FACTORS AFFECTING ECONOMIC EFFICIENCY IN MAIZE PRODUCTION: THE CASE OF BORICHA WOREDA IN SIDAMA REGION, ETHIOPIA

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ABSTRACT: *The objective of this paper was to determine the level of efficiency of smallholder maize farmers and to link the observed efficiency to farmers' socioeconomic and institutional characteristics in Boricha Woreda, Sidama Region of Ethiopia. A multi-stage sampling technique was used to select 204 sample farmers which were interviewed using structured questionnaire to obtain data pertaining to farm production, input usage, and other variables including socioeconomic and institutional factor. A Cobb-Douglas production function was employed to analyze the data. In the analysis, frontier 4.1c software was used to determine the levels of technical and economic efficiencies. Furthermore, descriptive statistics and a two-limit Tobit regression model were employed. It was established from a stochastic frontier model that maize yield was positively influenced by seed, labor, oxen, farm size, DAP and Urea fertilizers. The mean technical and allocative efficiencies were 72 and 70 percent, respectively while the mean economic efficiency was 53 percent. Tobit model results revealed that efficiency was positively and significantly affected by education, training, membership in cooperatives, access to credit, and family size whereas variables such as age, distance to extension center, distance to market, livestock and off-farm income affected it negatively. Based on the findings of the study policy implications for improvements in economic efficiency and productivity were drawn.*

Key words: Efficiency, Maize, Tobit

1. INTRODUCTION: The cultivation of maize most probably originated in Central America, particularly in Mexico. The oldest maize, about 7 000 years old, was found by archaeologists in Mexico. Maize crop was introduced into Europe at the end of the fifteenth century. And it was introduced to West Africa in the early 16th century (FAO, 1992) and to Ethiopia between the 16th and the 17th century (McCann, 2005). Africa produces 6% of the total world maize production, most of which is used for human consumption (Reynolds, 1999). Governments in East and South Africa have given top priority to maize production, because maize in this sub region is as important as rice and wheat in Asia (Byerlee and Eicher, 1997).

Maize is principal for the food security of Ethiopian households and it is also the lowest cost caloric and protein source among all major cereals. On average Ethiopian consumes a total of 1,858 kilocalories daily of which four major cereals (maize, teff, wheat, and sorghum) account for more than 60 percent, with maize and wheat representing 20 percent each (shahidur et al, 2010). And it has continued to be an important cereal crop in the SNNPRS as a source of both food and cash income (Million and Getahun, 2001).

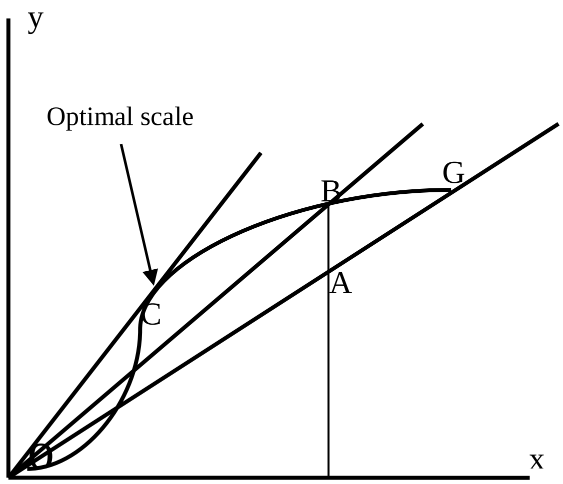
Maize cultivation is largely carried out by smallholder in Ethiopia. It is also the single most important crop in terms of both number of farmers engaged in cultivation and crop yield (shahidur et al, 2010). The small-scale farmers that comprise some 80 percent of Ethiopia's population are both the primary producers and consumers of maize **(**Dawit et al, 2008). Hence, in 2007/08, maize production was 4.2 million tons, 40 percent higher than teff, 56 percent higher than sorghum, and 75 percent higher than wheat production (shahidur et al, 2010). However, this high yield was achieved because of large number of smallholders participated in maize production and expansion of maize production area. Hence improvements in efficiency and productivity will reduce encroachment of population to marginal agricultural lands (Essa et al, 2011) and will lead to achieve more yield and higher-return to escape society from malnutrition and poverty (Mohammed, 2002).

The Ethiopian government has put in much effort in promoting agricultural productivity and efficiency of the smallholder farmers (Jema, 2008). The reason is that agriculture continues to be the dominant sector in Ethiopia's economy. Shahidur et al. 2010 showed that cereals account for 65 percent of the agricultural value added, equivalent to about 30 percent of the national GDP. The role of maize is central to agricultural policy decisions as a prime staple food for food security and overall development of the agricultural sector. Hence, much of the increase in crop production in the past decade has been due to increases in area cultivated in Ethiopia. But to what extent the area cultivated can continue to expand remains an important question. Even expansion of cultivated area will have to come almost exclusively from reduction in pasture land (Alemayehu et al, 2011). Given high population growth and the limits of area expansion, increasing productivity by enhancing efficiency and intensive usage of resources will lead to achieve more yield and higher-return to escape society from malnutrition and poverty (Mohammed, 2002). Hence improvements in use efficiency and productivity will reduce encroachment of population to marginal agricultural lands (Essa et al., 2011)

But the agricultural sector productivity is one of the lowest and even showing a decreasing trend bringing a decline in per capita cereal consumption (Jema, 2008). Why has productivity in maize production remained low in study area? Previous studies on study area have not addressed the question of the efficiency of maize production. In addition to this, no studies have tried to differentiate socio-economic factors that affect economic efficiency of farmers and to which factor the yield or efficiency of maize is more responsive or elastic. Most existing studies related to maize varieties and technological adoption. Thus, there is considerable scope to expand output and also productivity by increasing production efficiency at the relatively inefficient farms and sustaining the efficiency of those operating at or closer to the frontier (Elibariki et al., 2008). The general objective of the study was to assess the levels of economic efficiency and examine factors that affect economic efficiency in maize production among small holders in Boricha Woreda.

2. REVIEW OF LITERATURE: In economics, the conceptualization and measurement of efficiency relies on the specification of a production function. According to Coelli et al, (2005) the production function represents the maximum output attainable from the use of a given level of inputs. Productivity is defined as the ratio of the amount of output produced to the amount of resources used. However, efficiency is the ratio of the value of output produced to the cost of inputs used. Let us examine the difference between efficiency and productivity by taking a one input and one output case. Consider a production frontier described by the curve OG and a farmer operating at a point A (Figure 2.1). The farmer operating at point A is technically inefficient because he/she could increase the output to the level of the farmer that is operating at point B without requiring more input. However, the productivity of the farmer operating at point A is given by the slope of the ray through the origin and point A, which is equal to inputx/inputy. If the farmer operating at point A were to move to the technically efficient point B, the slope of the line would be greater, indicating higher productivity at point B. However, by moving to the point C, the ray from the origin is tangent to the frontier and hence represents the point of maximum possible productivity, which is a productivity increase attained by scale economies. Hence, a farmer may be technically efficient without being attaining optimal productivity level. A firm may be technically efficient but may still be able to improve its productivity by exploiting scale economies.

Figure 2.1: Productivity, technical efficiency and scale economies

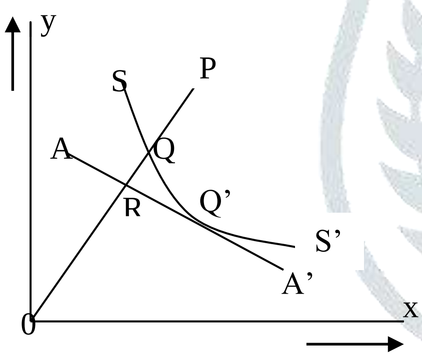


Source: (Coelli et al, 2005)

Graphical Explanation of Technical, Allocative and Economic Efficiencies

Efficiency can be considered in terms of the optimal combination of inputs to achieve a given level of output (an input-orientation), or the optimal output that could be produced given a set of inputs (an output-orientation). The concepts of producing maximum output with available inputs (technical efficiency) and optimal use of these resources to maximize profits given the inputs prices (allocative efficiency) can be illustrated graphically below (Khan and Saeed, 2011)

Figure 2.2: Graphical representation of technical, allocative, and economic efficiencies



Source: (Coelli et al, 2005)

Where, the SS' curve represents the isoquant and AA' is the isocost

In Figure 2.2, it is assumed that there are two inputs (x and y) used by a firm to produce a single output (Q) with assumption of constant returns to scale. If the firm employs amount inputs at point P to produce a unit of output, the technical inefficiency of that firm could be measured by the distance QP. This is the technically inefficiency proportion by which the use of inputs could be reduced without a decrease in output. And it is expressed in percentage as QP/OP. The TE of a firm is measured by the ratio: TE= OQ/OP. If a farmer has TE equal to 1, it is technically efficient. A farmer is technically inefficient if its TE value is less than 1.

At point Q the firm could gain full technical efficiency because point Q lies in the efficient production isoquant curve. If input prices are known, at Q' the cost of producing a given level of output is the minimum as it represents the most efficient allocation of inputs. The best use of inputs is at point Q' because it represents the minimum cost. The AE of the firm can be defined as: AE = OR/OQ. At point Q a farmer is technically efficient but allocatively inefficient. The farmer is technically as well as allocatively efficient at point Q'. The farmer would be fully allocatively efficient if its AE value is 1 and allocatively inefficient if its AE value is less than 1.

The economic efficiency is a combination of technical and allocative efficincy and can be obtained by multiplying TE and AE.

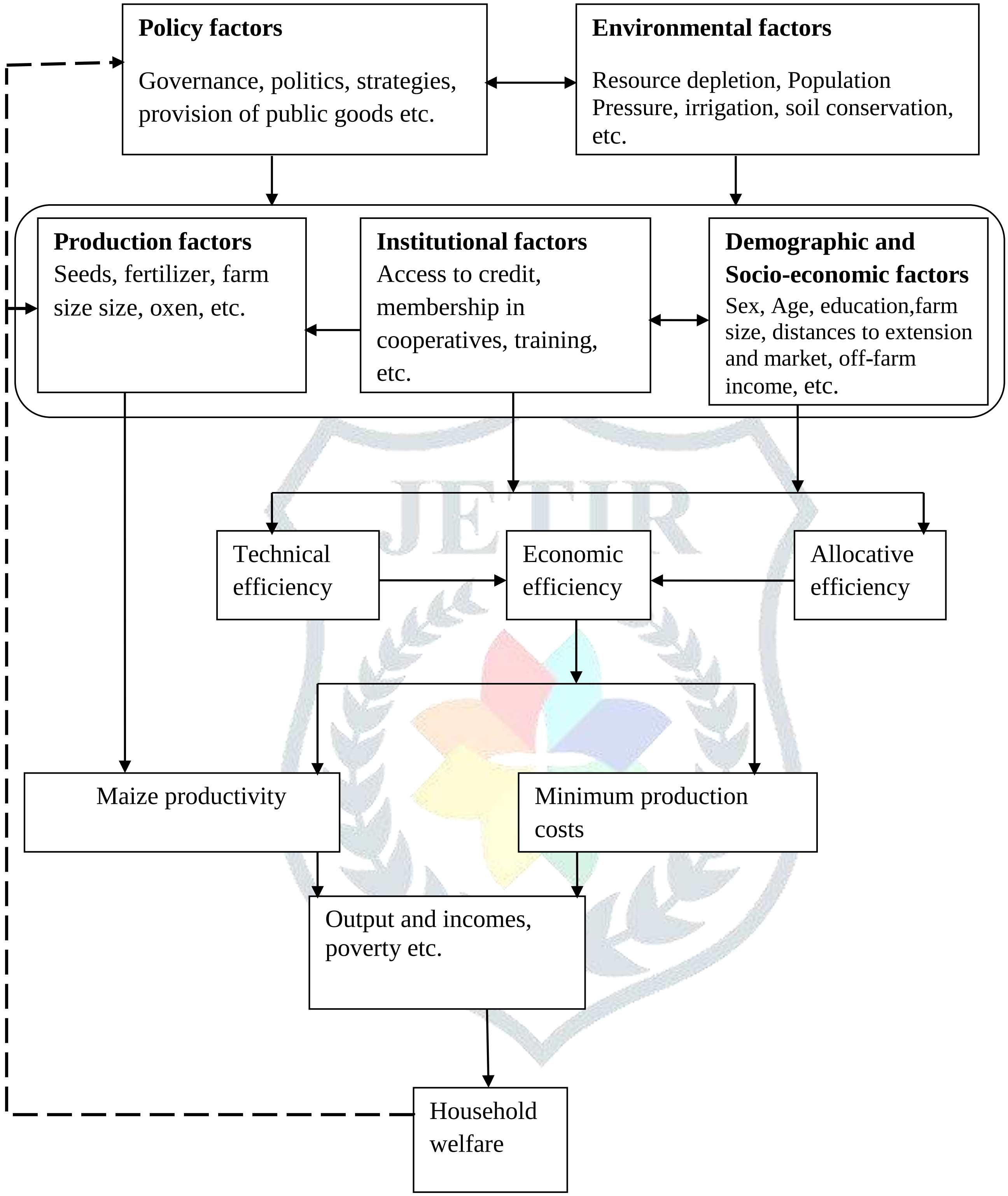
EE = TE * AE = OQ/OP * OR/OQ = OR/OP

The index of EE also varies between 0 and 1 where the latter implies that the firm is economically efficient. If the value of EE is less than 1 then the firm is economically inefficient.

Conceptual Framework

Figure 2.3 shows the interaction of various factors that were considered to have a various degrees and directions of impact on the level of economic efficiency in smallholder crops production. Production factors such as seeds, fertilizers, plot size, pesticides, herbicides and fungicides are used as inputs into the production process. The availability and distribution of these inputs may be influenced by the policy framework in place and environmental factors, which in turn determines institutional, demographic and socio-economic characteristics of the farmer. Maize productivity is also affected by production factors and economic efficiency. This is supported by the notion that for a production process to be effective, the manner in which available farm resources are utilized is crucial. But the farm's economic efficiency is also influenced by institutional, demographic and socio-economic characteristics of the farmer (Waluse, 2012). A farm that is technically, allocatively and economically efficient is therefore expected to realize higher output per hectare compared to one that is less efficient in production. But on the other hand, such a firm is hypothesized to incur less production costs leading to higher returns from the enterprise. This therefore has positive spillover effects on the welfare of the maize producing households. Improved welfare of the households then provides a feedback effect in form of increased access to production inputs and relevant lessons to policy makers.

Figure 2.3: The conceptual framework of factors influencing economic efficiency



Source: Adapted from Waluse (2012) and Essa (2011).

3. RESEARCH METHODOLOGY

3.1. Description of the Study Area

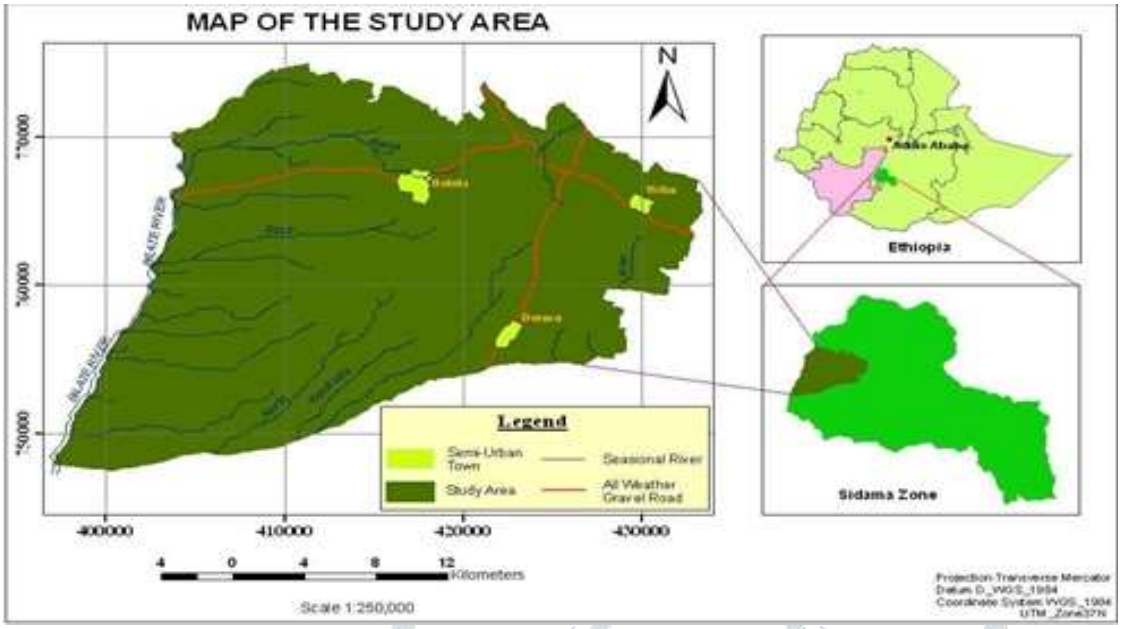


Figure 3.1: Administrative map of the Boricha Woreda

Source: Bechaye (2011)

This study was carried out in Boricha Woreda which is found in Sidama Region within Ethiopia, look at fig. 3.1. Boricha Woreda geographically is bordered on the south, by Loka Abaya Woreda, on the west by the Wolayita Zone, on the northwest by the Oromiya region, on the northeast by Hawassa Zuria Woreda, on the east by Shebedino Woreda, and on the southeast by Dale Woreda. It has an estimated area of 588.05sq km, comprising 39 Kebeles of which 3 Kebeles are urban Kebeles and the others are rural. It extends from the lowest point at south west of the mouth of tributary of Bilate river 1320m.a.s.l to north east 2080m.a.s.l (Bechaye, 2011). Boricha woreda has a total population of 250,260, of whom 125,524 are men and 124,736 women. Only 10,402 or 4.16% of its population are urban dwellers. The main land use of the Woreda is dominated by rain fed agriculture which is owned by smallholder producers. The major crops by coverage are maize, haricot bean, coffee, horticultural crops and teff (CSA, 2007). The study area has undertaken high extent of maize production. However, use of agro chemical, irrigation and manure for soil fertility practices and maize production is very low. In this area, cultivation of maize crop occupies much share in the crop production.

3.2. Types and Sources of Data

The study used both secondary and primary data to attain the stated objectives. The secondary data were collected from different sources including BoFED, EEA, agricultural offices and CSA. Moreover, different published sources including journals used to collect some secondary data. The primary data were collected through household survey and key informant interviews from sample households using structured questionnaire. Moreover, focus group discussions were held during the survey with 10-15 farmers, local administrators and development agents. During the survey, information was gathered on issues related to the socioeconomic factors that affect economic efficiencies in maize production in the study area, farmers' knowledge about the production of maize, inputs used and output produced

3.3. Sample Size Determination and Sampling Technique

3.3.1. Sample size determination

The following formula was used in the determination of sample size (Israel, 1992),

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

Where n is the sample size needed, N is the population size of the study area (= 280576), and e is the desired level of precision (in this case, e= 7%) with the same unit of measure as the variance and e^2 is the variance of an attribute in the population.

Then, the sample size (n) was calculated as follows,

$$n = \frac{280576}{1 + 280576(0.07)^2} = 204$$

Therefore, a total of 204 households were selected for the study. These households were selected from selected four Kebeles by using random sampling method. The population size of Woreda was obtained from Agriculture Office of Woreda.

3.3.2. Sampling techniques

A multi-stage stratified sampling technique was used to select sample farmers in Boricha Woreda. In the first stage, study Woreda was purposively selected based on the extent of maize production. In the second stage, Boricha woreda was grouped into three livelihood zones based on the way of living. These livelihood zones are Agro Pastoralist Livelihood Zone (APLZ), Coffee Livelihood Zone (CLZ) and Maize Livelihood Zone (MLZ). Each livelihood zone has 5, 10, and 24 Kebeles respectively (Bechaye, 2011). In the third stage, two Kebeles from maize Livelihood Zone, one Kebele from Agro Pastoralist Livelihood Zone and also one Kebele from Coffee Livelihood Zone were selected based on the extent of maize production, number of Kebeles in each zone and discussion with extension officers. Consequently, Koran Gogi and Konsore Arki Kebeles from maize Livelihood Zone, Shelo Elancho Kebele from Agro Pastoralist Livelihood Zone and Alabo Arke Kebele from Coffee Livelihood Zone were randomly selected from respective livelihood zones. Finally, from Koran Gogi, Konsore Arke, Shelo Elancho and Alawo Arke Kebeles, 64, 46, 36, and 58 households respectively were taken by using random sampling method and total of 204 households were sampled. The sample size was distributed in each sample Kebele based on the population size.

3.4. Methods of Data Analysis

The data collected from different sources were analyzed by using both descriptive statistics and econometric methods. The descriptive method includes simple ratios, percentages, tables, frequencies, standard deviations, etc. The quantitative and qualitative data were tabulated in the way that can enable to understand or capture the view of factors that affect economic efficiency in maize production. And frontier computer programming (version 4.1) software was used for estimation of the farm-specific economic efficiencies scores of maize producers in the study area. After that the efficiency scores were taken as a dependent variable and then regressed against farmer specific, demographic, socioeconomic and institutional factors.

In order to estimate farm level overall economic efficiency, the stochastic frontier cost functions model is specified as follows:

$$C_i = h(Y_i, P_i;\ \alpha_i) + \varepsilon_i \text{ ------------------------------ } (1)$$

Here C_i is the total production cost, Y_i stands for output produced, P_i is price of input, αi represents the parameters of the cost function to be estimated and ε_i is the error term. Since, inefficiencies are assumed to add to costs, error components, therefore, have positive signs.

The farm specific economic efficiency is defined as the ratio of minimum observed total production cost (C*) to actual total production cost (C) (Khan and Saeed, 2011):

$$EE_i = \frac{C_i^*}{C_i} = \frac{P_i{}'X_i{}^*}{P_i{}'X_i} = \frac{E\ (C_i\ |u_i\ , = o, Y_i, P_i\ )}{E\ (C_i\ |u_i, Y_i, P_i\ )} = e^{\left[E\left(\frac{u_i}{\varepsilon_i}\right)\right]} \text{ ------------------ } (2)$$

The model was run by frontier 4.1 program and it should be noted that the frontier 4.1 program estimates the cost efficiency (CE), which is computed originally as the inverse of equation (2). The economic efficiency (EE) was then obtained from the inverse of cost efficiency as follows (Ali et al, 2012).

$$EE = {}^{1}/_{CE} ---------------------------- (3)$$

3.6. Analytical Framework and Model Specification

3.6.1. Cobb-Douglas stochastic frontier production function

According to Kopp and Smith (1980), empirical studies relating to developing countries have used Cobb-Douglas functional forms. The Cobb-Douglas functional form also meets the requirement of methodology employed that needs cost and production functions should be self-dual. However, Rebecca (2011) showed that the Cobb-Douglas production function model has a number of limitations. The major criticism is firstly that it cannot represent all the three stages of neoclassical production function, representing only one stage at a time. Secondly, the elasticities of this type of a function are constant irrespective of the amount of input used. However, regardless of these limitations the Cobb-Douglas production function is used as the functional form of the production function for its mathematical simplicity and linearity in its logarithmic form. In addition to this, Cobb-Douglas functional form is used to specify the stochastic production frontier, which is the basis for deriving the cost frontier and the related efficiency measures. The specific Cobb-Douglas production model estimated is given by:

$$Y_i = \beta_0 * \prod_{i=1}^{n} X_i^{\beta_i} * e^{(V_i - U_i)} ------------------------(3)$$

By transforming it into double log-linear form:

$$\ln Y_i = \ln\beta_0 + \beta_i \sum_{i=1}^{6} \ln X_i + (V_i - U_i) --------------------(4)$$

Where Y_i represents maize yield harvested and X_i represents maize production inputs by i^{th} farmer. Where as $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ and β_6 are the regression parameters to be estimated and ln= natural logarithm. From the error term component ($V_i - U_i$),V_i is a two sided($-\infty < V < \infty$) normally distributed random error (v ~N $[0,\sigma^2{}_v]$) that represents the stochastic effects outside the farmer's control (e.g., weather, natural disasters, and luck), measurement errors, and other statistical noise while U_i is a one-sided ($u_i \geq 0$) efficiency component which is independent of v_i and is normally distributed with zero mean and a constant variance ($\sigma^2{}_u$) allowing the actual production to fall below the frontier but without attributing all short falls in output from the frontier as inefficiency.

3.6.2. Two-limit Tobit Model with maximum likelihood estimation

Following Amemiya (1981), Waluse (2011), Essa et al. (2011) and Endrias et al. (2013) the two-limit tobit model was defined as:

$$Y_i{}^*{}_{EE} = \delta_0 + \sum_{j=1}^{12} \delta_j Z_{ij} + \mu_i -------------------------- (5)$$

Where Y_i^* is latent variable representing the efficiency scores, $\delta_0, \delta_1, .., \delta_{12}$ are parameters to be estimated, and EE, is economic efficiency of the i^{th} farmer, respectively. Z_i is demographic, socio economic and institutional factors that affect efficiency level. And μ_i= an error term that is independently and normally distributed with mean zero and variance δ^2(μ_i ~IN $(0, \delta^2)$). And, farm-specific efficiency scores for the smallholder maize producers range between zero and one. Therefore, two-limit tobit model can be presented as follow

$$Y_i = \begin{cases} 1, & \text{if } Y_i^* \geq 1 \\ Y_i^*, & \text{if } 0 < Y_i^* < 1 \\ 0, & \text{if } Y_i^* \leq 0 \end{cases} ------------------------ (6)$$

Two-limit tobit model allows for censoring in both tails of the distribution (Greene, 2003). The log likelihood that is based on the doubly censored data and built up from sets of the two-limit Tobit model is given by

$$\ln L = \sum_{y_i = l_{0i}} \ln \Phi \left[\frac{l_{0i} - X'_i\beta}{\sigma}\right] + \sum_{y_i = y_i^*} \ln \frac{1}{\sigma} \emptyset \left[\frac{y_i - X'_i\beta}{\sigma}\right] + \sum_{y_i = l_{1i}} \ln \left[1 - \Phi\left(\frac{l_{1i} - X'_i\beta}{\sigma}\right)\right] ----(7)$$

Where L_{0i} = 0 (lower limit) and L_{1i} = 1 (upper limit) where Φ and $\emptyset$ are normal and standard density functions.

In efficiency analysis, it is not only the level of inefficiency that is important, but the identification of the socioeconomic and institutional factors that cause it. Even though the approaches for the identification of these factors may vary to some extent with the methodology employed, the most commonly followed procedure in both approaches is what is usually referred to as the two-step procedure (Jema, 2008). First, the efficiency or an inefficiency index estimation. Second, the inefficiency or efficiency index is taken as a dependent variable and is then regressed against a number of other explanatory variables that are hypothesized to affect efficiency levels

As explained by Endrias et al. (2013) the regression coefficients of the two-limit 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. By following McDonald and Moffitt (1980), Greene (2003) and Gould *et al.* (1989) cited in Endrias et al. (2013), from the likelihood function decomposition of marginal effects was proposed as follows two limit tobit model:

(1) The unconditional expected value of the dependent variable

$$\frac{\partial E(y)}{\partial x_j} = [\varphi(Z_u) - \varphi(Z_L)].\frac{\partial E(y*)}{\partial x_j} + \frac{\partial[\varphi(Z_u) - \varphi(Z_L)]}{\partial x_j} + \frac{\partial[1 - \varphi(Z_u)]}{\partial x_j} --- (8)$$

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

$$\frac{\partial E(y*)}{\partial x_j} = \beta_m.\left[1 + \frac{\{Z_L\emptyset(Z_L) - Z_u\emptyset(Z_u)\}}{\{\varphi(Z_u) - \varphi(Z_L)\}}\right] - \left[\frac{\{\emptyset(Z_L) - \emptyset(Z_u)\}^2}{\{\varphi(Z_u) - \varphi(Z_L)\}^2}\right] ------(9)$$

(3) The probability of being between the limits

$$\frac{\partial[\varphi(Z_u) - \varphi(Z_L)]}{\partial x_j} = \frac{\beta_m}{\sigma}[\emptyset(Z_L) - \emptyset(Z_u)] ---------------(10)$$

Where, $\varphi(.)$ = the cumulative normal distribution, $\emptyset(.)$ = the normal density function

$Z_L = -\frac{X'_i\beta}{\sigma}$ and $Z_u = \frac{(1-Xi\beta)}{1}$ are standardized variables that came from the likelihood function given the limits of y* and σ = standard deviation of the model.

4. RESULTS AND DISCUSSION

4.1. Results of stochastic frontier production function

Determination of elasticities is necessary for the estimation of responsiveness of output to inputs. Most of the inputs on the stochastic frontier were statistically significant and had the expected signs. Lambda (λ) was also statistically significant (Table 1). This is evidence that there were measurable inefficiencies in maize production probably caused by differences in socio-economic characteristics of the households and their farm management practices.

Farm size was the important factor of production, having an elasticity of 0.2582. This implies that a one percent increase in farm size used in *timad* increase the total output by about 0.3 percent. This result agrees with the findings of (Edet et al., 2006). Urea fertilizer also appeared to be the important factor, with an elasticity of 0.2085. This implies that a one percent increase in a urea fertilizer used increase the total output by about 0.2 percent. In addition, DAP fertilizer had significant effect on maize production with an elasticity of 0.1088, meaning a one percent increase in its use would increase output by 0.1 percent. Again, labor had an elasticity of 0.1717. This is consistent with the observation that maize production in the study area is labor intensive. Therefore an increase in labor measured in man days by one percent increase total maize farm output by about 0.2 percent while all other factors are held constant.

The elasticity of production with regards to seed use was 0.1464 and significant at 1 percent level. It further means a one percent increase in the quantity of seed used for maize production, holding all other inputs constant, results in 0.15 percent increase in maize output. Similarly, the effect of oxen holding on maize production was positive. The use of oxen power in farm operations such as land preparation, planting and weeding was significant in influencing maize output.

Table 1 shows that the sum of the elasticities for all variables was 0.9588 which is less than one. That is, the farm households were operating at a point of decreasing returns to scale. This is the rational stage which is called as stage II in the production function at which production should normally take place because output is increasing positively at diminishing rate with an increase in input utilization.

Table 1: Regression results of stochastic frontier production function

Variable	Coefficient	Standard error	z-value
Constant	5.9906	0.00017	3.4e+04
Seed	0. 1464***	0.00004	3226.75
Labor	0. 1717***	0.00039	440.27
Oxen	0. 0652***	0.00059	110.27
Dap	0. 1088***	0.00010	1028.77
Urea	0. 2085***	0.00007	2934.93
Farmsize	0. 2582***	0.00038	670.58
$\sigma^2 = \sigma_u{}^2 + \sigma_u{}^2$	0.3775	0.03738	
$\gamma = \sigma_u{}^2/\sigma^2$	0.9999		
$\lambda = \frac{\sigma_u}{\sigma_v}$	3463481	0.03041	
Returns to Scale (RTS)	0.9588		
Number of obs =	204	Wald chi2(6) =	1.80e+09
Log likelihood =	-48.705838	Prob > chi2 =	0.0000
Log likelihood-ratio test of sigma_u=0: chibar2(01) = 7.84 Prob>=chibar2 = 0.003			

*** Estimates are significant at 1% level

4.2. Efficiency scores level and distribution

The result showed that technical efficiency (TE) indices of sample farmers ranged from 0.15 to 0.94 (Table 2). The higher distributions of the technical efficiency level classes were 0.71 to 0.80 and 0.81 to 0.90 with each category representing 28.43 percent of the total sample. And the average technical efficiency was found to be 0.72. This indicates that if the average farmer in the sample was to achieve the technical efficiency level of its most efficient counterpart, then the average farmer could realize 23 percent reduction of wastage in inputs use to produce its most efficient counterpart output. By similarly manner, the most technically inefficient farmer in the sample was to achieve the technical efficiency level of its most efficient counterpart; then the least efficient farmer could realize 84 percent reduction of wastage in inputs use to produce its the most efficient counterpart output. This indicates that there was a substantial amount of technical inefficiency in maize production.

The mean allocative efficiency (AE) of the sample was 0.70, with a minimum of 0.17 and a maximum of 0.98. The higher distributions of economic efficiency level classes were 0.71 to 0.80 and 0.81 to 0.90 with each category representing 19.61 and 28.92 percent of the total sample respectively. The average economic efficiency (EE) level for the sample farmers was 0.53, with a minimum of 0.10 and a maximum of 0.91. These figures indicate that if the average farmer in the sample were to reach the economic efficiency level of its most efficient counterpart, then the average farmer could realize 41 percent total production cost savings. The similar manner for the most economically inefficient farmer could get could realize 89 percent total production cost savings. In sum, it is evident from these results that technical efficiency could be improved substantially, and that economic inefficiency constitutes a more serious problem than allocative inefficiency.

Table 2: Frequency distribution of TE, EE, and AE of maize producers

Efficiency	TE		EE		AE	
Range	Frequency	%	Frequency	%	Frequency	%
0.00-0.10	0	0.00	0	0.00	0	0.00
0.11-0.20	1	0.49	20	9.80	1	0.49
0.21-0.30	1	0.49	24	11.76	11	5.39
0.31-0.40	7	3.43	15	7.35	10	4.90
0.41-0.50	11	5.39	29	14.22	19	9.31
0.51-0.60	23	11.27	24	11.76	19	9.31
0.61-0.70	28	13.73	30	14.71	21	10.29
0.71-0.80	58	28.43	46	22.55	40	19.61
0.81-0.90	58	28.43	12	5.88	59	28.92
0.91-1.00	17	8.33	4	1.96	24	11.76
Total	204	100.00	204	100.00	204	100.00
Mean	0.7285		0.5354		0.705	
Minimum	0.1586		0.1023		0.179	
maximum	0.9480		0.9159		0.987	

Source: Model output.

4.3. Factors influencing economic efficiency of smallholder maize producers

Table 3 shows the two-limit Tobit regression results of EE scores against socioeconomic and institutional variables. The economic efficiency model showed that ten out of twelve variables were statistically significant at influencing economic efficiency of sample farmers. These include age, education, membership to cooperatives, training, distance to development agents and main market, off-farm income, credit, livestock, and family size.

Economic efficiency was significantly influenced by age of household head at 1 percent level. Age contributed negatively to the economic efficiency in this study; in other words, younger farmers were relatively more efficient than older farmers. The reason could be younger farmers were comparatively more educated than the older farmers. Therefore, by increasing the education status of older farmers through Adult Based Education and Training, government can increase the efficiency level of farmers. This result is consistent with the result of Boris et al., (1997) and Khan and Saeed (2011) which explained that the younger and educated is the farmer, the more technically and economically efficient he is. Since, education is used as a proxy for human capital. It potentially enhances farm efficiency and knowledge with regard to agricultural production. According to this study the education level of household head was highly significant affecting positively economic efficiency of smallholder maize producers. The reason is that educated farmers were able to apply better and newer forms of farming methods. Similarly Chiona (2011), Dolisca and Curtis (2008), Rebecca (2011), and Khan and Saeed (2011) found that the higher the level of formal schooling, the higher of economic efficiency. This is because educated farmers are likely to access information easily, and make well informed decisions with better management of farming activities.

Training farmers about farm management is important for farmers to improve their skills and practices and to have knowledge confirmed by professionals. It was positively related with economic efficiency of farmers at 1 percent level. It was established that participating in farmers' training program increased the possibility of efficiently using farm inputs. Trainings helped farmers to obtain information and to correct misconception concerning input usage. Organizations that provide inputs to farmers usually verify that whether farmers received some training or not before they provide inputs. Therefore, building the capacity of the existing farmers' training centers and expanding their coverage as well as strengthening the field level training programs are highly demanded to improve maize production system.

Membership to cooperatives was found to be positively related and significantly affecting economic efficiency of smallholder maize producers in the study area at 1 percent level. Farmers` organizations played an important role in organizing members into input cooperatives and in creating access to inputs and extension officers.

Economic efficiency was also influenced by credit. The results showed that credit had a positive influence on economic efficiency and it was significant at 10 percent level. Specifically, it was observed that access to credit was important in production in the sense that it improved farmers' ability to purchase the otherwise unaffordable farm inputs. Therefore credit has a great potential for improving farm economic efficiency in the study area. This finding is similar to that of Waluse (2012) and Dolisca and Curtis (2008) who found that farm households who used credit were more efficient

The farms those were closer to the office of extension centers had more contacts with extension agents. Those farmers who were closer to extension centers enabled to participate in agricultural meetings, field days, demonstration plots and best available practices**.** As result, farmers closer to the extension services were more efficient than their counterparts. Thus, distance to the extension center was found to be negatively related and significantly affecting economic efficiency of smallholder maize producers in the study area at 1 percent level of significance.

Distance to the main market was found to be negatively related and significantly affecting economic efficiency of smallholder maize producers at 1 percent level. This result showed that there were areas that transport vehicles could not reach. Farmers under these conditions face difficult to reach improved technology, transport inputs and farm produce easily.

Family size was found to be positively and significantly affecting economic efficiency of maize farmers at 1 percent level. This means that, as household members increase, there might be a more equitable labor distribution among farming activities. Results of this study match with findings of Douglas (2008) that found family size had a positive and significant effect on production efficiency.

Raising livestock affected maize economic efficiency significantly and negatively at 5 percent level of significance. This is consistent with the hypothesis that increased number of livestock reduces crop production and takes away farmers effort that could otherwise be used for maize production and hence reduces efficient maize production.

Additionally, the findings indicated that off-farm income had a negative and significant effect on economic efficiency. This might be the case if the type of off-farm activity deprives the farmer to attend to his/her farm.

Table 3: Tobit regression estimates of factors influencing economic efficiency

Variable	Coeffcient	Robust standard error	t-value
Constant	0.614***	0.051	12.10
Sex	-0.011	0.009	-1.28
Age	-0.003***	0.000	-3.33
Yearedu	0.005***	0.001	3.50
Training	0.029***	0.008	3.56
Membcoop	0.056***	0.007	7.85
Credit	0.013*	0.007	1.89
Disexten	-0.012***	0.004	-3.21
Dismkt	-0.018***	0.005	-3.66
Famlsize	0.034***	0.004	8.57
Farmsize	0.004	0.002	1.56
Livestock	-0.003**	0.001	-2.08
Offfarm	-0.000***	0.000	-2.72
		F(12, 192) =	1312.12
Log pseudolikelihood = 443.035		Prob > F =	0.0000

***, ** and * indicate level of significance at 1, 5 and 10 percent, respectively.

Marginal effects

Quantification of the marginal effects of these variables on economic efficiency is possible by partial differentiation of the economic efficiency predictor with respect to each variable in the efficiency function to indicate that the effects of a unit change in those variables on the unconditional expected value of economic efficiency, expected value of economic efficiency conditional upon being between 0 and 1, and probability of being between 0 and 1. For variables constructed as a dummy variable, the coefficient estimated represents a one-off shift in efficiency rather than a true marginal effect. The marginal effects of changes in explanatory variables from Tobit regression analysis were computed following the procedure proposed by McDonald and Moffitt (1980), Greene (2003), Waluse (2012), Essa (2011) and Endrias et al. (2013).

The results showed that, other variables keep constant; a unit increase in age of the farmer decreases the expected value of economic efficiency by about 0.3 percent. Similarly, a unit increase in livestock owned by a household decreases economic efficiency by about 0.3 percent. However, a unit increase in family size of household increases expected value of economic efficiency by about 3.4 percent (Table 4).

A unit increase in distance to the market decreases economic efficiency of small holder maize producers by about 1.8 percent. The result is attributed to the fact that a farmer located far from the market incurs more costs to transport farm inputs from the market, compared to the one closer to the market. The findings are consistent with results found by Waluse (2012). In a similar manner, a unit increase in distance to extension centers decreases economic efficiency of small holder maize producers by about 1.2 percent with other variables keep constant.

A one year increase in education of household head increases expected value of economic efficiency of a farmer by about 0.5 percent. Additionally, an increase in the dummy variable representing training increases an expected value of economic efficiency of farmers by about 2.9 percent. Again, an increase in the dummy variable representing being membership to farmers cooperatives increases an expected value of economic efficiency of farmers by about 5.6 percent as other variables keep constant. Specifically, it was also found that an increase in access to credit increases farmers' expected value of economic efficiency by about 1.3 percent.

Table 4: The marginal effects of explanatory variables on economic efficiency

Variable	$\partial E(y)$	standard error	z-value	At mean(x) value
Sex*	-0.0118	0.009	-1.28	0.921
Age	-0.0030	0.000	-3.33	39.96
Yearedu	0.0050	0.001	3.50	1.039
Training*	0.0291	0.008	3.56	0.769
Membcoop*	0.0568	0.007	7.85	0.651
Credit*	0.0135	0.007	1.89	0.313
Disexten	-0.0124	0.004	-3.21	7.568
Dismkt	-0.0186	0.005	-3.66	6.617
Famlsize	0.0348	0.004	8.57	6.593
Farmsize	0.0040	0.002	1.56	2.202
Livestock	-0.0030	0.001	-2.08	4.980
Offfarm	-0.0000	0.000	-2.72	1113.24

(*) is for discrete change of dummy variable from 0 to 1

5. Conclusion: More importantly, efficient resource use is the basis for achieving universal food security and poverty reduction strategies. As such, the objective of this study was to evaluate farm level economic efficiency for maize crop production and the factors influencing economic efficiency level of those farms in Boricha Woreda, southern Ethiopia. A multi stage sampling techniques was used to select 204 sampled farmers which were interviewed using structured questionnaire to obtain data pertaining to farm production, input usage, and other variables including socioeconomic and institutional factors. A Cobb-Douglas production function was employed to assess maize output elasticity. Various tests were conducted to prove the working hypotheses. Additionally, frontier 4.1c software was used to determine the levels of technical and economic efficiencies. Furthermore, descriptive statistics, a stochastic frontier and a two-limit Tobit regression models were employed.

It was also established from a stochastic frontier model that maize yield was positively influenced by seed, labor, oxen, Dap and Urea fertilizers and farm size. A contribution of labor on maize production was positive indicating underutilization of farm labor. The relationship between oxen holding and output in maize production was positive and significant. Thus, oxen availability is crucial to increase output level in maize production.

The mean technical and allocative efficiencies were 72 and 70 percent respectively while the mean economic efficiency among smallholder maize producers was 53 percent. This figure indicates that if the average farmer in the sample were to reach the economic efficiency level of its most efficient counterpart, then the average farmer could realize 41 percent total production cost savings. In general, based on parameters tests, σ^2 (0.376) and γ (0.999), the study established that smallholder maize producers used resources inefficiently.

Tobit regression model estimation also revealed that economic efficiency was positively and significantly affected by education, training, membership to cooperatives, access to credit, and family size whereas variables: age, distance to extension officers, distance to market, livestock and off farm income affected it negatively. Consequently, policies targeting and encouraging training, membership to cooperatives and access to education of smallholder maize producers would promote economic efficiency of maize production in the study area.

6.Recommendations

Based on the findings of the study the following policy implications were forwarded:

1. Providing continuous training and field follow up of smallholder farmers about recommended usage of inputs during maize production is important. Extension agent should educate the farmers so as to increase their efficiencies in maize production. This will substantially help smallholder maize producers to survive and exploit opportunities in the competitive market. This calls for more efforts by the government and NGOs to increase farmer's trainings on better usage of inputs. If such knowledge is disseminated then farmers will improve on their technical, allocative and economic efficiency resulting into increased maize output and incomes, hence poverty alleviation.
2. The usage of improved maize seeds was found to be vital for increasing farmers' maize output. However, its use has been challenged by supply shortage and high seed prices even farmers could not find these seeds in the market. Therefore, the government and NGOs should provide improved seeds and fertilizers at subsidized prices. In addition to encourage the use of improved maize seed and fertilizer, distribution of these inputs should be on credit basis.
3. Membership to farmers' cooperatives was found to affect economic efficiency positively and significantly. Therefore, it should be encouraged and strengthened to improve access to market information and other extension services. When farmers are better organized it becomes easier even for extension staff to offer extension services to the farmers. Therefore, it implies that there should be clear and agricultural oriented missions for cooperatives. Moreover, there must be active participation of farmers through giving leadership especially the marginalized people including women that help member farmers to increase their resource use efficiency
4. Development of market and road infrastructure could promote resource use efficiency and increase productivity. Therefore policy makers should focus on development of market and road infrastructure so as to facilitate market participation and integration of far distant resident smallholder maize producers.
5. Policies that motivate and mobilize the farm labor and oxen power in agricultural activities would be likely to bring a tremendous improvement in productivity.

6. It implies that there should be policies to improve resource use efficiency of older farmers and encourage them to be in farming activities by providing them incentives. Also, according to the findings, older farmers were less likely to have contacts with extension agents and were less willing to adopt new practices and modern inputs. This is an important finding which younger farmers were comparatively more educated than the older farmers. Therefore, by increasing the education status of older farmers through Adult Based Education and Training, government can increase the efficiency level of farmers.
7. Improvements in farm efficiency rely on institutional capacity building for farmers. policy makers need to focus on providing institutional support to farmers rather than focusing on introducing new technologies, which if the necessary technical and managerial skills are not in place may result in continued inefficiencies in production.

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