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Analysis of Production Efficiency, Productivity Variances and Resource Allocation among Small-holder Soybean Producers Farmers: Evidence from Benishangul-Gumuz Region, Western Ethiopia

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ABSTRACT This study aimed at estimating the technical, allocative, and economic efficiencies among smallholder soybean producers and identifying factors affecting production efficiency of the crop. The study used cross-sectional data collected from a sample of 266 soybean producer farmers. Multi-stage random sampling technique was employed to select sample respondents. Descriptive statistics were used to analyze socioeconomic characteristics while the Stochastic Frontier Production Function was used, in order to estimate the level of technical, allocative and economic efficiencies among small-holder farmers. The results revealed that the mean technical efficiency of soybean producer farmers was 72.81 percent while the average efficiency of allocative and economic were 55.13 percent and 40.08 percent, respectively. On the sources of inefficiency, the study found that educational level, farming experience, distance to cooperative and input center significantly reduce the technical inefficiencies among soybean farmers, whereas distance to main road, access to credit, frequency of extension contacts, farming experience and ownerships to tropical livestock unit decreases allocative inefficiency of soybean among producers. On the other hand, educational level, frequency of extension contact, experience in farming, distance to cooperative and input center significantly reduce economic inefficiencies among soybean producer farmers in study area. The result emphasized the need for building rural infrastructure, adult education and training of farmers in FTC and demonstrate new technologies, need support of credit services and increasing frequency of extension and improvements in livestock in the study area.

INTRODUCTION

Soybean is among the important pulse crops grown in different parts of Ethiopia as stable food and income generation source. The country has immense potential for soybean production and is popularized in different parts of the country with multiple food and economic advantages for small-scale farmers. According to CSA report (2018), soybean covered an area of 0.38 million hectares of land and obtained production of 0.86 million quintals in Ethiopia. On average, the productivity of soybean was around 22.71 quintals per hectare. In the same year, it covered an area of 0.27 million hectare with obtained production of 0.3 million quintals in the Benishangul-Gumuz region. This indicate that the lion share of soybean production comes from the western parts of Ethiopia.

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It is used as food for home consumption, raw materials for local factories and feed for animal as indicated by Abebe (2017) and Sisay (2017). According to Tinsley (2009) and Adelodun (2011), soybean crop has relatively high protein content (about 40%) with a good balance of the essential amino acids, unsaturated and non-cholesterol fatty acid (approximately 20%) and contains vitamins such as thiamine, niacin, riboflavin, choline, vitamins E and K, which are necessary for normal body growth and development.

Many efforts have been done in improving soybean varieties development and/or adaptation with different agronomic and other management options since 1950 in the Ethiopian agricultural production systems (Addisu et al. 2016). Assosa Agricultural Research Center also made great efforts to generate, promote and disseminated this technology in potential production areas of western Ethiopia, particularly in the Benishangul-Gumuz Region for more than ten years. Assosa zone is among the areas where this technology was introduced and disseminated to improve food security and income of smallholder farmers. In the area, smallholder farmers who are currently producing soybean are preparing different recipes with different types of cereal and vegetable crops as parts of their stable foods. It is widely produced by the majority of small-holder farmers and plays a crucial and diverse role in the diets of community, cash generation and enhancing soil fertility. This study is mainly concerned with combination of resources and cost minimization targeting optimum production. Identifying inefficiency sources in soybean production helps small-holder farmers to use their inputs efficiently thereby helping in minimizing the already scarce resources in the region. Moreover, the study is designed to find solutions which would promote the crop productivity as well as overall output.

General Objective

The main objective of this study is to evaluate the technical, allocative and economic efficiency and identify sources that explain the variations in inefficiency of soybean production in the study area.

Specific Objectives

1. To determine the level of technical, allocative and economic efficiency of soybean production among small-holders.
2. To evaluate the main sources of inefficiency among soybean producers of small-holders in the study area.

MATERIAL AND METHODS

Study Area

The study area covers one of the main soybean production potentials of the country. Benishangul-Gumuz region is located 661 km West of Addis Ababa that extends to the Sudanese border. The area found at 9º 30' - 11º 30' latitude in the North and 34º 20' - 36º 30' longitudes in the East. It is bordered with the Sudan in the West, Amhara regional state in the North, Oromia regional state in the East and South East and Gambella regional state in the South.

The region has three administrative zones, and one special district. The altitude of the region ranges mainly between 580-2731 meters above sea level. It endowed with various resources that if properly utilized can significantly contribute to the economic development of the country. Hence the study has been conducted at Assosa and Bambasi districts of Assosa zone which have the best practice and high concentration areas for soybean production in the region.

Sample Size Determination

Determination of the sample size followed a proportionate to population size methodology as specified by Kothari (2004) and is calculated as:

$$n = \frac{Z^2 pq}{e^2} \quad (1)$$

Where, n= required sample size

Z^2 = confidence level at 95 percent (standard value of 1.96)

p= estimate of small-holder soybean producers, that is, 0.78. This was an assumption that 78 percent of household participates in soybean production in the area.

q= the weighting variable given by 1-p

e^2= margin error at 5 percent (standard value of 0.05)

$$n = \frac{Z^2 pq}{e^2} = \frac{1.96^2\, 0.78^*\, 0.22}{0.05^2} \approx 266 \quad (2)$$

Sampling Procedure

The study was conducted in Benishangul-Gumuz region with considering population of all soybean producers. A multi-stage sampling technique was employed for the purpose of this study data needs. The first stage involved selection of districts from the region where the survey was conducted. Thus, Assosa and Bambasi districts were selected. The second stage involved selection of 9 rural villages or *kebeles* (4 from Assosa and 5 from Bambasi districts) that were considered for the study. Finally, the third stage involved random selection of soybean producers from each community/village level, giving a total target households of 266 soybean producers (90 for Assosa and 176 for Bambasi). The number of rural villages and farmers chosen from Bambasi district were more because of its large potential of soybean producers and have better experiences relative to Assosa district.

Data Sources and Data Collection Methods

This study involved the use of both primary and secondary data sources. The primary data was collected from field survey by direct interview with soybean producers for the 2009 (2016/2017) cropping season. Secondary data which acted as supplementary was obtained from various sources like journal articles, unpublished reports, and other archives. Socio-economic and institutional factors included during data gathering were sex, age, marital status, educational levels and other demographic characteristics. Production information collected comprised farm size, land tenure system, land allocated for soybean production, labour used in production, varieties planted, amount of seed and fertilizer used, input prices (seeds and fertilizer) and seasonal yields obtained. Access to credit and extension services (number of visits) were also among production information.

Methods of Data Analysis

Descriptive statistics (mean, percentage, range, etc.) was used to summarize the variables in the model and describe the study area. Econometric model, stochastic production frontier model, was used to estimate the production function, determine the sources of inefficiency and estimate the level of efficiency. Given that we are considering a developing country setting whereby the main concern is output shortfall rather than input over use, preference has been given to primal or output oriented approach of measuring efficiency.

Econometric Analysis

Model Specification of Stochastic Frontier Function

Stochastic production frontier approach requires a prior specification of the functional form. Cobb-Douglas production function was selected for this study for several reasons. Foremost it was selected due to its simplicity and the logarithmic nature of the production function that makes econometric estimation of the parameters a simple matter. It is also very parsimonious with respect to degrees of freedom and convenient in interpreting elasticity of production. The linear functional form of Cobb Douglas production function used for the study is given by:

$$\text{In } Y_i = \beta_0 + \text{In} \sum_{j=1}^{k} \beta_j \, x_{ij} + \varepsilon_i \quad (3)$$

$$\Sigma_\iota = v_i - u_i$$

Where, j= 1…k inputs; i= i^{th} soybean producer/number of farmers in the study; (ln) Yi=natural log of soybean output/yield of the i^{th} farmer; X_{ij}= is a vector of actual j^{th} inputs quantities used by the i^{th} farmer; β= is a vector of unknown parameters/vector production coefficients to be estimated, Σ_ι = disturbance term composed of v_i (random error term/random effect) and u_i (error term related with technical inefficiency).

Aigner et al. (1977) proposed the log likelihood function for the model in equation (3) assuming half normal distribution for technical inefficiency effects (u_i). They expressed the likelihood function using λ parameterization, where λ is the ratio of the standard errors of the non-symmetric to symmetric error term (i.e. $\lambda = \sigma_u/\sigma_v$). However, Battese and Corra (1977) proposed that the γ parameterization, where $\gamma = \sigma^2_u/(\sigma^2_v + \sigma^2_u)$ to be used instead of λ. The reason is that λ could be any non-negative value while γ ranges from zero to one and better measures the distance between the frontier output and the observed level of output resulting from technical inefficiency. However, there is an association between γ and λ. According to Bravo and Pinheiro (1997) gamma (γ) can be formulated as:

$$\gamma = \lambda^2 / (1 + \lambda^2) \quad (4)$$

According to Battese and Corra (1977) the log likelihood function of the model is specified as:

$$\ln(L) = -\frac{N}{2}\left(\ln\left(\frac{\pi}{2}\right) + \ln\sigma^2\right) + \sum_{i=1}^{N} \ln\left[1 - \Phi\left(\frac{\varepsilon_i\sqrt{\gamma}}{\sigma^2}\sqrt{\frac{\gamma}{1-\gamma}}\right)\right] - \frac{1}{2\sigma^2}\sum_{i=1}^{N}\varepsilon_i^2 \quad (5)$$

Where $\varepsilon_\iota = \text{In } Y_\iota - \text{In } X_\iota\beta - \alpha_k \text{ In } z_{ik}$, is the residual of (3); N= is the number of observation; ϕ is the standard normal distribution $\sigma^2 = \sigma^2_v + \sigma^2_u$, and $\gamma = \sigma^2_v/\sigma^2$ are variance parameters. The minimization of (5) with respect to β, σ^2, α, and solving the resulting partial derivatives simultaneously, produces the ML estimates of β, σ^2, α.

The existence of inefficiency can be tested using γ parameter and interpreted as the percentage of the variation in output that is due to technical inefficiency. Likewise the significance of δ^2 indicate whether the conventional average production function adequately represent the data or not.

Dual Cost Frontier Model

The production function could also be estimated through an alternative form, called dual, such as cost function. Sharma et al. (1999) suggests that the corresponding dual cost frontier of the Cobb Douglas production function. Production function could be either Cobb-Douglas or translog that requires specification by likelihood ratio test. As it was developed by Battese and Coelli (1995) Cobb-Douglass production function of dual cost used to specify cost function with its inefficiency where cost function represents dual approach; Chambers (1988). The stochastic nature of cost frontier would still imply the theoretically minimum cost frontier; stochastic in nature, given as:

$$C = C\left(\mathrm{P}, \mathrm{Y}^*, \alpha\right) \quad (6)$$

Or

$$\ln C_i = \alpha_0 + \left(\sum_{j=i}^{k} \mathrm{P}_{ij}, \alpha_i\right), + \alpha_j \mathrm{Y}_i^* \quad (7)$$

Where, i= i[th] household; C_i=minimum cost; j=1…k, inputs used; P_{ij}=input price; Y^*_i=farm revenue adjusted for noise v_i, and α's =parameters to be estimated.

Production Function

The efficiency of each farm was assumed to be characterized by a Cobb–Douglas function. Cobb Douglas function is one of the most popular ways of functional form to estimate the relationship between inputs and outputs. The dependent variable is given by the following equation:

$$\ln(\mathrm{Y_i}) = \beta_0 + \beta_1 \ln(\mathrm{area}) + \beta_2 \ln(\mathrm{seed}) + \beta_3 \ln(\mathrm{fert}) + \beta_4 \ln(\mathrm{chem}) + \beta_5 \ln(\mathrm{labour}) + \beta_6 \ln(\mathrm{oxen}) + \mathrm{v_i} + \mathrm{u_i} \quad (8)$$

Where Y_i, represents the total soybean output in quintal/ha, *area* denotes soybean area cultivated (ha), *fert* denotes fertilizer quantity (kg/ha) used, *Seed* denotes seed quantity (kg/ha) used, *labour* denotes labour (man-day/ha), *chem* denotes quantity/volume of agrochemical (kg/ha) used, *oxen* denotes oxen (oxen-day/ha), β are unknown parameters of the production function, v_i are two sided normally distributed random error and u_i is a one sided efficiency component with a half normal distribution.

The corresponding Cobb-Douglas dual cost frontier is derived using vectors of input prices for the j[th] farm. The stochastic frontier production function b*i* and the input oriented adjusted output level Yj^* are known. Thus the corresponding CD dual cost frontier:

$$\ln(C) = \beta_0 + \beta_1 \ln(\mathrm{Ps}) + \beta_2 \ln(\mathrm{Pl}) + \beta_3 \ln(\mathrm{Pf}) + \beta_4 \ln(\mathrm{Pch}) + \beta_5 \ln(\mathrm{Pm}) + \beta_6 \ln(\mathrm{Po}) + \beta_7 \ln(\mathrm{Y}_j^*) \quad (9)$$

Where, ln *C* denotes the natural logarithm soybean cost of production, *Pl* denotes labour cost, *Pf* denotes the average fertilizer cost, *Ps* denotes seed cost, *Pch* denotes agro-chemical cost, *Po* denotes the cost of oxen used and Y_j^* denotes the total soybean output measured in quintals.

For driving the dual cost frontier, the following equation was employed.

$$Min_{\,x} C = \sum_{\mathrm{n}} \omega_n \mathrm{X}_n \quad (10)$$

Subject to

$$\mathrm{Y}_k^{i^*} = \hat{\mathrm{A}} \prod_n \chi_n \hat{\beta}_n$$

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

To get dual cost function by minimizing input quantities:

$$C(\mathrm{Y}_k^{i*}, \mathrm{w}) = \mathrm{H}\mathrm{Y}_k^{i*\mu} \prod_n \omega_n^{\alpha_n} \quad (11)$$

Where,

$$\alpha_n = \hat{\beta}_n, \quad \mu = \left(\Sigma_n \hat{\beta}_\mathrm{n}\right)^{-1} \text{ and } \mathrm{H} = \frac{1}{\mu}\left(\hat{\mathrm{A}} \prod_{\mathrm{n}} \hat{\beta}_n \hat{\beta}_n\right)^{-\mu}$$

Generally, the dual cost frontier function can be represented in general form as follows:

$$C_i = c\,(\omega_i = Y^{i*}_i; \alpha) \quad (12)$$

Where,

C_i: The minimum cost of ith farm associated with output Y^{i*};

ω_i: Vector of input prices for the i^{th} farm

α: The vector of parameters to be estimated.

The economic efficiency for the i^{th} farmer derived by applying Shepard's Lemma and substituting the farms input price and adjusted output level into the resulting system of input demand equations.

$$\frac{\alpha C_i}{\alpha \omega_n} = X_i^e\left(\omega_i, Y_i^{i*}; \theta\right) \quad (13)$$

Where:

θ: is the vector of parameters and n = 1, 2, 3… N inputs.

The observed, technically and economically efficient cost of production for the i^{th} farm are equal to $\omega_i X_i$, $\omega_i X^t_i$ and $\omega_i X^t_i$. Those cost measures used to compute technically and economically efficient indices the i^{th} farmer as follows:

$$TE = {\omega_i X_i^t}/{\omega'_i X_i} \quad (14)$$

$$EE_i = {\omega' X_i^t}/{\omega'_i X_i} \quad (15)$$

Allocative efficiency index of the i^{th} farmer could derive from equations 13 and 14 as follows:

$$AE_i = {EE_i}/{TE_i} = {\omega'_i}/{\omega'_i X_i^t} \quad (16)$$

Definition, Measurement and Expectation of Variables

Variables used in the analysis include: production, fertilizer, seed, labour, and farm size/area under soybean production. These variables are inputs used in soybean production efficiency which could be production factors and cost inputs that combined to determine the overall production efficiency of small-holder soybean producer farmers (Table 1).

Output which is the dependent variable in the estimation of production functions, is measured in quintals and inputs refers to explanatory variables used in the estimation of production functions.

Output: the quantity of soybean produced by each household in 2016/17 cropping season measured in quintals.

Labour: measured as man-day used in soybean production by the farmers in the study area. In this case it was considering family labour and casual labour used during the stated cropping season.

Farm size: the area which was cultivated for soybean production during the period defined and measured in hectares.

Fertilizer: the quantity of chemical fertilizer applied on soybean plot in kg per ha during 2016/17 cropping season. Thus, fertilizer was assumed to be the quantity of inorganic fertilizers that was purchased and applied per hectare of land by soybean producers during the period under considered and was measured in kilograms. Fertilizer is expected to have a positive effect on yield, but when overdose happens it can lead to low yield or total crop failure.

Seed: are the backbone of agricultural production. Seed was a measure of the quantity of soybean seeds in kilograms used in 2016/17 cropping season.

Table 1: Expected variables influencing output/yield, and cost of soybean production in the area.

Variables	*Description*	*Measurement*	*Expected effect*
Output	Soybean output	Quintal/ha	+
Area	Farm size/area of land under soybean	Hectare (ha)	+
Labour	Family and hired labour	Man-days	+
Fertilizer	Quantity of fertilizer	Kilograms	+
Seed	Quantity of soybean seed	Kilograms	+
Oxen	Oxen for ploughing	Oxen-days	+
Chemical	Volume/quantity of agro-chemicals	Liters/kilograms	+
Labour cost	Cost of labour used	Eth. Birr per man-day	+
Fert cost	Cost of fertilizer used	Eth. Birr per kilograms	+
Seed cost	Cost of seed used	Eth. Birr/kilograms	+
Agro-chem cost	Cost of chemicals used	Eth. Birr/lit or kg	+
Oxen cost	Cost of oxen for ploughing used	Eth. Birr per Oxen-day	+
Material cost	Cost of other materials	Ethiopian Birr	+

Labour: measured as the man-days spent on the farm from land preparation to harvesting and transporting on a hectare of land. The following tables show the definition, measurement and expectation effected of variables used in this efficiency study.

Efficiency Indices was the dependent variable and show the efficiency level of an individual farm/farmer in the study area. Several socioeconomic independent variables are known to have influenced it; a positive sign of an estimated parameter implies that the associated variable has a positive effect on efficiency but negative effect on inefficiency and vice versa (Table 2). Moreover, determinants of inefficiency refers those socioeconomic, institutional, production, and biological variables, chosen in reference to former studies and logical reasoning.

Table 2: Expected socio-economic variables influencing soybean producer farmers efficiency

Description of variables	*Measurement*	*Expected effects*
Efficiency Indices	*TE, AE and EE*	+/-
Age	Number of years	+/-
Educational level	Number of years stayed in school	+
Farming experience	Number of years	+
Urban distance	Kilometers	+
Extension agents office distance	Kilometers	+
Road distance	Kilometers	+/-
Market distance	Kilometers	+/-
Cooperative distance	Kilometers	+/-
Household size	Number of persons in the house	+/-
Soil fertility	Categorical	+/-
Livestock ownership	Tropical livestock unit _tlu	+
Extension frequency	Number of days visited	+
Access to credit	1= Access/receive credit; 0= otherwise	+
Membership of coop	1=yes; 0= otherwise	+/-
Income	Eth. Birr	+
Weeding frequency	Number of weeding per unit ha	+

RESULTS AND DISCUSSION

Descriptive Results

Farm level efficiency has been discussed widely in literature. According to the study by Kumbhakar and Lovell (2000), farm efficiency has been influenced by several farm and household characteristics. The age, sex, education level, household size, access to credit, extension services, membership to cooperatives, farming experience and soil fertility condition are the characteristics that were analyzed for the purpose of this study.

Demographic, Institutional and Socioeconomic Description

Among soybean producers, majority of the respondents were male-headed households that accounted 95.46 percent of the total sample and only 4.51 percent were female-headed households. Soybean production in the region particularly in the study area is predominantly male activity. About 56.02 percent of the sample respondents were followers of Muslim religion, while 43.98 percent were orthodox followers in the study area. The study revealed about 95.11 percent of soybean producers who were married and 1.13 percent reported being single while 1.88 percent and 1.88 percent were widowed and divorced, respectively. Credit is important variable that influences farm level efficiency. On average about 69.55 percent of respondents' have access to different sources of credit services (Table 3).

Table 3: Sex and marital status of households

Description	*Number*	*Percent*
Sex of Household		
Male	254	95.49
Female	12	4.51
Religion of the Household		
Orthodox	117	43.98
Muslim	149	56.02
Marital Status		
Married	253	95.11
Single	3	1.13
Divorced	5	1.88
Widowed	5	1.88
Access to Credit Sources		
Yes	185	69.55
No	81	30.45

Source: Survey results, 2009 (2016/17)

Experienced farmers are expected to have greater access to productive resources and be able to apply improved agricultural technologies, recommended agronomic practices and expected to be faster in adopting new technologies than inexperienced farmers. Higher skill increases the opportunity cost of not growing the traditional enterprise. According to Abadi et al. (1999), more experienced grower may have a lower uncertainty about the innovation's performance. Farmers with higher experience appear to have often full information, better knowledge and were able to evaluate the advantage of the technology in question. Thus, experience of the head of the household in farming was affect soybean production efficiency positively. The mean farming experiences of soybean producers was found to be 6 years (Table 4). The maximum experience among soybean producers in the study area showed that about 32 years.

Since majority of labor force in rural area is supplied by family members and easy accessibility of labor the production of soybean might be influenced positively by family size. It is a proxy for agricultural labor and contributed for soybean efficiency. Family size affects allocation of financial and human resources depending upon the family composition. The average family size was 6 per household ranging from 1 to 22 persons with a standard deviation 2.54 without converting into the labor force unit (Table 4). In traditionally operated agriculture, like in the study area the larger the household size the more labor force is available for the farm activities.

Education is an important factor that sharpens managerial capabilities of farmers. It helps farmers in timely decision making, capturing extensive advices and practical knowledge. The study found that the mean number of years spend in formal learning, by sampled soybean producer farmers, was 3 years with maximum 13 years of formal education. On average farmers spent 3 years in school and thus most were primary dropouts (Table 4).

Access to different services has vital contribution for improving production and productivity and thereby increasing efficiency of soybean among smallholder farmers. The most important services that are expected to promote production and efficiency of soybean in the study area include proximity to urban center and agricultural inputs, access to nearest main road, distance to extension agents' office, and distance from cooperatives. The role of these institutional services access to farmers enabled them to make the right decision in soybean production. There are varying ranges in terms of household average distance from nearest urban center, main road and distance to get nearest agricultural input to get agricultural services and access information (Table 4).

The average land holding size was 1.542 ha with minimum 0.125 ha holding while the maximum was 5.024 ha in the study area (Table 5). Concerning the size of land under soybean production, the results show that the mean size of land by the sampled farmers was 0.382 hectare. The largest size of land cultivated was found to be 2 hectares. These confirm that all soybean

Table 4: Demographic and institutional characteristic of sample households

Description	*Mean*	*Min*	*Max*	*SD*
Education level in years of schooling	3.338	0	13	3.367
Farming experience in years	27.20	1	65	11.14
Soybean growing experience in years	5.673	1	32	4.277
Age of the household head in years	45.259	22	80	11.257
Year stayed in the village _numbers of years	27.568	2	57	8.525
Distance from urban center _km	12.215	0	19.5	4.613
Walking distance from urban center _min	124.812	8	195	44.238
Distance to nearest road _km	0.326	0.01	12	0.868
Walking distance to nearest road _min	3.265	.1	120	8.680
Distance to cooperative _km	1.015	0	6	1.176
Walking distance to cooperative _min	10.376	1	60	11.713
Distance to extension agent office _km	0.848	0	9	0.994
Walking distance to extension agent office _min	8.613	1	90	9.961
Total family size/ number of family members in house	5.906	1	22	2.544

Source: Survey result, 2009 (2016/17)

Table 5: Farm land holding size and farm tools ownership

Description	*Mean*	*Min*	*Max*	*SD*
Farm size_ ha	1.778	0.25	6	1.054
Tot own land _ha	1.542	0.125	5.024	0.959
Rented in land_ ha	0.166	0	4.875	0.517
Rented out land _ha	0.008	0	1	0.078
Shared in land _ha	0.118	0	2	0.315
Shared out land _ha	0.037	0	2	0.229
Land under soybean operated _ha	0.382	0.01	2	0.247
Soybean production/yield_ qt	5.461	0.50	35	4.720
Amount of soybean carried over_ qt	0.124	0	8	0.723
Quantity of soybean purchased _qt	0.049	0	6	0.421
Quantity of soybean sold_ qt	5.063	0.50	34	4.404
Sales price of soybean _birr/qt	767.951	350	1500	133.831
Soybean consumed _qt	0.426	0	3	0.647

Source: Survey results, 2009 (2016/17)

producer farmers were small-holder farmers. In terms of output, the results show that the maximum yield obtained by farmers in the area was 5.461 quintals per area under soybean cultivated. On average, the results showed that soybean producers obtained 5.46 quintals per 0.38 hectare of land (Table 5).

Econometric Results

Estimation of Soybean Production Function

The estimation of Cobb-Douglas stochastic production function simultaneously with the technical inefficiency generates the results of technical efficiency. According to Piesse and Thirtle (2000), the parameter sigma-squared lies between 0 and 1; with a value equal to 0 implying that technical inefficiency is not present and a value close or equal to 1 implying that the frontier model is appropriate. The value of the sigma-square indicates the goodness of fit and correctness in the specified assumption of the composite error terms distribution. The value of sigma-squared (0.42) is statistically significant at 1% significance level, which implies about 42 percents of the residual variation is due to the inefficiency effect (Table 6). Since the Wald chi-square statistic is significant at 1% level, we rejected the null hypothesis that there is absence of inefficiency in favour of inefficiency presence.

The dependent variable in the estimation of stochastic production function for soybean outputs in quintals were analyzed on the six major inputs with some of log-transformed. The major inputs were area of farm land under soybean, quantity of soybean seed used, fertilizer applied, agro-chemicals used, labour and oxen power.

All the coefficients of the inputs in the production function are positive and significant (Table 6). The positive effects of inputs on the output was expected because more inputs used in rightful proportions increases production. The

Table 6: Estimation results of the production frontier for the sample households

Variables description/ Soybean Output (ln) _Qt	*Coefficient*	*Std. Error*	*Z-Statistics*
Ln land area _ha	0.515***	0.067	7.70
Ln seed _kg	0.281***	0.045	6.20
Ln fertilizer _kg	0.123***	0.045	2.74
Ln labour _man day	0.189**	0.081	2.35
Ln oxen _oxen day	0.389***	0.114	3.42
Ln agro-chemical _ lit/kg	0.140**	0.062	2.26
Constant	0.486*	0.258	1.89
Wald Chi-square	245.93 (0.0000)***		
Sigma (σ_v)_v	0.264	0.030	
Sigma (σ_u)_u		0.263	0.083
Sigma-squared ($\sigma_s^2 = \sigma_v^2 + \sigma_u^2$)	0.422	0.119	
Gamma (γ)	0.46		
Lambda		0.913	0.261
Log likelihood	-216.044		
Number of observation	266		

Source: Survey results, 2016/17
Note: *,** and *** refers to 10%, 5% and 1% significance level, respectively.

coefficients of land, seed (kg), labour in man-day, oxen (oxen day) and fertilizer (kg) and agro-chemicals were positive; implying that increase in the use of any these factors, all things held constant, will increase the total production of soybean. The combination of these production resources to soybean would lead to increased output among small-holders. The magnitude of land coefficient is higher followed by oxen power and seeds. This implies that farm land, oxen power in days for ploughing and seed are the most constraining factors in soybean production.

The coefficient of area allocated to soybean was positive and significant at 1 percent level of probability, indicating the relevance of farm size on soybean production in the area. Results show that a percentage increase in area of farm land under soybean would be increased output by 51.1 percents (Table 6). This could be so because large farm size motivates adoption of improved technologies which can translate into higher output. This finding consistent with Baten et al. (2009), Ibrahim et al. (2014), Wassie (2014), Chakwera (2015) and Ermiyas et al. (2015) that found farm size was significant in determining production.

Production of soybean cannot be embarked upon if seed is not involved in the production process. The coefficient of seed used positively affects soybean outputs (Table 6). The implication is that if quantity of improved seed used increased with required rate by 1 percent , keeping other factors constant, soybean output will rise by 28.1 percent in the study area.

The estimated coefficient of fertilizer used was positive and significant at 1 percent probability level (Table 6). This agrees with expectation that as the quantity of fertilizer used increased, yield obtained might be increased as well. This indicating that soybean output can be increased by 12.3 percent with a percentage increase in quantity of recommended fertilizers keeping other factors constant. Even though, soybean does not require much fertilizer as it improves soil fertility by converting/ fixing nitrogen from the atmosphere into the soil, some amount of nitrogen fertilizer would be applied as starter particularly on fertility degraded farm land areas. This finding agrees with Baten et al. (2009), Ibrahim et al. (2014), Wassie (2014), Chakwera (2015) and Ermiyas et al. (2015) which found fertilizer significantly increase output.

The estimated coefficient of labour was found to be positive and statistically significant at 5 percent level (Table 6). The output can therefore, be increased by 18.9 percent with a percentage increase in labour if other inputs are held constant. This indicates that as labour used in the production of soybean increases, quantity of soybean produced increase.

The coefficient of oxen power (measured oxen-day) used by soybean farmers have positive and significant relationship with output. The coefficient of oxen power was significant at 1 percent level of significance, and the positive production elasticity implies by 1 percent increase in oxen power, the level of soybean output can increase by 38.9 percent in the study area.

Estimation of Soybean Production Cost Functions

The estimated parameters for the cost function in the soybean production are presented in Table 7. The model is appropriately estimated since Wald Chi-square was strongly significant at 1 percent level. It implies that the variations in the total cost of soybean production in the study area was due to differences in their cost efficiencies. The gamma (γ) estimate was 0.97 and significant at 1 percent level; indicates about 97 percent of the variation in the total production cost among the sampled households were due to differences in their cost efficiencies. The explanatory variables chosen for the model were able to explain the variations in the stochastic frontier cost function. This means cost inefficiency make significant contributions to the cost of producing soybean in the study area**.** The important cost function included in allocative efficiency were; fertilizer cost, labour cost, oxen power cost for ploughing, agro-chemicals cost and cost of other materials that affect total cost of production positively and significantly (Table 7). It implies an increase in any cost of these variables would lead to increase in the total cost of soybean production in the study area. Therefore, prices of these inputs contribute to the cost of production.

The coefficient of soybean seed cost was negative and insignificant with total cost of producing the crop in the area. The seed is the variable that transformed into output, hence output cannot be realized without seed. However, majority of the farmers used own saved seed for continues years by recycling and they did not purchase improved seeds (Table 7).

Table 7: Estimation results of the stochastic cost frontier

Variables	*Coefficient*	*Std. Error*	*Z-Statistics*
Ln cost of seed	-0.001	0.001	-1.24
Ln cost of fertilizer	0.111**	0.048	2.33
Ln cost of agro-chemical	0.009***	0.004	2.56
Ln labour cost	0.008***	0.001	9.56
Ln oxen cost for ploughing	0.007***	0.001	8.58
Cost of other materials	0.003***	0.001	3.89
Ln output	0.084***	0.020	4.13
Constant	2.621	6.747	0.39
Wald Chi-square	235.86 (0.000)***		
Gamma (γ)	0.97		
Sigma-squared (σ_s^2)	7.633	0.870	
Lambda	5.339	2.527	
Log likelihood	-526.501		
N	266		

Source: Survey results, 2016/17
Note: ** and *** refers to 5% and 1% significance level, respectively

The estimated coefficient of fertilizer cost was positively related, implying a positive effect of fertilizer cost on allocative efficiency. This relationship confirms to an expectation that an increase in the fertilizer cost will increase the total cost used for the production of soybean in the study area. With this, if the price of fertilizer increases, total cost of production will be affected. Fertilizer cost was significant at 5 percent probability level (Table 7). This is obvious as fertilizer increases fertility of the soil to supply nutrients and productivity which can affect output positively.

Labour cost had positive effect on allocative efficiency in the production of soybean, implying that farmers' total production cost increased as more labour put into use. Soybean production is labour intensive work that required more labour for cultivation/ploughing, planting, fertilizer application, weeding, bird scaring, harvesting, threshing and transporting/carrying of soybean produce. This implies that if labour employed in the soybean production increased by a unit, the total cost of soybean production would be increased by 0.8 percent (Table 7).

As small-holders, the farmers in the study area practiced cultivation of farm land by using oxen power, heifers and donkey draught power for ploughing, planting/row making, and cultivation purpose. This farming activities required cost of operation particularly for those haven't their own oxen. An estimated positive coefficient oxen power costs shows direct effect on cost allocation (Table 7). Cost of oxen power was significant at 1 percent level of probability for producing soybean, indicating that the oxen cost for ploughing farm land is very pertinent in the cultivation of soybean.

Increase in the cost of materials like sacks, cart for carrying produce, hand tools, knapsack rent would bring about increase in the total production cost of soybean in the area. The positive sign of the variable indicates that the cost of other materials can increase the total cost of production by 0.3 percent if the cost of those materials increased by 1 percent holding other factors constant (Table 7).

Another important input in terms of its effect on the soybean production is the amount of chemicals applied during soybean production among small-holder farmers. An addition of 1 percent application of agro-chemical increases output by 0.9 percent (Table 7). This implies that increase in the volume of agro-chemical use holding other inputs constant, will increase soybean output.

Efficiency Score of Soybean Producers

Technical Efficiency

The mean technical efficiency level among soybean producer farmers found in the study area was 72.81 percent, and ranges from 45.3 to 89.4 percent (Table 8). This implies that if the average soybean producer wants to achieve the most efficient farming group, the farmers could achieved 19.56 percent input saving [that is, 1-(72.8/89.39) x100]. From estimation, there is evidence that most of smallholders can improve their technical efficiency by 72.81 percent while

Table 8: Distribution of efficiency among soybean producer sampled households

Efficiency ranges	*TE*		*AE*		*EE*	
	Frequency	*Percentages*	*Frequency*	*Percenages*	*Frequency*	*Percentages*
0.00-0.20	0	0	0	0	60	22.56
0.21-0.30	0	0	79	29.70	39	14.66
0.31-0.40	0	0	15	5.64	38	14.29
0.41-50	7	2.63	30	11.28	39	14.66
0.51-0.60	18	6.77	29	10.90	46	17.29
0.61-0.70	63	23.68	24	9.02	31	11.65
0.71-0.80	134	50.38	28	10.53	10	3.76
0.81-0.90	44	16.54	34	12.78	3	1.13
0.91-0.99	0	0	27	10.15	0	0
Maximum		89.4		99.69		82.64
Minimum		45.3		19.53		11.21
Mean		72.81		55.13		40.08

Source: Survey results, 2016/17

they can make best use of roughly 27 percent without requiring additional inputs and a need of new production technology. Thus, the average level of technical efficiency confirm that there is an opportunity to increase efficiency on average by 27.20 percent if inputs allocated properly. This study is consistent with the result of Amaza et al. (2010), Chimai (2011), Abba (2012), Dawit et al. (2013), Endrias et al. (2013), Getahun (2014), Getachew and Bamlak (2014), Hussain et al. (2014), and Wassie (2014).

The distribution show that 50.38 % of the sample had technical efficiency measure of 73 percent and above, while only 2.63 percent had an efficiency level of below 50 percent. This implies that in the long run there is a room for improving the existing technical efficiency level among producers by providing a special attention to introduce best farming practices and improved technologies.

Allocative Efficiency

The mean allocative efficiency level of smallholder soybean producers was 55.13 percent and it ranged 19.53 percent to 99.69 percent (Table 8). With this deviation, if the average producer wants to operate to the most efficient, the farmers could obtain cost saving of 45.70 percent [that is, 1-(55.13/ 99.69) x100]. Generally, there is a considerable amount of efficiency variation among soybean producers in allocative efficiency level. The result is complementary with the results obtained by Ogundari and Ojo (2005, 2007) and Desale (2017).

Economic Efficiency (EE)

Following the relative ratio of actual cost to the hypothetical minimum cost, economic efficiency could be obtained which is the multiplication of technical efficiency and allocative efficiency. Applying this procedure this study found mean economic efficiency of 40.08 percent and ranged from 11.21 percent to 82.64 percent (Table 8). Taking this range, if the average producer wants to reach economic efficiency to the most efficient counterpart, the farm household could experience the cost saving of 52.50 percent ([that is, 1-(40.08/82.64) x100]. As presented in Table 10, about 51.51 percent of the sampled households' economic efficiency was below mean which is an indication that among soybean producers were unequally efficient; implying there was more variability in their attainment. The mean economic efficiency found is similar with the results of Endrias et al. (2013), Myo et al. (2012), Dawit et al. (2013), and Berhan (2015).

Sources of Technical, Allocative and Economic Inefficiency among Soybean Produce

Level of Education

The educational level of farmers had negative relation with technical and economic inefficiency and significant at 5 percent significance level (Table 9). Education can be a proxy variable for managerial ability of the farmer. For ev-

Table 9: Sources of technical, allocative and economic inefficiencies in soybean production among households

Variables	*TE*		*AE*		*EE*	
	Coefficient	*Std. error*	*Coefficient*	*Std. error*	*Coefficient*	*Std. error*
Constant	0.901***	0.405	1.029	0.854	-1.449***	0.607
Educational level	-0.322**	0.141	0.017	0.037	-0.081**	0.037
Farming experience	-0.011**	0.005	-0.037***	0.012	-0.414*	0.216
Distance from extension	1.829**	0.802	-0.087	0.145	0.263**	0.133
Distance to cooperative	-0.189	0.129	-0.278**	0.119	-0.187*	0.113
Distance to urban center	-0.063***	0.009	0.012	0.029	-0.185	0.293
Distance to main road	-8.094	8.399	-0.663***	0.215	-0.652***	0.186
Distance from market center	0.005	0.028	0.048*	0.025	0.045**	0.019
Distance to input sources	-1.849**	0.962	0.032	0.027	-0.525***	0.127
Access to credit services	-0.054	0.092	-0.631**	0.246	0.077	0.197
Frequency of extension services	-0.001	0.002	-0.019***	0.007	-0.001	0.006
Weeding frequency	-0.006	0.109	0.368***	0.135	-0.097	0.104
Soil fertility status	0.104	0.155	0.641***	0.144	-0.067	0.151
Livestock _tlu	-0.003	0.004	-0.009***	0.003	-0.002	0.002
Log likelihood	-216.920					
Wald Chi-square	245.93 (0.0000)***					
Number of observation	266					

Source: Survey results, 2016/17
Note: ***, ** and * are statistically significant at 1%, 5%, and 10% respectively.

Table 10: Economic efficiency distribution among sample households

EE score	*Number*	*Percents*
0.00-0.20	60	22.56
0.21-0.30	39	14.66
0.31-0.40	38	14.29
0.41-0.50	39	14.66
0.51-0.60	46	17.29
0.61-0.70	31	11.65
0.71-0.80	10	3.76
0.81-0.99	3	1.13
Mean EE	40.08	

Source: Survey results, 2016/17

ery increment in educational level by one years of schooling, the technical and economic inefficiency of farmers would decreased by 32.2 percent and 8.1 percent, respectively. Thus, the result in agreement with the study found by Amos (2007) on productivity and technical efficiency of smallholder Cocoa farmers in Nigeria and Ogundari and Ojo's (2007) study on economic efficiency of small scale food crop production in Nigeria. Similarly, the result is consistent with the results by Shumet (2011), Rahman et al. (2012), Abba (2012), Hussain et al. (2014), Shalma (2014) and Wassie (2014).

Farming Experiences

Results have revealed that, farming experience has a negative effect on technical, allocative and economic inefficiency, and statistically significant at 5 percent, 1 percent, and 10 percent significance levels, respectively (Table 9). Farmers with more years of farming experience are better placed to acquire knowledge and skills necessary for choosing appropriate farm technologies. Thus, farming experience tends to increase the capability to do better; they become more technically efficient. Furthermore, increased farming experience may lead to better assessment and complexities of good farming decision, including efficient use of resources. The result is found consistent with Abu et al. (2012, 2011), Myo et al. (2012), Hidayah et al. (2013) and Biam et al. (2016).

Distance from Extension Agent's Offices

Distance from extension agents' offices was affecting the efficiency of soybean production. This is because the nearer to agents; the easier to access updated information than the farmers far away from extension agents' offices. Proximity to the extension agent enables farmers to get relevant information on application of new packages and enhances the soybean production efficiency. Distance from extension agents' office was significant at 5 percent level of probability, indicating the relevance of extension agents in soybean farming (Table 9). As the farmers' residence located a kilometer far away from extension agents' office, leads to increase technical and economic inefficiency by respective coefficients.

Distance to Cooperatives

The estimated coefficient for distance to primary cooperative has shown a negative relationship with cost and economic efficiency for soybean producer farmers and is statistically significant at 5 percent and 10 percent level (Table 9). It indicates that residence of farmers nearest to cooperatives tends to reduce allocative and economic inefficiency of small-holder soybean producers. This might be have opportunities of quick government support and intervention, easy and timely access to inputs, sharing information on improved soybean production activities and interacting with other farmers on other production activities that can easily be enhanced through cooperatives at vicinity area.

Distance to Urban Center

The parameter estimate for farmers residence to nearest urban centers was found to be negative; indicating decrease in technical inefficiency as respondents' get closest to nearest urban center since it is considered as proxy to information sources (Table 9). This shows the importance of nearest urban center to soybean producer farmers because they access information about input and output market and how to apply new agricultural technologies that increases opportunity to acquire production inputs on time thereby enhancing productivity.

Distance to Main Road

Distance to nearest main road was negatively related with cost and economic inefficiency of soybean producers in the study area. Respondents with access to main road at nearby tend to be more efficient in cost allocation and economic than respondents with far away from main road (Table 9). This is adjudged so because access to main road helps farmers to purchase the needed inputs on time and sell their output.

Distance from Market Center

The estimated coefficient for distance from market center which used as proxy to information sources was positively related with allocative and economic inefficiency, implying that respondents distant from market center tend to be cost inefficient than households located nearby to market centers in accessing inputs and delivering output (Table 9). This might be due to the fact that as farmers are located far from market center, there would be limited access to input and output markets and information.

Distance to Agricultural Input Sources

The parameter estimate for the variable was found to be negative; indicating a decline in technical and economic inefficiency as households' nearest to agricultural input sources get closest (Table 9). Therefore, as the farmers' located one kilometer closest to agricultural input sources, soybean production might be increased and technical and economic inefficiency would be declined by respective coefficients.

Access to Credit Services

The coefficient for access to credit services have negative relationships with allocative inefficiency and statistically significant at 1 percent level (Table 9). These negative relationships between access to credit services and cost efficiency suggested that farmers who accessed credit ostensibly to purchase inputs have a higher probability of experiencing lower levels of inefficiency. It is generally believed that access to credit positively influences allocative efficiency and providing credit is judiciously utilize in farm activities. This might be ensured if farmers seek credit for to purchase farm inputs and farm operation. It is possible if framer's accessed credit for agricultural production rather than other activities or for household consumption. Credit access indicates liquidity, which is a prerequisite for flexibility in timely decision making, purchase of inputs and farm operation. There is need for capital to purchase inputs such as seed, fertilizer, farm tools and rent for land. Thus, access to credit service influence on allocative inefficiency of soybean producing farmers. This is in conformity with the work of Ogundari and Ojo (2007) study on economic efficiency of small scale food crop production in Nigeria, the coefficient of credit availability in technical efficiency model was negative which means that food crops production inefficiency decreased with increase in credit availability.

Extension Frequency

The frequency of extension services was found to be negative and significant at 1 percent level of probability, indicating a decline in allocative inefficiency while farmers' get more number of extension contacts (Table 9). Extension frequency which is the number of days farmers visited by developments agents and agricultural experts in a year/months. This shows the importance of extension contacts with soybean producer farmers in conveying agricultural information and application of new packages of technologies by acquiring updated information and production inputs on time thereby enhancing productivity. Extension workers play a central role in informing, motivating, and educating farmers about available technology.

Weeding Frequency

Number of weeding was also among the significant variables determining allocative inefficiency of farmers (Table 9). The result indicated that weeding improves the level of allocative efficiency among soybean growing farmers of the study area. Hence, there is a possibility to increase the yield of soybean through advising farmers to protect their field from weeds. Thus, it decrease the cost inefficiency producer farmers as more time of days engaged for weed control.

Soil Fertility Status

The coefficient for soil fertility was positive and had a significant influence on allocative efficiency (Table 9). The farmers who allocate fertile land had good efficiency. Moreover, farm land found in the study area might be degraded due to over cultivation and this required inorganic fertilizers and other soil fertility improvement measures. Allocation of poor soil fertility for soybean production would be increase the cost inefficiency. Therefore, decline in soil fertility could be taken as cause for significant output loss.

Tropical Livestock Unit

The coefficient for livestock holding (TLU) was negative and had a significant effect on allocative inefficiency, which confirms the considerable contribution of livestock in soybean production (Table 9). If unit increase for this factor in the production of soybean are increased the allocative inefficiency would be decreased by the respective coefficients.

CONCLUSION

The study was set to characterize soybean producer farmers in Assosa and Bambasi districts of Assosa zone in Benishangul-Gumuz Region, Western Ethiopia; estimate the level of efficiencies and find out the sources of inefficiencies influencing among small-holder farmers. The study was carried out on cross-sectional data gathered from a sample of 266 soybean producer farmers. In the stochastic frontier production, the production inputs, particularly farm size, labour, improved seed, fertilizer and oxen power were positive and had significant effect on soybean production.

Cost of fertilizer, labour cost, cost of oxen power and cost of other materials all affect total cost of production positively and significantly, meaning an increase in the cost these variables would lead to increase in the total cost of soybean production in the study area. Therefore, prices of these inputs contribute to the cost of production. The average technical, allocative and economic efficiency for small-holder soybean producer farmers were 72.8 percent, 55.13 percent and 40.08 percent, respectively in the study area. It implies that farmers are not operating on the production frontier which is to the maximum efficiency level, suggesting that considerable potential exists for increasing soybean production with current available technology and resources to farmers.

RECOMMENDATIONS AND POLICY IMPLICATIONS

The study has concluded that there is substantial existence of inefficiencies variations among soybean producing farmers which reduces productivity of the crop. Given the empirical findings of this study, the following recommendations are suggested:

Production factors such as farm land, seed, fertilizer, agro-chemical, labour, and oxen power were the major inputs influencing the soybean production in the area. Furthermore, these inputs should be made available on time, in right quantities and at affordable prices to the farmers' through government organizations and respective stakeholders in agriculture. Concerned bodies should give due attention for technology introduction that support for labour demanding activities. The provision of adequate rural infrastructural facilities such as nearest main roads and nearby input center and other social amenities should be the principal attention of government decision making. This will encourage rural-urban linkage that provide agricultural raw materials to industry and also promote good investment climate for agricultural development activities.

There is need for government through micro-finance, cooperatives and other financial institutions to make small-holder farmers based farm activity support credit availability that focus the needs of farmers. Therefore, respective stakeholders should make available soft loans to the farmers to enable them acquire needed inputs on time and in the right quantity. Extension services frequency was also found to be significantly reduce allocative inefficiencies among farmers. Thus, there is need to increase the frequency of extension contacts with development agents through agricultural offices and NGO's. Efforts should be made to improve farmers' basic education, since education was found to affect farmers' technical and economic inefficiency of farmers. This can be achieved through increased extension contacts and production based training, non-formal education and farmer-based organizations that promote farmer education and awareness. Training and awareness creation programs through farmers training center method as well as result demonstrations should be arranged before the implementation of the newly introduced technologies.

Stakeholders in agricultural sector should make efforts to address primary cooperatives and support with financial, human resources and agricultural input supply to farmers at their localities. Thus, cooperatives are used as entry points to sharing information on agricultural production activities and founding interaction with other farmers. Appropriate livestock packages need to be introduced and promoted in the study area since farmers used livestock as liquid asset sources and draught power for cultivation and household assets building mechanisms. This might be, through improved veterinary service, supplying feed and water development as deemed necessary.

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