood ratio test was applied on the null hypothesis which states the coefficients on square and interaction terms of input variables in the translog functional forms are not statistically different from zero (H0: βij=0) against the alternate hypothesis which states that the coefficients of all interaction terms and square specification in the translog functional forms are different from zero (H1: βij≠0). The value of likelihood ratio (LR) was computed form the log likelihood value of both Cobb-Douglas and translog production functions. The result of likelihood ratio test found to be lower than the x2 critical value (Table 5), which indicates the coefficient of the interaction terms and the square specification of the production variables under the Translog specification are not different from zero. Therefore, the Cobb-Douglas functional form found to be adequately represent the data. Hence, the Cobb-Douglas functional form was used to estimate efficiency of the sample farmers in the study area.

The final hypothesis was to check whether the explanatory variables in the inefficiency model contribute significantly to the explanation of efficiency variation for the soya bean-growing farmers. This hypothesis was also tested similarly by calculating the likelihood ratio value using the value of the log likelihood function under the stochastic frontier model (without explanatory variables of inefficiency effects (H0)) and the full frontier model with variables that are supposed to determine efficiency level of each farmer (H1). The λ value 60.52obtained from Table 5 was higher than the x2 critical value 27.59 at 17 degree of freedom. As a result, the null hypothesis was rejected in favor of the alternative hypothesis that the explanatory variables associated with Tobit model are simultaneously different from zero. Hence, these variables simultaneously explain the difference in efficiency among farmers.

Table 5: Generalized likelihood ratio tests of hypothesis for the parameters of SPF

Null hypothesis	λ	Critical value (x^2, 0.05)	Decision
H0: $\gamma = 0$	7.09	2.71	Rejected
H0: $\beta ij = 0$	28.49	41.34	Accepted
H0; $\delta 1 = \delta 2 \ldots \delta n = 0$	60.52	27.59	Rejected

Source: Own survey result, 2020

4.1 Estimation of Production and Cost Functions

The regress and variable in the production function was soya bean production (Qt/ha) and the input variables used in the analysis were area under soybean (ha), labor (man days in man equivalent), quantity of seed (kg), quantity of DAP (kg), quantity of urea (kg), oxen (pair of oxen days) and chemical (litter). Out of the seven input variables estimated in the maximum likelihood estimate, land, labor and DAP were statistically significant at 1%, 5% and 5% levels, respectively.

The parametric coefficients of significant input variables were 0.5478, 0.1445, and 0.0106 for area, labor and DAP, respectively. These values indicate the relative importance of each factor in soya bean production. Thus, a one percent increase in the use of land, labor and DAP will result in 0.5478%, 0.1445%, and 0.0106% increase in the level of soybean output, respectively. Consequently, land (area) appeared as one of the major important factors of production followed by labor and DAP in the order, respectively. This indicates that other things remaining constant, a 1% increase in area will increase the output of soya bean output by 0.5478%.

The return to scale value that is obtained from the maximum likelihood estimation of the Cobb-Douglas production function was 0.948 which indicates a 1%increase in all the specified production inputs will increase output by 0.948%. Therefore, an increase in all production inputs by one percent will increase soya bean yield by less than one percent. It can be escaped from stage III of production area by using their existing resources and technology efficiently in the production process. This result was consistent with a study by Gbigbi (2011) in Nigeria found returns to scale to be 0.85. The estimated value of gamma is 0.7384 which indicates that 73.84% of the variation in soya bean output was due to technical inefficiency (Table 6).

Table 6: OLS and ML estimate for the Cobb- Douglas production function

Variables	OLS		MLE	
	Coefficient	Std.Err	Coefficient	Std.Err
Land	0.5513**	0. 0615	0.5478***	0.05799
Labor	0.1280*	0. 0684	0.1445**	0.06178
Seed	0.2954*	0.1164	0.1805	0.11210
DAP	0.0088	0.0053	0.0106**	0.00504
Urea	0.0004	0.0047	0.0001	0.004366
Oxen power	0.1020	0.0693	0.0552	0.06442
Chemical	0.0156	0.0423	0.0091	0.04015
Constant	0.8757*	0.5288	1.7694***	0.52076
Lambda			1.6797	0.08302
Sigma square			0.2725	0.04429
Gama Return to scale = 0.948			0.7383	

Note: The symbol ***, ** and * shows the level of significance at 1, 5 and 10%, respectively.

Source: Own survey result, 2020

Insufficient farm level price data coupled with little or no input price variation across farmers of Ethiopia precludes any econometric estimation of a cost or profit frontier function. Thus, the use of self-dual production function allows the cost frontier function to be derived and used to estimate economic efficiency in situations where producers face the same prices was given as follows:

$$ln\, Cm_i = 2.433 + 0.033\omega_{1i} + 0.3737\omega_{2i} + 0.0066\omega_{3i} + 0.0055\omega_{4i} + 0.0867\omega_{5i} + 0.2836\omega_{6i} + 0.0874\omega_{7i} + 0.0261\, lnY_i^* \quad \textbf{(11)}$$

Where C is cost of producing soya bean; Y_i^* refers to the index of output adjusted for any statistical noise; ω1 is the observed seasonal rent of a hectare of land; ω2 is the daily wage of labor; ω3 is the price of DAP per kg; ω4 is the price of Urea per kg; ω5 is the price of seed per kg; ω6 is the daily rent of oxen and ω7 is the price index of agro chemicals per liter.

4.2 Estimation Efficiency Scores

The mean technical efficiency of sample respondents was about 72.72% with a minimum of 30.54 and a maximum level of 94.66%. Therefore, if the average smallholder farmer of the sample could achieve the technical efficiency level of its most efficient counterpart, then average sample farmers' could increase their output by 23.17% approximately [that is, 1- (72.72/94.66)]*100. Similarly, the most technically inefficient sample farmer could increase the production by 67.73% approximately [that is, 1- (30.54/94.66)]*100 if he could increase the level of technical efficiency to his most efficient counterpart.

The average allocative efficiency of sampled households was about 35.38% with a minimum 15.44% and a maximum of 62.50%. This implies that farmers are not allocatively efficient in producing soybean and hence, a farmer with an average level of allocative efficiency would enjoy a cost saving of about 43.39% (1-0.3538/0.6250)*100 to attain the level of the most efficient farmer. The most allocative inefficient farmer would have an efficiency gain of 75.29% derived from (10.1544/0.6250)*100 to attain the level of the most efficient farmer.

The average economic efficiency of the sample farmers was also about 25.05% with a minimum 12.77% and a maximum of 40.12%. This indicates that there was a significant level of economic inefficiency in the production process. The producer with an average economic efficiency level could reduce the current average cost of production by 62.43% 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 62.43%. Sampled households in the study area were relatively good in technical efficiency than allocative efficiency or economic efficiency. However, none of the respondents had a technical, allocative and economic efficiency of 100 percent (Table 7).

Table 7: Summary statistics efficiency estimates

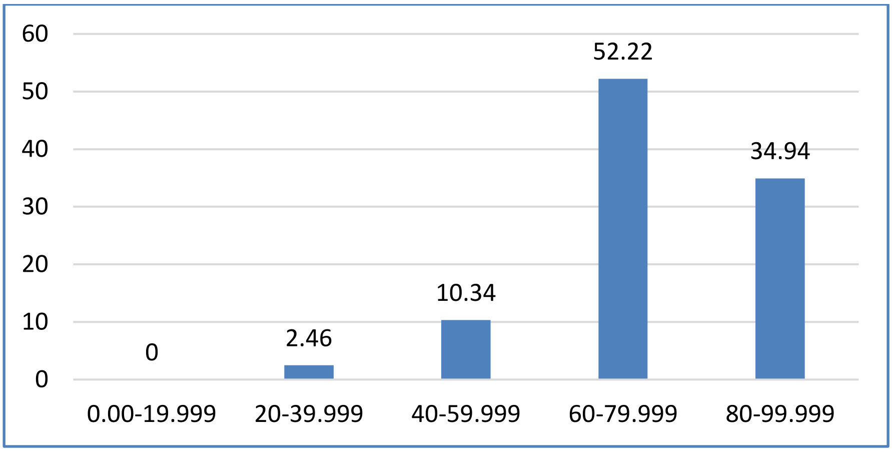
Variable	Mean	Std.Dev	Min	Max
TE	0.7272	0.1237	0.3054	0.9466
AE	0.3538	0.0818	0.1544	0.6250
EE	0.2505	0.0472	0.1277	0.4012

Source: own survey result, 2020

4.3 Frequency Distribution of Technical Efficiency

A frequency distribution presented in Figure 3 shows that most of the farmers (about 65.06 per cent) scored TE of less than 80%. The result also shows that, about 71 (34.98%) respondents in the study area were operating above the technical efficiency level of 80% while 106 (52.22%) of them were operating in the range of 60-80% of technical efficiency levels. In addition, 21 (10.34%) of the farmers were operating from 40-60% of technical efficiency level. Only 5 (2.46%) of sampled households were in the range 20-40% of technical efficiency level. However, none of sampled households were operating below 20% of the technical efficiency level (Figure 3).

Figure 3: Distribution of technical efficiency

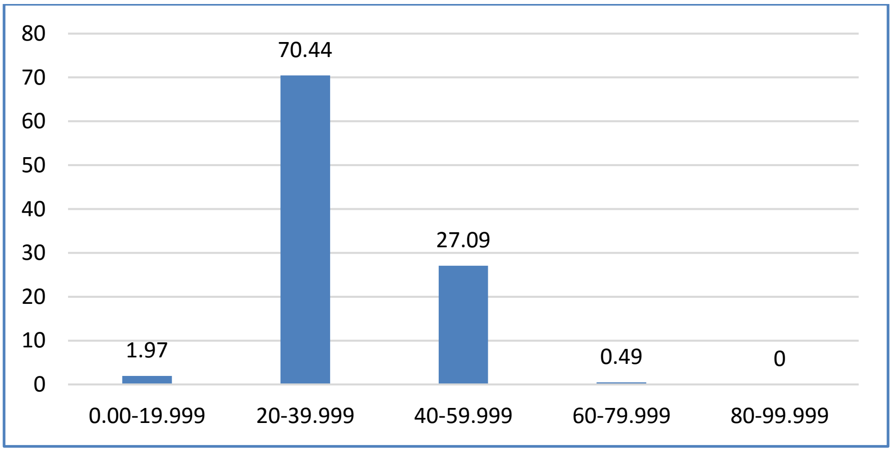


Source: own survey result, 2020

4.4 Frequency Distribution of Allocative Efficiency

The allocative efficiency presented in Figure 4 shows that the distribution is skewed to the left which indicates there are more farmers whose efficiency is far below the average allocative efficiency. This may be due to other factors that were not considered in the model. About 70.44% of the respondent was operating from 20-39.99% of allocative efficiency level while 27.09% were operating from 40-59.99%. In addition, merely 0.49% was operating 60-79.99% allocative efficiency.

Figure 4: Distribution of allocative efficiency

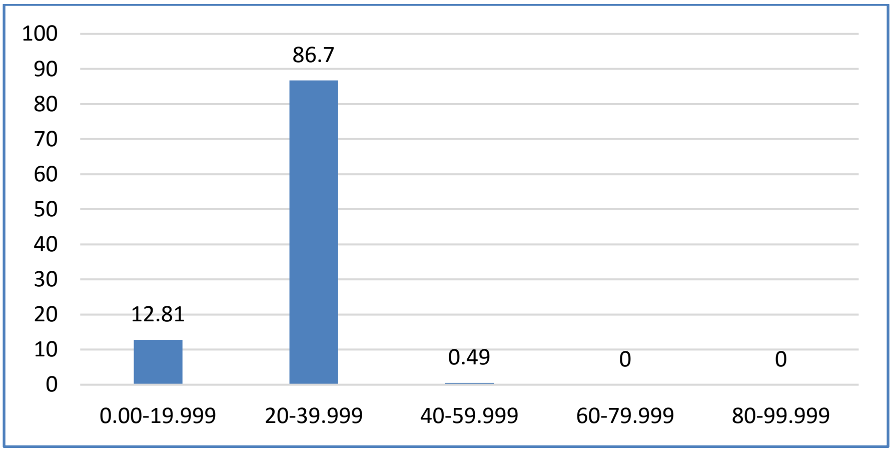


Source: own survey result, 2020

4.5 Frequency Distribution of Economic Efficiency

The result presented in Figure 5 shows that there were also considerable differences in the economic efficiency among farmers in the study area. The study found that 86.7% of the sampled producers' economic efficiency was below 40% which is an indication that more producers were economically inefficient; indicating there was greater variability in their achievement.

Figure 5: Distribution of technical efficiency



Source: own survey result, 2020

4.6 Determinants of TE, AE and EE in Soybean Production

The main interest behind measuring efficiency level is to know what factors determine the efficiency level of individual farmers. In this study, the dependent variable is efficiency not inefficiency. Therefore, technical, allocative and economic efficiency of sample respondents were estimated and regressed on socioeconomic and institutional variables that explain variations in efficiency across sampled households using Tobit regression model.

Age of farmer had a negative and significant effect on allocative and economic efficiencies of soya bean production in the study area at 5% significance levels each, indicating older farmers were allocatively and economically less efficient than younger ones. This might be due to the fact that as the farmer gets older; his ability to manage farming activities becomes decreased and resulting decrease in allocative and economic efficiency. The computed marginal effect of age of the sampled households showed that other things remain constant, a one-year increase in the age of the sampled household head decrease allocative and economic efficiency by 0.19 and 0.11%, respectively. This result is in line with the findings of some studies (Battese and Coelli, 1992; Battese and Coelli, 1995).

Access to credit has a positive and significant effect on the technical efficiency of soybean production. This variable is significant at 5% significance level. The positive sign shows that credit recipients are more technically efficient than their counterpart of non-recipient. This is due to the fact that credit permits a sample smallholder farmer to enhance technical efficiency by overcoming liquidity constraints. Hence, the use of credit access ensures timely acquisition and use of agricultural inputs such as improved seed, DAP, Urea, herbicide, education and implement farm management decisions on time and these results increased production of efficiency. This suggests that the availability of credit is an important factor for attaining a higher level of technical efficiency. Thus, credit access increases technical efficiency by 0.92%. This result is in line with the study done by Kifle (2014) and Sandip and Mohamed (2018).

The farming experience of soya bean producers significantly and positively affected allocative and economic efficiencies at 5 and 1% significance levels, respectively. This could be; because experience is a proxy for managerial aspects and improves the skill and technical capacity that enables to best match inputs and in cost saving aspect so attain higher productivity at minimum cost. The marginal effect result indicates that keeping all other variables constant, an increase in farm experience of the respondent by one year would increase allocative and economic efficiencies by 0.23 and 0.18%, respectively. The result is consistent with previous findings (Mustefa et al., 2017; Leake et al., 2018; Regasa et al., 2019).

As expected, frequency of extension contact had a positive and statistically significant effect on allocative and economic efficiency at 5% and 1% significance levels, respectively, but it was statistically insignificant for technical efficiency. This implies that households who getting more frequent extension contact increased the allocative and economic efficiency. This is due to extension service is expected to increase the farmer’s knowhow on some agronomic practices such as pest and disease control and adoption of improved seed varieties as well as soil and water conservation technologies. This puts the framer in the better position to utilize his/her limited resource to achieve higher results and hence increase their allocative and economic efficiencies. The marginal effect indicates that keeping all other variables constant, for a one-day additional extension agent contact with farmers increases the sampled households' allocative and economic efficiency by 0.3 and 0.19%, respectively. The result is in line with the previous findings done by (Desale, 2017; Mustefa et al., 2017; Osman et al., 2018; Sandip and Muhammed, 2018; Regasa et al. (2019)).

Off/non-farm participation had a positive and significant effect on farmers' technical and economic efficiency at 10% and 5% significance levels, respectively. This implies that households getting off/non-farm income were technically and economically efficient than their counter parts. This is due to the income obtained from such activities could be used for the purchase agricultural inputs and augments financing of household expenditures which would entirely dependent on agriculture. This income availability shifts cash constraint outward and helps farmers to make timely purchase of those inputs which they cannot provide from on farm income. The marginal effect indicates that holding all other variables remain constant, being households participated in off/non-farm income generating activities would increase the technical and economic efficiencies by 3.52 and 1.41%, respectively. The result of this study is found to be similar with some researchers who tried to examine the effect of off/non-farm income participation on economic efficiency (Getahun, 2014; Kifle, 2014; Milkessa et al., 2019).

The result indicated that training was positively and significantly affected technical and economic efficiencies at 1% and 5% significance levels, respectively. This implies that sampled households who have received any kind of training related to soya bean production increased technical and economic efficiency. The marginal effect indicates that holding all other variables remain constant, as farmers got training, the probabilities of sample households would increase technical and economic efficiencies 7.5% and 2.4%, respectively. Similar results were found in the work of Getahun (2014) and Moges (2018).

Table 4: Tobit model result

Dependent Variable	**TE**		**AE**		**EE**	
Independent Variables	**Coefficient (Robust.std.err)**	**Marginal effect**	**Coefficient (Robust.std.err)**	**Marginal effect**	**Coefficient (Robust.std.err)**	**Marginal effect**
AGEHH	0.00061 (0.0011)	0.0006	-0.00183** (0.00095)	-0.0019	-0.00105** (0.00044)	-0.0011
ACSTCDT	0.0377** (0.0176)	0.0372	-0.00963 (0.01256)	0.0096	0.00559 (0.00664)	0.0055
EDUCATION	0.00264 (0.00462)	0.0026	0.00723** (0.00286)	0.0072	0.00369** (0.00155)	0.0035
FRMEXP	-0.00020 0.00136	0.0002	0.00239** (0.00120)	0.0023	0.00182*** (0.00051)	0.0018
FQECT	-0.00034 (0.00199)	0.0003	0.00318** (0.00147)	0.0030	0.00208*** (0.00068)	0.0019
OFFARM	0.03563* (0.01695)	0.0352	-0.00714 (0.01220)	0.0071	0.01402** (0.00663)	0.0141
TRAINING	0.07648*** (0.02263)	0.0750	-0.01257 (0.01525)	0.0125	0.02368** (0.00954)	0.0237
Constant	0.65562*** (0.08086)		0.31969*** (0.04908)		0.18461*** (0.02567)	

Note: ***, ** and * shows the level of significance at 1, 5 and 10%, respectively
Source: Own survey result, 2020

5. Conclusions and Recommendations

This study was conducted to estimate technical, allocative and economic efficiencies and identify factors affecting efficiency among soya bean producer households in Pawe district, Benishangul-Gumuz Regional State, Ethiopia. The estimated SPF model showed that amount of land, labor and DAP were found to explain the frontier function. The positive coefficient of these input variables indicate that output increases as these inputs increases. Therefore, a concerned body or agricultural office of the district should focus on these input allocation. Moreover, the finding showed that soybean producers in Pawe district were technically, allocatively and economically inefficient. For example, the mean economic efficiency in the study area was 25.5%, indicating there are opportunity to increase soya bean output by 74.95% through improving farmers' economic efficiency.

The result found that age of the household heads, measured in years affect allocative and economic efficiency negatively. This might be due to the fact that as the farmer gets older; his ability to manage farming activities becomes decreased. In addition, older farmers may not easily able to adopt new technology and modern inputs. Hence, policy makers should devote a great effort to give more training to older farmers than the younger farmer regarding to adoption of new technology and modern inputs in the study area.

Access to credit was very important determining factor that has positive and significant effect to technical efficiency in the Pawe district. This could be credit enables smallholder farmers to purchases inputs that they cannot afford from their own resources, which enhance production and productivity of soybean resulting increase in technical efficiency. Thus, policy makers should devote a great effort on a reduction in the interest rate, bureaucracies and collaterals of banks on loans which will facilitate credit accessibility to smallholder farmers.

The result of the study also showed that education is positively and significantly affected allocative and economic efficiency. An increase in education level would increase farmers' allocative and economic efficiency. This might be, education helps farmers to have greater ability to understand, adopt and correlate inputs with lower cost and misuse. Thus, government should give due attention in strengthening and establishing both formal and informal type of framers' education.

Farmers who have more experience in farm increased allocative and economic efficiency than less experience farmers. This might be, as farmers get more experience, they will have more knowledge and skills that are required for prudent resource allocation and resulting increase in allocative and economic efficiency. Therefore, mechanisms should be devised to increase farmers' experience.

As expected, frequency of extension contact had positive and significant contribution to allocative and economic efficiency. This is due to extension service is expected to increase the farmer's knowhow on some agronomic practices such as pest and disease control and adoption of improved seed varieties as well as soil and water conservation technologies. This puts the framer in the better position to utilize his/her limited resource to achieve higher results and hence increase their allocative and economic efficiencies. Thus, extension services should be increase to farmers by the government agents especially District Agriculture Development Unit, and NGOs to assist these farmers to have easy access to extension so as to increase farm technical and allocative efficiencies.

Technical and economic efficiencies were significantly and positively determined by off/non-farm income activity, indicating financing timely and enough use of inputs through additional income generated by off/non-farm farm are important. Therefore, strategies that enhance the ease use of off-farm employment opportunities would help to increase technical and economic efficiency in soybean production in the study area.

It is found that training on farm affected technical and economic efficiencies positively and significantly. This is due to provision of training to farmers could improve their skills in use of improved seed and general farm management capabilities will increase their farm productivity. Therefore, efforts should be made to raise farmers training on farm.

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