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Technical, allocative, and economic efficiency among smallholder maize farmers in Southwestern Ethiopia: Parametric approach

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Maize is one of the major five staple cereal crops in Ethiopia. High productivity and efficacy in its production is critical to improve food security, reduce the level of poverty and achieve or maintain agricultural growth. A multi-stage sampling technique was used to select 385 household heads and interviewed using a structured questionnaire during 2013/2014 production year. The study estimates, technical, allocative and economic efficiency using a parametric stochastic frontier production function (Cobb-Douglas). Inefficiency effects are modeled in a second stage applying a two-limit Tobit regression model. The results show that the mean technical, allocative and economic efficiency score was found to be 62.3, 57.1 and 39%, respectively, indicating a substantial level of inefficiency in maize production. The result depicted that important factors that affected technical, allocative and economic efficiency are a number of family size, level of education, extension service, cooperative membership, farm size, livestock holding and use of mobile. Based on the findings the following recommendations are forwarded. The government should motivate and mobilize the youth in agricultural activities, invest in the provision of basic education and facilitate the necessary materials, strengthen the existing agricultural extension system, organize non-member farmers in cooperative association and due attention should be given to enhance the efficiency of farmers with large land holding size. Further, government and stakeholders should promote the expansion of mobile networking in the study area.

Key words: Efficiencies, parametric stochastic approach, two-limit Tobit model, Ethiopia.

INTRODUCTION

The agriculture sector in Ethiopia plays pivotal roles in economic growth, poverty alleviation, employment creation, foreign exchange earnings and food security. Despite the enormous contribution over the past years, its significance is limited because of various factors and hence it is becoming increasingly difficult to meet the food requirements of the growing population (Jon, 2007; Abera, 2011; UNDP, 2013). One of the significant contributors for its deprived performance is the low productivity of the sector in general and cereal production

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in particular over the past years (Alemayehu, 2009; Alemayehu et al., 2012). Such low productivity leads to increasing poverty and food insecurity of rural poor farm households in the country.

During the past years, the government and NGOs have undertaken various attempts to enhance agricultural productivity particularly that of cereal crops so as to achieve food security and to reduce poverty in the country. The available studies on the productivity of cereal crops in general and maize production in particular in Ethiopia found low productivity in comparison with the international standards (Alemayehu, 2009), although, the current average national maize productivity of Ethiopia (32.54 quintal per ha) is better than the national productivity of many African countries. However, it is still low compared to that of the world average maize productivity (50 quintal per ha) (CSA, 2014; MoA, 2014). Besides, spatial variability in maize productivity is another concern for maize productivity enhancement in Ethiopia. For instance, in 2013/14, average maize productivity in Oromiya region varied from 40.03 quintal per ha (East Welega zone) to 24.06 quintal per ha (East Harerge zone). In the same year, the average maize productivity ranged from 39.42 quintal per ha (West Gojam zone) to 14.45 quintal per ha (Waghemra zone) in Amhara region. It also ranged from 39.45 quintal per ha (Silitie zone) to 18.91 quintal per ha (Bench-Maji zone) in the Southern Nations Nationalities and People's Region (SNNPR). Similarly, the average maize productivity varied from place to place in other regions too (CSA, 2014). Thus, raising production levels and reducing its variability are both essential aspects to improve food security and well-being of the people of Ethiopia.

According to previous research, a number of factors explain the low productivity and variability of maize in Ethiopia. Among others the existence of production inefficiency at farm level, lack of and inexistence of improved production technologies are the main factors that affect productivity of maize (Arega, 2003; Arega and Rashid, 2005; Jon, 2007). There are also different risk factors, which adversely affect maize yield. Weather risk and market risks are the major challenges for farmers. In addition to the above mentioned factors, low level of crop management practices, weeds, pest and diseases, erratic rainfall, erosion, low soil fertility, poor infrastructure, and post harvest crop losses are also growing concerns for the low productivity of maize crop in Ethiopia (ECEA, 2009).

On the other hand, the spatial variability of productivity of maize production could be due to several factors such as fluctuations in areas sown, fluctuations in weather conditions, changes in pricing and marketing policies, differences in the soil fertility status, availability of moisture during the growing season, and utilization of the recommended maize production and protection technologies (Zerihun, 2003; Anderson and Kay, 2010). Thus, the existence of such constraints significantly affects farmers' efforts of improving productivity, enhancing their food self-sufficiency and increasing their family income.

Previous studies conducted in the area of maize production efficiency, except that of Arega (2003), Arega and Rashid (2005), Aye and Mungatana (2010) deals exclusively with technical efficiency of farmers and the factors considered to be important in determining the efficiency of maize farming (Wambui, 2005; Ephraim, 2007; Elibariki et al., 2008; Endrias et al., 2010), Although the analysis of technical efficiency of maize farming is important, there is limited empirical research done so far in Ethiopia particularly on the estimation of other efficiencies (allocative and economic) of maize farming in the country. Understanding the levels of these efficiencies and their determinants contribute a lot to the identification of production constraints at farm level and thereby improve the food security and income sources in the farm sector and the rest of the economy. Furthermore, such knowledge may help policy-makers to design appropriate policies to increase agricultural productivity through improving on farm-and crop specific efficiencies. This research aims to take a step towards filling the above noticeable gaps of knowledge by collecting cross-sectional data from maize-dominated smallholder farmers of southwestern Ethiopia.

METHODOLOGY

Study area

The study was carried out in the Jimma zone of Oromia regional state in southwestern Ethiopia. Jimma zone is located southwestern parts of Addis Ababa and it is one of the major maize growing areas of Ethiopia. Based on the 2008 census report of CSA the zone has a total population of 2,495,795 of whom 1,255,130 are men and 1,240,665 women. Jimma zone bordered with east Wollega zone in the north, with east shawa zone and southwest Shawa zone in the northeast, with SNNPR administration in the southeast and south part, and with Illubabor zone in the west. Jimma zone divided into 17 *woredas* (districts) and it lies between latitudes 7°15´ N and 8°45´ S, and longitudes 36° 00´ E and 37°40´ E (BoFED, 2008). Jimma zone generally lies with the altitude ranges between 900 and 3334 m above sea level. More than half of the zone (52%) lies between 1500 and 2000 m above sea level. Areas between 1500 and 2000 m above sea level are found in the all areas of *Limmu*-Seka, Menna, east Kersa, northern area of Dedo, Omonada, eastern and southern Gera, Seka-Chekorsa and Sokoru and eastern Gomma. On the other hand, the majority of the remaining *woredas* has an intermediate plateau topography that highly ideal for farming, which lies within altitude 2000 to 2500 m (Socio-Economic Profile Report, 2009).

Sampling techniques and the data

The study was based on cross-sectional data that were obtained through a farm household survey administered on 385 randomly selected smallholder farmers drawn by multi-stage sampling techniques in 2013/14 production season. The three-stages that involve the selection of (1) *woredas (district)*, (2) *kebeles* (lower administrative unit) and (3) smallholder farmers are as follows: In the first stage, three *woreda,* namely Omonada, Seka-Chekorsa and Kersa were randomly selected from 12 maize growing *woredas* of Jimma zone of southwestern Ethiopia. In the second stage, the study included 15% of total maize growing *Kebeles* within each of the three selected *woredas* using simple random sampling method. Based on these criteria, four *kebeles* from Omonada and two *kebeles* from Seka-Chekorsa and three *kebeles* from Kersa *woreda* were selected randomly that give rise to a total of nine *Kebeles*. In the third stage, the study selected 385 smallholder farmers randomly from lists of names of maize farmers in the *kebeles* using a computer-generated random number table. The data set contains detailed information on households' demographic and socioeconomic characteristics, farm specific attributes, marketing, and institutional characteristics.

Analytical methods

The analysis of efficiency was carried out following the Aigner et al. (1977) method of the estimating the Stochastic Frontier Production Functions (SFPF). The study specified the SFPF using a Cobb-Douglas production function for smallholder maize producing farmers in the Jimma zone of southwestern Ethiopia as:

$$LogY_i = \beta_0 + \sum_{J=1}^{4} \beta_j LogX_{ji} + (v_i - u_i) \quad (1)$$

Where Y is the total quantity of maize cultivated (in kilogram); X_1 represents the plot size under maize cultivation (hectares) on the i^{th} farm; X_2 represents family and hired labor used for maize production (man-days) on the i^{th} farm; X_3 denotes the amount of fertilizer in kilogram applied to land for maize production of the i^{th} farm; X_4 denotes the amount of other inputs such as seed in kilogram, pesticide and herbicide in liters applied to land for maize production of the i^{th} farm; β_j j = 0, 1,..., 4 are parameters to be estimated; v_i are assumed to be independent and identically distributed N (0, σ^2) random variables; μ_i s are assumed to be independent and identically distributed non-negative truncations of the N(u, δ^2) distribution.

The second stage of analysis is to explain Technical Efficiency (TE) of maize farming. TE is the ability of a farmer to obtain maximum (optimal) output from a given set of inputs and technology. Using the above estimated Cobb-Douglas production function in Equation (1), estimation of TE for individual farms is predicted by obtaining the ratio of the observed production values to the corresponding estimated frontier values. The value achieves its maximum feasible value if and only if TE_i =1 otherwise, TE_i<1. The TE for the i^{th} farms can be computed as:

$$TE_i = \left[\frac{\log Y_i = \beta_0 + \sum_{J=1}^{4} \beta_j LogX_{ji} + (v_i - u_i)}{\log Y_i = \beta_0 + \sum_{J=1}^{4} \beta_j LogX_{ji} + v_i} \right] \quad (2)$$

Following Bravo-Ureta and Rieger (1991) Efficiency Decomposition Techniques (EDT), the study computed the dual cost frontier in Equation (3) based on the estimated production frontier in Equation (2) and this forms the basis of computing the EE and AE of maize production. The dual cost frontier was computed as:

$$\ln C_i = \phi_0 + \phi_1 \ln C_{land} + \phi_2 \ln C_{labour} + \phi_3 \ln C_{Fertilzer} + \phi_4 \ln C_{Others} + \delta \ln Y_i + \mu_i \quad (3)$$

Where C is the cost of maize production for the i^{th} farmer, C_{Land} is the total rental price of land per hectare estimated at market price. C_{Labor} the total price of labor per day estimated at market price, $C_{Fertilizer}$ is the total price of fertilizer per kg estimated at market price, and C_{others} are the total price of seed per kg, pesticide and herbicides per liter estimated at market. The maximum likelihood estimates of the parameters of the parametric approach of stochastic frontier estimation for both SFPF and EDT were estimated using the STATA version 12.

To analyze the effect of demographic, socioeconomic, farm attributes, marketing, institutional variables on efficiencies, a second stage procedure was used where the efficiency scores regressed on selected explanatory variables using two-limit Tobit model. This model is best suited for such analysis because of the nature of the dependent variable (efficiency scores), which takes values between 0 and 1 and yield the consistent estimates for unknown parameter vector (Maddala, 1999).

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

$$Y_j^* = \beta' X_{jk} + \mu_i \quad (4)$$

Denoting Y_j as the observed dependent (censored) variable:

$$y_i = \begin{cases} L & if \ Y_j^* \leq L \\ Y_j^* & if \ 0 \quad L < Y^* < U \\ U & if \ Y_i^* \geq U \end{cases} \quad (5)$$

Where y_i is the observed dependent variables, in our case efficiency of maize production of farm j (unobserved for values smaller than 0 and greater than 1), X_{jk} is a vector of explanatory variable k (l = 1, 2, ...,k) for farm k and μ_i an error term that is independently and normally distributed with mean zero and variance σ^2 and is independent of X_{jk}. The distribution of the dependent variable in the equation (5) is not a normal distribution because its value varies between 0 and 1.

Following Maddala (1999), the likelihood function of this model is specified as:

$$L(\beta,\delta | y_j, X_j L_{1j}, L_{2j}) = \prod_{y_j - L_{1j}} \varphi\left(\frac{L_{1j} - \beta' X_j}{\delta}\right) \prod_{y_j = y_j^*} \varphi\left(\frac{y_j - \beta' X_j}{\delta}\right) \prod_{y_j - L_{2j}} \varphi\left(\frac{L_{2j} - \beta' X_j}{\delta}\right) \quad (6)$$

Where L_{1j} = 0 (lower limit) and L_{2j} = 1 (upper limit) were and are normal and standard density functions.

In a two-limit Tobit model, each marginal effect includes both the influence of explanatory variables on the probability of the 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 explanatory variable will have a simultaneous effect on the probability of being efficient in maize production and value of efficiency scores in maize production.

McDonald and Moffitt (1980) proposed useful decomposition techniques of total marginal effects and later developed by Gould et al. (1989). Based on the likelihood function of the model stated in equation (6), the total marginal effect divided into the three marginal effects as follows:

1. The unconditional expected value of the dependent variable:

Table 1. Descriptive statistics of variables and their expected hypothesis.

Notation	Variable description	Mean (S.D)	Measurement	Expected sign
	Demographic characteristics			
FEMALE	Female household head	11.4 (0.32)	Dummy	**-**
AGE	Age of household head	45.35 (8.85)	Years	**+**
FAMSIZE	Total family size	5.5 (2.05)	Number	**+**
	Socio-economic characteristics			
EDUFAR	Number of years of formal education	2.78 (1.66)	Years	**+**
TLU	Total number of livestock size	4.71 (2.52)	TLU	**+**
	Farm attributes			
EXPMFAR	Experience of farmer in maize production	22.67 (9.21)	Years	**+**
FARMSIZE	Total farm size	1.63 (0.67)	Hectare	**+/-**
	Institutional service			
FREEXT	Frequency of extension contact	3.32 (3.3)	Number	+
DSTCD	Distance to development center	0.86 (0.79)	Walking hour	-
COOP	Membership of farmer cooperative	45.97 (0.50)	Dummy	**+**
CREDIT	Use of cash credit for maize	16.36 (0.37)	Dummy	**+**
	Marketing access			
MOBILE	Use of mobile cell phone	71.14 (0.45)	Dummy	+
DSTMKT	Distance of to market center	2.31 (1.42)	Walking hour	-

Source: Computed from survey data

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

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

$$\frac{\partial E(y^*)}{\partial x_j} = \beta_k\left[1 + \frac{\{Z_L\varphi(Z_L) - Z_U\varphi(Z_U)\}}{\{\varphi(Z_U) - \varphi(Z_L)\}}\right] - \left[\frac{\{\phi(Z_L) - \phi(Z_U)\}^2}{\{\varphi(Z_U) - \varphi(Z_L)\}^2}\right] \quad (8)$$

3. The probability of being between the limits:

$$\frac{\partial\left[\varphi(Z_U - \varphi(Z_L\right]}{\partial x_j} = \frac{\beta_k}{\delta}.\left[\phi(Z_L) - \phi(Z_U)\right] \quad (9)$$

Where $\varphi(.)$ is the cumulative normal distribution, $\phi(.)$ is the normal density function, $Z_L = -\beta' X / \delta$ and $Z_U = (1-\beta X)/\delta$ are standardized variables that came from the likelihood function given the limits of y*, and δ is the standard deviation of the model.

Definition of variables, measurement and hypotheses

Adoption literature provides a number of factors influencing the level of efficiency of maize production. Generally, the level of efficiency are hypothesized to be influenced by a combined effect of various factors such as demographic, socioeconomic, farm attributes, marketing and institutional characteristics. Summary statistics of the variables used in the two-limit Tobit model provided in Table 1.

RESULTS AND DISCUSSION

The maximum likelihood (ML) estimates of the parameter of the stochastic frontier Cobb-Douglas production function results are presented in Table 2. The standard ordinary least squares (OLS) estimate is also presented for comparison. The results show that all coefficient estimates are significant at one percent level of significance and have expected signs thereby determining maize production in the Jimma zone of southwestern Ethiopia. The ratio of the standard error of $\mu(\delta_\mu)$ to the standard error of $\nu(\delta_\nu)$, known as lambda (λ) is 3.1, which measures the effect of technical inefficiency in the variation of observed output, $\gamma = \lambda^2 / \left[1+\lambda^2\right] = \delta_\mu^2 / \delta_\varepsilon^2$. The estimated value of (γ) is 0.48, which is an estimate of the variance parameter and significant at 1% level of significance implying that 48% of the total variation in output is due to existence of production inefficiency. This result is confirmed by conducting a likelihood ratio test to compare OLS model versus frontier model in representing the surveyed data. Likelihood ratio test statistic provided a statistic of 11.61 distributed with chi-square four degrees of freedom, which is significant at one percent level of significance, thus rejecting the adequacy of the OLS model in representing the data.

The cost frontier dual to the Cobb-Douglas production

Table 2. The ML and OLS estimates of the parametric stochastic production frontier.

Variable	Parameter	ML estimates	OLS estimates
		Coefficient (Std. Err.)	Coefficient (Std. Err.)
Intercept	δ	2.06 *** (0.325)	1.05 *** (0.325)
Ln (Land)	β_1	0.46 *** (0.874)	0.45 *** (0.099)
Ln (Labor)	β_2	0.140 *** (0.041)	0.173 *** (0.053)
Ln (Fertilizer)	β_3	0.088 *** (0.017)	0.10 *** (0.016)
Ln (Others)	β_4	0.16 *** (0.063)	0.24 *** (0.069)
Variance parameters:			
Sigma-Squared	$\delta^2 = \delta_u^2 + \delta_v^2$	3.1*** (0.10)	
Gamma	$\gamma = \delta_u^2 / \delta^2$	0.48*** (0.07)	
Log-likelihood		-225.14	

Source: Model result.

frontier shown in Table 3 is analytically derived and this formed the basis of computing the AE (allocative efficiency) and EE (economic efficiency). The dual cost frontier is given as:

$$LnC_i = 1.95+0.38lnC_{land}+0.21lnC_{labour} +0.06LnC_{Fertilizer} +0.26C_{othres} +0.05lnY_{PRODi}$$

Where C_i is the cost of maize production for the i^{th} farmer, Y_{PRODi} is total maize output in kg of the i^{th} farm, C_{Land} is the rental price of land per hectare estimated at Birr 3,500, C_{Labour} is the price of labor per day estimated at Birr 20, $C_{Fertilizer}$ is the price of chemical fertilizer per kg estimated at Birr 29.21 and C_{Others} is a price index of seed estimated at Birr 17.44 per kg of seed and price of pesticide and herbicide estimated at 550 Birr per liter.

The study found out that the average technical efficiency of the sample farms is 0.623, with a minimum level of 0.211 and the maximum level of 0.943. This means that if the average farmer in the sample was to achieve the technical efficient level of its most efficient counterpart, then the average farmer could realize a 34% increase in output by improving technical efficiency with existing technology. The mean allocative efficiency of the sample farms is estimated at 0.571, with a low of 0.183 and a high of 0.887. A similar calculation for the allocative efficiency farmer reveals 36% increase in output by improving allocative efficiency, with existing technology. The combined effect of technical and allocative factors shows that the average economic efficiency level is only 0.39, with a low of 0.041 and a high of 0.837. This result indicates that if the average farmer in the sample were to reach the economic efficiency level of his/her most efficient counterpart, then the average farmer could experience a 53% increase in output by improving both economic and allocative efficiency, with the existing technology. Therefore, this result shows the existence of significant technical, allocative and economic inefficiency in maize production among maize producing smallholder farmers in the study area.

The mean levels of efficiencies were comparable to those from other similar studies in Ethiopia. For example, Seyoum et al. (1998) find the mean technical efficiency of maize producers in Eastern Ethiopia for farmers within and outside the Sasakawa-Global 2000 project to be 88 and 74%, respectively. Arega and Rashid (2005) found mean technical, allocative and economic efficiencies of 68, 83 and 56% respectively for traditional maize producers and 78, 77 and 61% respectively for hybrid maize producing farmers in Eastern Ethiopia. However, Endrias et al. (2010) found low average technical efficiencies of 40% among maize producing farmers in Southern Ethiopia using DEA and normalized Translog production function.

After measuring the level of TE, AE and EE index, it was necessary to identify which demographic, socio-economic, farm attributes, marketing, institutional factors influencing the level of TE, AE and EE in maize production. To identify factors influencing efficiencies, a “second step” estimation techniques of Bravo-Ureta and Rieger (1991) followed, the following two-limit Tobit model estimated in Table 3. Before explaining the model, a test on multi-collinearity and hetroscedasticity were made. The VIF was found to be low (a maximum VIF of 1.62). This shows that there is no problem of multi-collinearity in the data set. The Breusch-Pagan test for hetroscedasticity indicated a small chi-square (0.91 for TE and 0.94 for AE and 1.92 for EE), implying there was

Table 3. Tobit results on technical, allocative and economic efficiency of maize production.

Variables	Technical efficiency		Allocative efficiency		Economic efficiency	
	Coefficient (Std. Error)	Marginal effects	Coefficient (Std. Error)	Marginal effects	Coefficient (Std. Error)	Marginal effects
FAMSIZE	0.02 ***	0.0200	0.02 ***	0.0189	0.02 ***	0.0223
	(0.005)	0.0189	(0.004)	0.0185	(0.005)	0.0207
		0.0032		0.0008		0.0050
EDUFAR	0.01 **	0.0108	0.01 *	0.0098	0.01 **	0.0114
	(0.005)	0.0102	(0.005)	0.0096	(0.006)	0.0105
		0.0017		0.0004		0.0044
TLU	0.02 ***	0.0204	0.02 **	0.0211	0.02 ***	0.0221
	(0.004)	0.0193	(0.004)	0.0207	(0.0040)	0.0205
		0.0033		0.0207		0.0044
FARMSIZE	-0.04 ***	-0.0439	-0.04 ***	-0.0442	-0.06 ***	-0.0006
	(0.013)	-0.0415	(0.013)	-0.0433	(0.014)	-0.0568
		-0.0071		-0.0020		-0.0001
FREEXT	0.01 ***	0.0140	0.01 ***	0.0127	0.02 ***	0.0155
	(0.003)	0.0133	(0.003)	0.0125	(0.003)	0.0144
		0.0023		0.0006		0.0031
COOP	0.04 **	0.0360	0.03 **	0.0320	0.04 **	0.0437
	(0.018)	0.0340	(0.017)	0.0314	(0.020)	0.0106
		0.0060		0.0049		0.0085
MOBILE	0.06 ****	0.0603	0.05 **	0.0240	0.06 ***	0.0635
	(0.020)	0.0575	(0.020)	0.0457	(0.224)	0.0017
		0.0002		0.0002		0.0153
CONS	0.32***		0.31 ***		0.07	
	(0.059)		(0.055)		(0.064)	

***, ** and * indicate the level of significance at 1, 5 and 10%, respectively; Marginal effects computed only for significant variables and value in cell explain $\frac{\partial E(y)}{\partial X_j}$ (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 results.

no hetroscedasticity problem in the data. In addition, a test for normality of TE, AE and EE were also made using Kernel density estimate and Jargue-Bera test. Kernel density estimate graph resembles the normally distributed curve (Figure 1). Jarque-Bera test also indicated a higher chi-square for 25.11 (TE), 21.11 (AE) and 21.98 (EE), implying TE, AE and EE is normality distributed.

The parameter estimates of the model are presented in Table 3. According to the result of the model, technical, allocative and economic efficiency of maize production are positively and significantly influenced by the size of household (FAMSIZE), education level of household head (EDUFAR), the size of livestock holding (TLU), extension service (frequency of contacts) (FREEXT), cooperative membership (COOP) and use of mobile cell-phone (MOBILE) whereas, negatively and significantly influencing total landholding size of the household head (FARMSIZE).

The number of family size in the household has a positive and highly significant impact on TE, AE and EE at one percent level of significance. A possible reason for this result might be that a larger household size guarantees availability of family labor for farm operations to be accomplished in time. At the time of peak seasons, there is a shortage of labor and hence household with large family size would deploy more labor to undertake the necessary farming activities like ploughing, weeding and harvesting on time than their counterparts and hence they are efficient in maize production. Moreover, the computed marginal effect of household size showed that a one person change in the number of household size would increase the probability of farmer to fall under TE, AE and EE category by 0.32, 0.08 and 0.5% and the

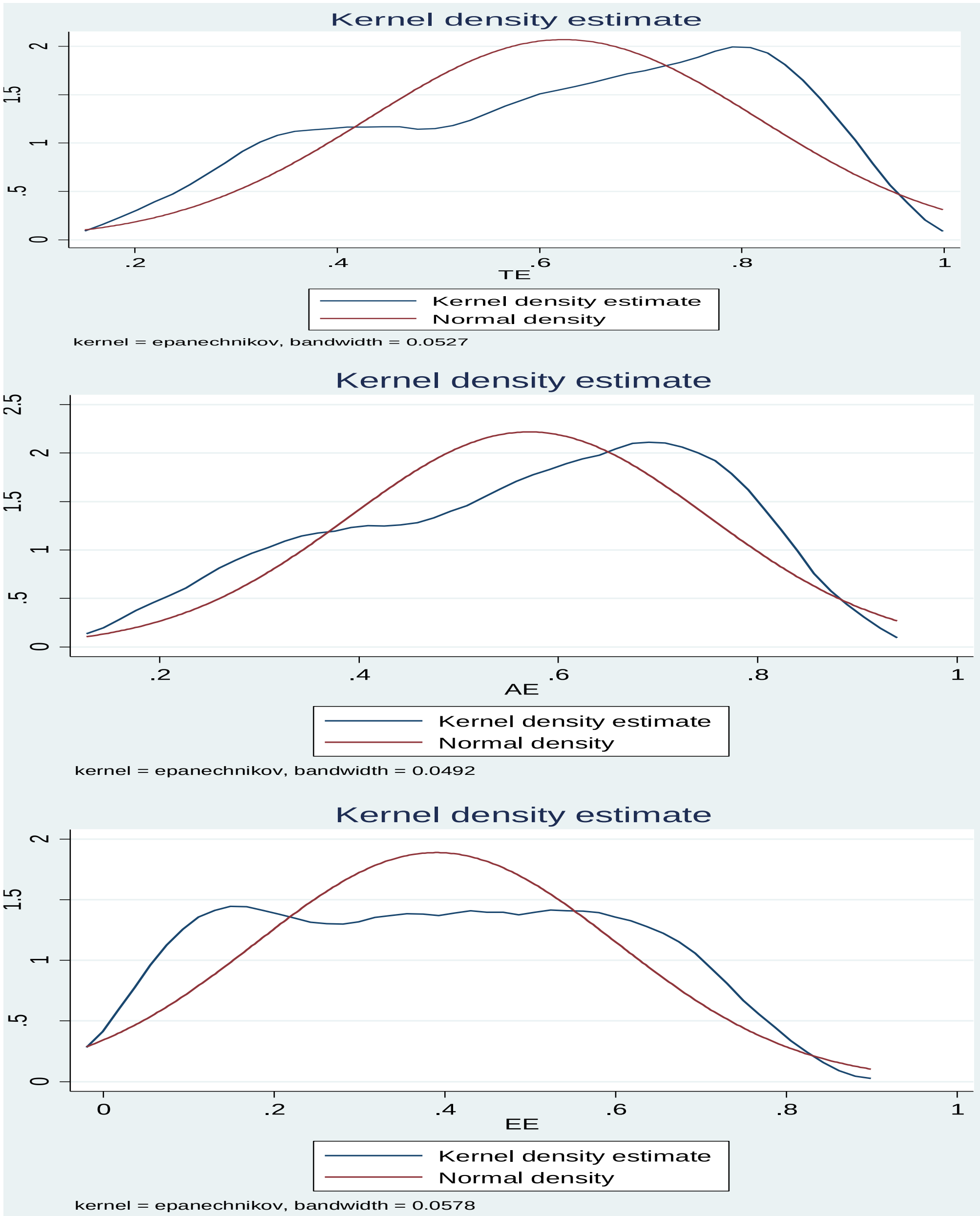

Figure 1. Kernel density estimate for efficiencies. Source: Computed from survey data.

expected value of TE, AE and EE by 0.19, 0.19 and 0.21% with an overall increase in the probability and the level of efficiencies by 0.20 0.19 and 0.22%, respectively. Similar positive and significant impact of household size on efficiency was found by Elibariki et al. (2008), Aye and Mungatana (2010) and Shumet (2011) in their respective studies.

As expected, education of the household head has a positive and significant effect on TE, AE and EE of maize production at five and ten percent level of significance, suggesting that better-educated household head can understand agricultural instructions easily, have higher tendency to adopt improved production technologies, have better access to information, and be able to apply technical skills imparted to them than uneducated ones. Thus, the level of education of household head emerges as an important factor in enhancing efficiencies of maize production in the study areas. Moreover, a one year increase in educational attainment level of the household head increases the probability of a farmer to fall under TE, AE and EE category by 0.17 0.04 and 0.44% and change in the expected value of TE, AE and EE by about 0.10, 0.96 and 0.11% with an overall increase in the probability and levels of efficiencies by 0.11, 0.98 and 0.11%, respectively. This result is consonant with other similar studies such as Arega and Reshid (2005), Elibariki et al. (2008), Aye and Mungatana (2010), Otitoju and Arene (2010), Shehu et al. (2010) and Shumet (2011) who found that a farmer with greater year of schooling tends to be higher efficient in crop production.

The amount of livestock owned, which is a proxy for estimating wealth status of a farmer, has a positive and significant effect on TE, AE and EE in maize production at one percent level of significance. Farmers who owned a few number of livestock's were technically, allocativelly and economically more efficient than those who owned less number of livestock's in the production of maize. This is because livestock provides a working power (oxen for draught power), manure fertilizer and is a source of income that can be used to purchase the necessary agricultural inputs. Thus, possessing a large number of livestock's is crucial to increase TE, AE and EE in maize production in the study areas. Each unit increase in the value of TLU would increase the probability of a farmer to fall under TE, AE and EE category by 0.33, 0.21 and 0.44% and the expected value of TE, AE and EE by about 0.19, 0.21 and 0.21% with an overall increase in the probability and the level of efficiencies by 0.20, 0.21 and 0.22%, respectively. These results are consistent with the findings of Beyene (2004), Amos et al. (2007), Idiong et al. (2009), Otitoju and Arene (2010) and Shehu et al. (2010) in their respective studies.

A negative and statistically significant relationship between land holding size and TE, AE and EE at one percent level of significance supports the notion that small-size farms have an efficiency advantage of efficiency over the other farms in the sample. The link between efficiency and land holding size has been the subject of much discussion in the literature. Various studies have found a small landholding size to have a positive impact on crop level efficiency because of its simplicity in management and less transaction cost compared to the large farm size (Amos et al., 2007; Elibariki et al., 2008; Idiong et al., 2009; Otitoju and Arene, 2010). On the other hand, several other researchers have found a negative and statistically significant relationship between these two variables because large land holding farmers are more likely to employ modern agricultural practices and hence could be more efficient due to its advantage of the economic scale and scope associated with large farm size (Beyene, 2004; Hussein, 2007; Endrias et al., 2010). Thus, this study contributes to the ongoing debate on the relationship between farm size and efficiency by providing more results showing land holding size has a negative and significant effect on the efficiencies of maize production. Moreover, a unit change in farm size would result in 0.71, 0.20 and 0.01% change in the probability of a farmer being technically, allocativelly and economically efficient and the expected value of TE, AE and EE by 0.42, 0.43 and 0.57% with an overall increase in the probability and the level of efficiency by 0.44, 0.44 and 0.06%, respectively.

The relationship between extension service (frequency of extension contacts) and TE, AE and EE in maize production has a positive and statistically significant effect at one percent level of significance. That is, farmers who had more number of extension contact during the cropping period were technically, allocativelly and economically more efficient than those who had less number of extension contact during the cropping period. Thus, frequency of extension contacts with development agents is crucial to increase TE, AE and EE of maize production in the study areas. Each increase in the frequency of extension contact would increase the probability of a farmer to fall under TE, AE and EE category by 0.23, 0.06 and 0.31% and the expected value of TE, AE and EE by about 0.13, 0.13 and 0.14% with an overall increase in the probability and the level of efficiencies by 0.14, 0.13 and 0.16%, respectively. The results of studies by Arega and Reshid (2005), Fasorant (2006), Hussein (2007), Aye and Mungatana (2010), Otitoju and Arene (2010) and Shehu et al. (2010) who found that extension agents provide farmers with new information on improved production technologies, recommended agronomic practices, market and etc. Farmers who had more number of contacts with such agents improved their access to improved inputs and farming management practices thereby increased their production efficiencies.

The results concerning membership of the household head to farmer cooperatives has a positive and statistically significant effect on TE, AE, and EE at five percent level of significance. Farmer membership to farmer cooperatives is used as a proxy for measuring the role of social organization in the production process. Farmers who are members of farmer cooperatives received viable information on production technologies than farmers who are not members of the cooperatives. As a result, they experiment and apply new production technologies and hence they are more efficient in maize production. Moreover, a change in the dummy variable representing the membership of farmer cooperatives by the household head ordered from 0 to 1 would increase the probability of the farmers to fall under TE, AE and EE category by about 0.60, 0.49 and 0.85% and change the expected value of TE, AE and EE by about 3.4, 3.1 and 1.1% with an overall increase in the probability and the level of efficiencies by 3.6, 3.2 and 4.4%, respectively. Similarly, Benin et al. (2004), Fasorant (2006), Ephraim (2007) and Shehu et al. (2010) also arrived at the same result using the club membership to capture the role of social organization in providing incentives for efficient crop production.

Finally, the coefficient of the dummy variable for use of mobile cell phone for accessing marketing information has a positive and statistically significant effect on both TE and EE at one percent levels of significance. The association with AE is also positive and significant at five percent level of significance. The result implies that a farmer who owns a mobile cell phone has a better market information access and hence more likely to be efficient in maize production than those farmers who did not own mobile cell phone. Moreover, a change in the dummy variable representing the use of mobile cell phone order from 0 to 1 would increase the probability of the farmers to fall under TE, AE and EE category by about 0.02, 0.02 and 0.15% and change the expected value of TE, AE and EE by about 5.8, 4.6 and 0.17% with an overall increase in the probability and levels of efficiencies by 0.6, 2.4 and 6.4%, respectively.

CONCLUSION AND POLICY IMPLICATION

The study found the existence of substantial technical, allocative and economic inefficiency in maize production in the study area. The average technical, allocative and economic efficiency levels have estimated at 62.3, 57.1 and 39%, respectively. This implied an average of 53% growth of maize production through full technical and economic efficiency improvement, which indicates a considerable potential for enhancing productivity of maize in the area. Therefore, the attention of policy makers to improve food security, reduce poverty and achieve or maintain agricultural growth by raising the productivity of smallholder agriculture should not stick only on the use of improved production technologies and best farm technologies, but they should also give due attention towards improving the existing level of the inefficiencies of maize producing farmers. These inefficiencies, however, can be improved if major factors that determine efficiencies are identified.

The positive significant and higher elasticity of production inputs indicates the importance of these inputs in maize production. This implies that enhanced access and better use of these production inputs could lead to higher maize production in the study area. The key policy implication therefore is that strengthening policies that motivate and mobilize the rural population in agricultural activities, providing easy and affordable credit service as the high cost of chemical fertilizer was the most frequently mentioned problems that hindered its use in the area would increase the use of chemical fertilizer inputs, and policies that can further increases land allotted for maize production can be taken as an alternative to enhance productivity. This may include the consolidation and efficient use of the existing fragmented farms and strengthening the resettlement programs in the area.

The positive contribution of size of household on TE, AE and EE of farm households' needs policy attention that would motivate and mobilize the rural population, particularly the youth, in agricultural activities. Education attainment level is an important factor in TE, AE and EE, the key policy implication is that appropriate policy should be designed to provide adequate and effective basic educational opportunities for farmers in the study area. In this regards, the regional government should have a prime responsibility 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 product information and use the available inputs more efficiently. The size of livestock holding by household positively affected the TE, AE and EE of maize producing farmers, the study suggested strengthening the existing livestock production system through providing improved health service, better nutrition, targeted credit, and providing other necessary supports. Total farm size was a negatively affecting the TE, AE and EE, this provides an important lesson for other similar agro-ecology areas of small-size farm owners that better efficiency in maize production could be obtained with their limited land sizes. At the same time, the result suggests the regional agriculture offices should give due attention to large size farmers so as to enhance efficiencies in their production. Based on a positive contribution of extension service on TE, AE and EE, policies and strategies should therefore place more emphasis on strengthening the existing agricultural extension service through providing incentive, recruitment, training and upgrading the educational level of extension workers, and providing non-overlapping and congruent responsibilities of extension worker in the study area. Membership of household to farmer cooperatives plays a positive role in affecting the TE, AE and EE, this need strengthening the existing farmer cooperatives through providing incentives, awareness creation on its benefits should be taken as an important step towards organizing non-member farmers in the cooperatives. Finally, the use of mobile cell phone was positively related to TE and EE, improving the existing telecommunication service, particularly the expansion of mobile networking in the study areas should be given policy attention.

Conflict of Interest

The authors have not declared any conflict of interest.

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