ORIGINAL RESEARCH

Resource use efficiency of smallholder maize producers' in Bilo Nopa District, Ilu Ababor Zone, Oromia Region, Ethiopia: An application of stochastic frontier analysis

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ABSTRACT

Increasing productivity and efficiency in crop production could be taken as a topic of investigation towards attaining food security. This study was aimed at estimating the levels of technical efficiency of smallholder maize producers; and to identify factors affecting it in Bilo Nopa district using cross-sectional data collected from 152 smallholder maize producing farmers using structured questionnaires. Both primary and secondary data sources were used. The Stochastic Frontier Analysis approach was used to estimate the level of technical efficiency, whereas the Tobit model was used to identify factors affecting technical efficiency levels of the sample farmers. The Stochastic Frontier Analysis model indicated that input variables such as seed, land, number of oxen, and labor were the significant inputs to increase the quantity of maize output in the study area. The discrepancy ratio (γ) implied that about 85% of the variation in maize production was attributed to technical inefficiency effects. The mean technical efficiency of maize producers was 72.5%. This implies that output can be increased by 27.5% given the existing level of technology and resources. A Tobit model results indicated that education, family size, soil fertility, frequency of extension contact and credit utilization were positively and significantly determine the technical efficiency of farmers. The study result indicated that there is a room to increase the efficiency of maize producers in the district. Hence, emphasis should be given to improve the technical efficiency level of those less efficient farmers through expansion of education facilities, improving soil fertility, strengthening the extension services, and facilitating credit services in the study area.

Keywords: Cobb-Douglas, Maize, Smallholder farmers, Technical Efficiency, Tobit

INTRODUCTION

In Ethiopia, agriculture remains to be the principal engine of growth of the economy and building block of the social life of the people. This sector contributes about 36.3% of GDP, provides employment opportunities to more than 73% of total population that is directly or indirectly engaged in agriculture, generates about 70% of the foreign exchange earnings of the country and 70% of raw materials for the industries in the country (UNDP, 2018).

According to Musa (2013), Ethiopian agriculture is largely small-scale, subsistence-oriented, and heavily dependent on rainfall. Regardless of the massive contribution over the past years, its significance is limited because of various factors and hence it is becoming more and more difficult to meet the food requirements of the growing population (Sisay et. al, 2015). One of the major contributors for its deprived performance is the low productivity of the sector in general and cereal production in particular over the past years (Sisay et. al, 2015). Such low productivity leads to increasing poverty and food insecurity in the country. However, production and productivity can be improved through increased use of modern input or enhancement in modern technology given some level of input. The other technique of improving productivity is to enhance the efficiency of producers (Tolesa et. al, 2019). In countries like Ethiopia (having labor abundant), it is advisable to benefit from increased productivity through improving the efficiency of smallholder farmers in the use of available resource.

The major five staple cereal crops grown in Ethiopia are teff, maize, wheat, barley, sorghum and millet (Mustefa, 2014; CSA, 2017). In Ethiopia, maize is grown under a wide range of environmental conditions between 500 to 2400 meters above sea level (WB, 2018). It is cultivated in different parts of Ethiopia, mainly Oromia, Amhara, Southern Nations Nationalities and Peoples and Tigray regions (CSA, 2017; Tolesa et. al, 2019).

According to the CSA (2017), maize is cultivated on over 2.13 million hectares of land, with an annual production of 8.4 million tons with a yield of 39.44 qt/ha. In terms of area planted, maize stands second by covering 16.98% of the total cereal crop areas preceded by only teff (24.00%), and followed by sorghum (14.97%) and wheat (13.49%). From the total cereal production, maize ranks first by contributing about 27.02% of the total cereal production in Ethiopia. In Oromia region, the total area covered by maize in the production year of 2016/17 was 1.14 million hectares and 43.62 million quintals of maize were produced by 5.36 million smallholder farmers and average productivity was 38.18 qt/ha. According to CSA, 2017, there were 329,242 smallholders' producing 4.61 million quintals of maize with a yield of 42.30 qt/ha from 108,914 ha of land in Illubabor zone. In the Bilo Nopa district, where this study was conducted, maize production is the means of livelihood of the people to meet the household consumptions and to generate income. Among the cereal crops grown in the study area, maize is the major crop in terms of volume of production (145420.8 quintals) and area planted (3912.125 ha of land) with the productivity of 37.17 qt/ha during 2016/2017 which is lower than regional productivity.

Even though cereals especially maize are the most predominant crop in Bilo Nopa district, there is knowledge gap and no empirical study that shows whether the farmers are producing by efficiently utilizing the existing scarce resources and technologies in maize production. Also, the extent, causes and possible remedies of inefficiency of smallholder's farmers in maize production are not yet given attention. Therefore, this study aims to fill the above noticeable gaps of knowledge by collecting cross-sectional data from maize producers in the study area.

RESEARCH METHODOLOGY

Description of the Study Area

Bilo-Nopa district is found in Illu Abba Bora zone of Oromia Regional State at about 615 km from Finfinne (Addis Ababa) and 18 km from Mettu, which is the administrative seat of Ilu Abba Bora zone. The total land area of the district is 37,009 hectors and the district is composed of 16 Kebeles. Agro-ecological zone of the district is fall in high land and lowland. The total population of the district is 39,848 from this the number of males is 22,269 and the number of females is 17,579. With regard to the economic activities of the local community, the majority of them engaged in agriculture and agriculture-related activities. Forest-derived goods and service like (coffee and honey) are the major agricultural activities of the community in the study area (Kelifa et al., 2021; BNDADO, 2018).

Sampling Technique and Sample Size Determination

In this study, two-stage random sampling technique was used to select sample households. In the first stage, out of the 16 kebeles of the district; three kebeles (Kitabir, Bilo Karo, and Abu) were selected randomly since all kebeles are potential producers of maize. In the second stage, the total of 152 sample farmers were selected using simple random sampling technique based on probability proportional to the size of the maize producers in each of the three selected kebeles.

Data Types, Sources and Method of Data Collection

This study used both qualitative and quantitative type of data. Both primary and secondary data sources were used. The primary data was collected from sample households using a structured questionnaire. Secondary data was collected from local administration offices, governmental and NGOs, published and unpublished documents and CSA which were used as additional information to strengthen the primary information provided by the sample households in the study area.

Method of Data Analysis

To address the objectives of the study, the data collected were analyzed using descriptive statistics and econometric models. Specific methods of data analysis employed in the study are presented below.

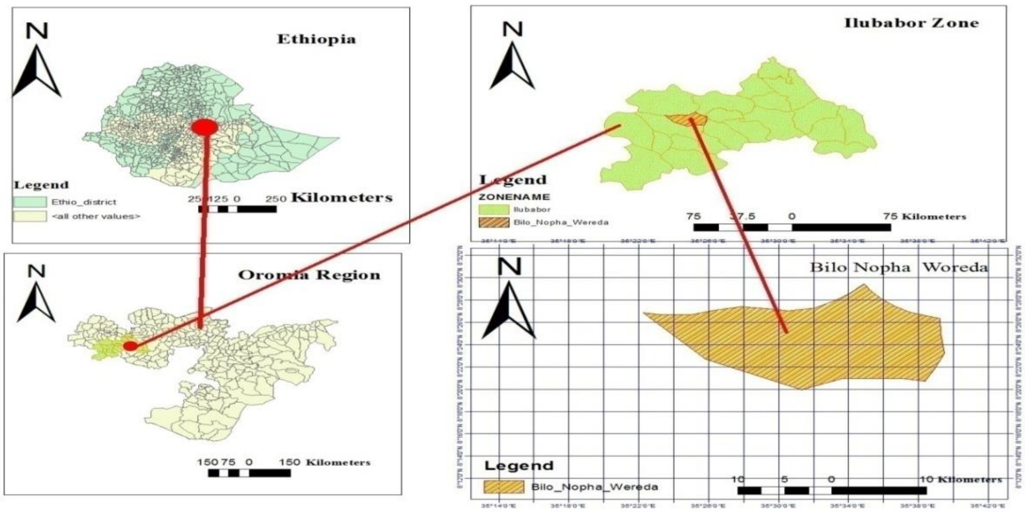

Figure 1. Location map of the study area**;** Source: Ethio-GIS, 2019

Efficiency measurement

Most empirical studies on technical efficiency in Ethiopia were analyzed using Cobb-Douglas stochastic production frontier model (Nigusu 2018; Asfaw et. al, 2019 and Tolesa et. al, 2019). The main reason is that the SPF approach allows for statistical noise such as measurement error and climate change which are beyond the control of the farmers. But, the translog functional form imposes no restrictions up on returns to scale or substitution possibilities and the generalized Leontief form removes the return to scale restriction. Following Aigner et al. (1977) the specified stochastic production frontier (SPF) model was defined as follows:

$$\ln(Y_i) = F(X_i, \beta_i) + v_i - \mu_i \qquad i = 1,2,3 \ldots n$$

Where: $i -$ Indicates the number of sample households $\ln(\mathrm{Yi}) -$ Indicates the natural log of (scalar) output of the i[th] household; $F(X_i, \beta_i)$ is a convenient frontier production function (e.g. Cobb-Douglas); $X_i -$ Represent a vector of input quantities used by the i[th] household $\beta_i -$ Indicates a vector of unknown parameters to be estimated v_i- is a symmetric component and permits a random variation in output due to factors beyond the control of the decision making unit such as weather, measurement error, omitted variables and other exogenous shocks. It is assumed to be independently and identically distributed $N\sim(0,\sigma^2{}_v)$ and μ_i - intended to capture inefficiency effects in the production of maize measured as the ratio of observed output to maximum feasible output of the i^{th}farmer. It was assumed to be independently and identically distributed as half-normal, $u\sim N\ (u, \sigma^2{}_u)$.

After specification of the model, the next step was the estimation of TE for individual farmers. Using the above specified Cobb-Douglas production function in equation (2), estimation of TE for individual firms is predicted by obtaining the ratio of the observed production values to the corresponding estimated frontier values. Accordingly, the study computes TE for the i[th] firms as:

$$TE = \frac{Y_i}{Y_i^*}$$

This value lies between zero and one implying fully technically inefficient and fully technically efficient respectively.

Determinants of technical efficiency

In this study, to analyze the effect of demographic, socio-economic, farm attributes and institutional variables on efficiencies, a second stage procedure was used the efficiency scores estimated from stochastic production frontier was regressed on hypothesized explanatory variables using Tobit model due to the existence of the efficient farmers. Following Maddala (1999) the model can be specified as:

$$y^*_{iTE} = \delta_0 + \sum_{n=1}^{n} \delta_n Z_{in} + \mu_i \quad (3)$$

Where: i refers to the i^{th} farm in the sample households; n is the number of factors affecting technical efficiency; y_i is efficiency scores representing the technical efficiency of the i^{th} farm. y^*_i is the latent variable, δ_n are unknown parameters to be estimated and μ_i is a random error term that is independently and normally distributed with mean zero and common variance of $\sigma^2 (\mu_i \sim IN(0, \sigma^2))$. Z_{in} are demographic, institutional, socio-economic and farm-related variables which was expect to affect technical efficiencies. Denoting y_i as the observed variables,

$$y_i = \begin{vmatrix} 1 & if y^*_i \geq 1 \\ y^*_i & if 0 < y^*_i < 1 \\ 0 & if y^*_i \leq 1 \end{vmatrix} \quad (4)$$

(4)

The distribution of the dependent variable in equation (4) is not a normal distribution because its value varies between 0 and 1. The ordinary least square (OLS) estimation will give biased estimates if the efficiency score has 0 or 1 (Maddala, 1999). Therefore, the alternative approach is using the maximum likelihood estimation which can yield the consistent estimates for unknown parameters. Following Maddala (1999), the likelihood function of this model is given by:

$$L(\beta, \delta | y_j, X_j L_{1j}, L_{2j}) = \prod_{y_j = L_{1j}} \varphi\left(\frac{L_{1j} - \beta' X_j}{\delta}\right) \prod_{y_j = y^*_j} \frac{1}{\delta} \phi\left(\frac{y_j - \beta' X_j}{\delta}\right) \prod_{y_j = L_{2j}} 1 - \varphi\left(\frac{L_{2j} - \beta' X_j}{\delta}\right) \quad (5)$$

Where $L_{1j} = 0$ (lower limit) and $L_{2j} = 1$ (upper limit) where $\varphi(.)$ and $\phi(.)$ are normal and standard density functions. In practice, since the log function is monotonically increasing function, it is simpler to work with log of likelihood function rather than likelihood function and the maximum values of these two functions are the same (Greene, 2003).

The regression coefficients of the Tobit regression model cannot be interpreted like traditional regression coefficients that give the magnitude of the marginal effects of change in the explanatory variables on the expected value of the dependent variable. In a Tobit model, each marginal effect includes both the influence of explanatory variables on the probability of dependent variable to fall in the uncensored part of the distribution and on the expected value of the dependent variable conditional on it being larger than the lower bound. Thus, the total marginal effect takes into account that a change in the explanatory variable will have a simultaneous effect on the probability of being technically efficient and value of technical efficiency score. A useful decomposition of marginal effects that was extended by Gould et al. (1989) was proposed by McDonald and Moffitt (1980). From the likelihood function of this model stated in equation (5), Gould et al. (1989) showed the equations of three marginal effects as follows:

1) The unconditional expected value of the dependent variable:

$$\frac{\partial E(y)}{\partial x_j} = [\varphi(Z_U) - \varphi(Z_L)]. \frac{\partial E(y^*)}{\partial x_j} + \frac{\partial[\varphi(Z_U - \varphi(Z_L)]}{\partial x_j} + \frac{\partial(1 - \varphi(Z_U)}{\partial x_j} \quad (6)$$

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

$$\frac{\partial E(y^*)}{\partial x_j} = \beta_n . \left[1 + \frac{\{Z_L \phi(Z_L) - Z_U \phi(Z_U)\}}{\{\{\varphi(Z_U) - \varphi(Z_L)\}\}}\right] - \left[\frac{[\{\phi(Z_L) - \phi(Z_U)\}^2}{\{\varphi(Z_U) - \varphi(Z_L)\}^2}\right] \quad (7)$$

3) The probability of being between the limits

$$\frac{\partial[(\varphi(Z_U) - \varphi(Z_L)]}{\partial x_j} = \frac{\beta_n}{\sigma} . [\phi(Z_L) - \phi(Z_U)] \quad (8)$$

Where $\varphi(.) =$ the cumulative normal distribution, $\phi(.) =$ the normal density function, $Z_L = -\beta' X/\sigma$ and $Z_U = (1 - \beta X/\sigma$ are standardized variables that came from the likelihood function given the limits of y^*, and $\sigma =$ standard deviation of the model. The marginal effects represented by the equations above were calculated by the STATA command mfx which was complemented by specific options that allowed the estimation of marginal effects of change in explanatory variables.

Table 1. Summary of hypothesized production Function variables

Variables	Definition of variables	Measurement	Expected sign
SEED	Seed used for maize production	Kilograms	+
LAND	Area of land used for maize production	Hectare	+
NPS	NPS Fertilizer used for maize production	Kilograms	+
UREA	UREA Fertilizer used for maize production	Kilograms	+
OXEN	Oxen number used for maize production	Oxen-days	+
LABOR	Labor used for maize production	Man-days	+

Table 2. Summary of hypothesized efficiency variables used in Tobit model

Variables	Type	Measurement	Expected Sign
Age of the HH	Continues	Years	+
Education of the HH	Continues	Years	+
Family size of the HH	Continues	ME	+
Livestock size	Continues	TLU	+
Soil fertility	Dummy	1=Fertile 0=otherwise	+
Sex of the HH	Dummy	1= Male and 0=Female	+
Total cultivated land	Continues	Hectares	-
Extension contact	Continues	Numbers	+
Credit utilization	Dummy	1=Yes 0=No	+
Off/non farm income	Dummy	1=Yes 0=No	+
Distance to market	Continues	Minute	-
Land fragmentation	Continues	Plot	-

HH, ME and TLU refers to household head, man equivalent and Total livestock unit respectively.

RESULTS AND DISCUSSION

Summary statistics of variables used in the production

On average, sample farmers obtained 23.25 quintal of maize. The average land allocated to maize production (owned, shared and rented land) by household was 0.81 ha and ranged from 0.23 ha to 2.5 ha. The mean amount of seed that sampled households used were 16.47 kg. Like other inputs, human labor and oxen power inputs were also important, given a traditional farming system in the study area. Sampled households, on average, used 69.96 man equivalent labor and 14.72 oxen days for the production of maize during 2018/19 production season. Sample farmers also on average, used 71.06 kg and 135.56 kg of NPS and Urea respectively (Table 3).

Table 3. Summary statistics of variables used to estimate the production. Source: Own computation from survey data (2019)

Variable	Mean	Standard Deviation	Min	Max
Output (Qt)	23.25	14.67	5	72
Seed (Kg)	16.47	10.03	4	67
Land (Ha)	0.81	0.50	0.23	2.5
NPS (Kg)	71.06	45.18	10	240
Urea (Kg)	135.56	84.90	25	405
Oxen (Oxen number)	14.72	10.08	4	45
Labor (Man-day)	69.96	37.53	15.6	195.50

Qt, Kg and Ha refers to Quintals, Kilogram and Hectare respectively

Econometric Model Results

The MLE of the parametric SPF

The result of the model showed that, from the total of six variables considered in the production function, four inputs (land, seed, number of oxen, and labor) had a significant effect in explaining the variation in maize yield among sampled farmers. The coefficients of the production function are interpreted as the elasticity of output produced with respect to the input used. If there is a 1% increase in the area of land, amount of seed, number of oxen and amount of labor allotted for maize production, maize output would increase by 0.3190%, 0.2827%, 0.1244% and 0.1574% respectively, suggesting that maize production was responsive to land, seed, oxen, and labor in the study area. The result is in line with the finding of Debebe et al. (2015); Bati et al. (2017). Hence, the increase in these inputs would increase the production of maize significantly as expected. Moreover, the coefficient for land used was 0.3190, which implies that, at ceterus paribus, a 1% increase in the area of land would result in 0.3190% increase in maize production. Alternatively, this indicates maize production was more responsive to land.

Return to the scale of all input used in the production process is the measure of total factors productivity. The scale coefficient was calculated to be 1.035, indicating increasing returns to scale (Table 4). This implies that there is potential for maize producers to continue to expand their production because they are in stage I of the production surface, where resource use and production is believed to be inefficient. Therefore, a percent increase in all inputs proportionally would increase the total production by 1.035%. This is consistent with the finding of Mustefa (2014) and Tolesa et al. (2019), who estimated the returns to scale to be 1.039% and 1.0341% respectively in their studies, which falls in stage I of production surface. The diagnostic statistics of inefficiency component reveals that sigma squared (δ^2) 0.2306 was statistically significant at 1%. This indicates the goodness of fit and the correctness of the distributional form assumed for the composite error term. The ratio of the standard error of u (δu) to standard error v (δv) known as lambda (λ), was 2.3802. Based on the value of lambda, gamma value is derived using the formula $\gamma = \lambda^2 / _{1+\lambda^2}$ the gamma (γ) was 85%.

It also shows that about 85% of the variations in output of maize are caused by technical inefficiency. The remaining 15% variation was due to random noise that is beyond the control of the smallholder farmers.

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

Variables	**MLE Parameters**	**Coefficient**	**Standard Error**
Constant	β_0	1.1751**	0.5064
Lan of seed	β_1	0.2827***	0.0945
Lan of land	β_2	0.3190***	0.1031
Lan of NPS	β_3	0.0615	0.0704
Lan of urea	β_4	0.0900	0.0690
Lan of oxen number	β_5	0.1244*	0.0609
Lan of labor	β_6	0.1574*	0.0800
Variance Parameters			
$\sigma^2 = \sigma_v^2 + \sigma_u^2$		0.2306***	0.0512
$\lambda = {}^{\sigma_u}/_{\sigma_v}$		2.3802***	0.1130
Gamma (γ)		0.850	
Log likelihood		-40.97	
Return to scale		1.035	

*Note: *, **and *** refers to 10%, 5% and 1% significance level, respectively. MLE refers to maximum likelihood estimation. Source: Model output from survey data (2019)*

Technical Efficiency score of maize producers in the study area

The results of the efficiency scores indicate that there were wide ranges of differences in technical efficiency among smallholder maize farmers in the study area. The model output presented in Table 5 indicates that the mean technical efficiency of sampled farmers was 72.5% with a minimum level of 31.11% and the maximum of 100.00%. This shows that maize producing farmers have an opportunity to efficiently utilize the resources and hence they could increase the current maize output by 27.5% using the existing technology. In other words, it implies that on average sample households in the study area can decrease their inputs (seed, land, NPS, urea, oxen, and labor) by 27.5% to get the output they are currently getting. This shows that there is a wide difference among farmers in their level of technical efficiency. This result is close to the results of Sapkota et al. (2017) and Tolesa et al. (2019) who found the mean TE score of maize production71% and 71.65%.

Table 5. **Summary statistics of technical efficiency score of sample households**

Variable	Observation	Mean	Standard Deviation	Minimum	Maximum
TE	152	0.725	0.141	0.311	100.00

Source: Author's computation from survey data (2019)

Distribution of technical efficiency scores

The distribution of the technical efficiency scores showed that around 30.26% of the sample farmers were failing between the range of 70 to 79.99% followed by 28.29% between the range of 80 to 89.99%. Out of the total sample households, only 5.92% had technical efficiency score of greater than 90%. This implies that about 94.08% of the households can increase their production at least by 10% and it suggests that out of total sample household fewer numbers of the maize producers in the study area are operating close to the frontier (Fig. 2).

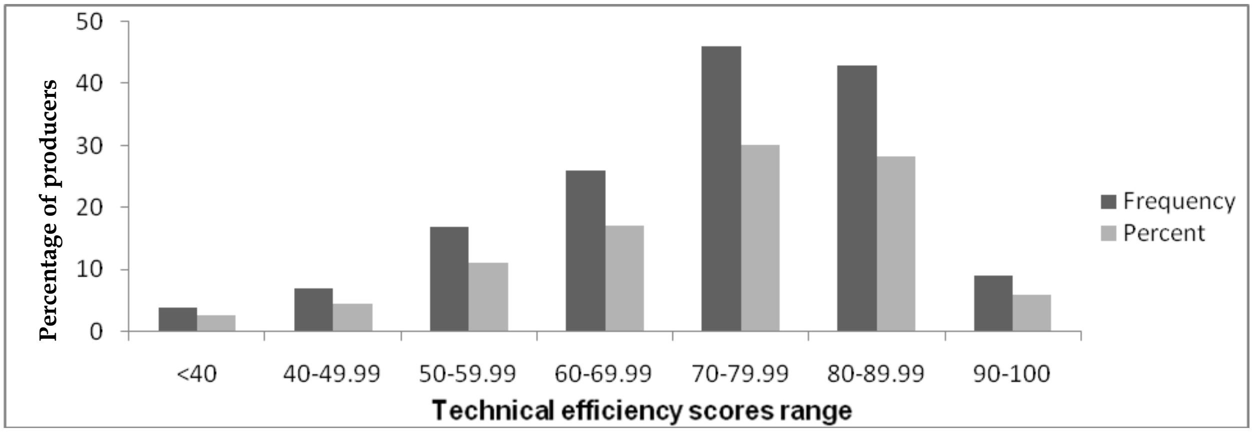

Figure 2. Distribution of technical efficiency scores (%). Source: Author's computation from survey data (2019)

Determinants of efficiency in maize production

The results of the Tobit regression model showed that among the twelve hypothesized variables five variables were found to be statistically significant in affecting the level of technical efficiency of maize producers in the study area.

Education level: As expected, the education level was positively and significantly affects technical efficiency at 1% level of significance. This implies that more educated farmers are more technically efficient than those who have relatively less level of education (Fetagn et al., 2017; Tolesa et al., 2019). This could be because; educated farmers have the ability to use information from various sources and can apply the new information on their farm that would increase their maize outputs. Moreover, a one year increase in educational level of the household head increases the probability of the farmer being technically efficient by 0.752% and change in the expected value of TE by 0.759% with an overall increase in the probability and levels of TE by 0.896% respectively. This result was consistent with the result of Sisay et al. (2015); Mustefa et al. (2017); and Getachew et al. (2017).

Family size: The coefficient of family size on TE is positive and statistically significant at the 10% significance level as expected. Hence the farmers who had more available labor were better managers; therefore, they produced closer to their production frontier. Moreover, the computed marginal effect of family size showed that a one person change in the number of family in man equivalent would increase the probability of farmer being technically efficient by 1.225% and change in the expected value of TE by 1.135%, with an overall increase in the probability and the level of TE by 1.340%, respectively. This result is similar to the findings of Mustefa (2014); Fetagn et al. (2017).

Soil fertility status: The model result also indicated that soil fertility was positively and significantly related to technical efficiencies at a 5% level of significance. This may be associated with those fertile lands require less commercial fertilizer application which leads to a reduction in cost and leads to a reduction in the inefficiency of farmers. Moreover, a change in the dummy variable, fertility status of the soil from (0 to 1), would increase the probability of the farmer being technically efficient by about 4.167% and the expected values of technical efficiencies by about 4.289% with an overall increase in the probability and the level of TE by 5.051%, respectively. A similar result was found by Getachew et al. (2017).

Frequency of extension contact: Frequency of extension contact had a significant and positive effect on technical efficiency at 1% level of significance. That is, farmers who had a number of extension contact during the production period were technically more efficient than those who had less number of extension contact. Furthermore, the computed marginal effect result shows that, a unit increase in the number of extension contact would increase the probability of a farmer being technically efficient by 0.250% and the mean values of technical efficiencies by about 0.253% with an overall increase in the probability and the level of technical efficiencies by about 0.298%. This result is similar to the findings of Fetagn et al. (2017) and Nigusu (2018).

Credit utilization: The result also indicated that credit utilization had a positive and significant effect on TE level at 1% level of significance. This suggests that on average households who use credit tend to exhibit higher levels of efficiency. Moreover, a change in the dummy variable representing the uses of credit by the household ordered from 0 to 1 would increase the probability of the farmers being technically efficient by about 4.35% and change in the expected value of TE by about 4.93% with an overall increase in the probability and the levels of TE by 5.76% respectively. This result is consistent with the finding of Musa (2013); Musa et al. (2015).

Table 6. Tobit model estimates for determinant of TE and its Marginal effects

Variable	TE		Marginal effects (TE)		
	Coefficient	Standard Error	$\frac{\partial E(y)}{\partial xj}$	$\frac{\partial E(y^{*})}{\partial xj}$	$\frac{\partial[(\varphi(Z_U)-\varphi(Z_L)]}{\partial x_j}$
Education of the HH	0.00943***	0.00351	0.00896	0.00759	0.00752
Family size of the HH	0.01411*	0.00830	0 .01340	0.01135	0.01125
Soil fertility	0.05316**	0.02237	0 .05051	0.04289	0.04167
Extension contact	0.00314***	0.00113	0.00298	0.00253	0.00250
Credit utilization	0.0603***	0.02174	0.05764	0.04934	0.04350

Note: *, **and *** significant at 10%, 5% and 1% level of significance, respectively. HH and TE refers to Household head and Technical Efficiency respectively. $\frac{\partial E(y)}{\partial x_j}$ (Total change), $\frac{\partial E(y^{*})}{\partial x_j}$ (Expected change) and $\frac{\partial[(\varphi(Z_U)-\varphi(Z_L)]}{\partial x_j}$ (change in probability). Source: Model result of household survey data (2019)

CONCLUSIONS AND THE WAY FORWARD

This study was conducted to analyze the level of technical efficiency and to identify factors affecting efficiency levels of smallholder maize producers in Bilo Nopa district. In this study, two stage random sampling technique was employed to select 152 sampled household heads that represent the population in the district. Both qualitative and quantitative data types are used. The data were collected from both primary and secondary data sources. The primary data was collected from sample respondents by using structured questionnaires. Secondary data were collected from relevant sources to supplement the primary data. To analyze the data, both descriptive statistics and econometric models were utilized. Descriptive statistics like minimum, maximum, mean, standard deviation and percentage were used to summarize demographic, socio-economic, institutional and farm characteristics of the sampled households in the study area. Econometrics model like the stochastic production frontier and Tobit model were applied to accomplish the objectives of this study. Tobit model was employed to identify factors affecting the efficiency levels of the sampled farmers. In general, this study tried to cover resource use efficiency of smallholder farmers in maize production. However, it is limited to resource use efficiency which is a single part of efficiency studies, single crop which is maize from output side in subject matter and one district which is Bilo Nopa in terms of area coverage. Therefore, we suggest that future research should focus on widening the scope interms of all efficiency parts, area coverage and subject matter.

The following policy recommendations are drawn based on the results of the study:

In the study area, the education level of the household had a positive and significant effect on the TE of smallholder maize producers. Hence, the key policy implication is that, the regional government give due attention to keep on providing basic education in these areas and facilitates the necessary materials so that farmers can understand agricultural instructions easily and have better access to information and use the available inputs more efficiently.

Family size has a positive and significant effect on technical efficiency. The result suggests the policies that motivate and mobilize the rural population especially the youth in agricultural activities should be designed by the regional government.

Moreover, TE was positively and significantly affected by the fertility of the soil. Therefore, it's better for farmers to improve the soil fertility status by applying organic manures and practicing different soil conservation techniques. In addition, extension workers in the study area can play a great role in improving soil fertility by working closely with the farmers.

Since extension services are the main instrument used in the promotion of demand for modern technologies, appropriate and adequate extension services should be provided. Therefore, it's recommended that extension agents give due attention to appropriate input allocation in addition to their acknowledgeable efforts to increase production. This calls more effective policy support for extension services and additional efforts need to be devoted to upgrading the skills and knowledge of the extension agents.

The study found that credit utilization was positively and significantly related to technical efficiency of smallholder maize producers. Therefore, the regional government could establish adequate rural financial institutions at an affordable interest rate and facilitating the available micro-finance institutions to assist farmers in terms of financial support to improve farmer's efficiency. Since most farmers fear the risk of repayment due to what they are planning to repay may be destroyed by climate change or other factors, the government and concerned bodies advised to creating awareness on microfinance institution and training on loan repayment.

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