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RESEARCH ARTICLE

ANALYZING PRODUCTIVITY IN MAIZE PRODUCTION: THE CASE OF BORICHA *WOREDA* IN SIDAMA ZONE, SOUTHERN ETHIOPIA

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ABSTRACT

The study was aimed to analyze productivity and to link the observed technical efficiency levels to farmers' socioeconomic and institutional characteristics in Boricha Woreda, Southern Ethiopia. A multi-stage sampling technique was used to select 204 sample farmers to obtain data pertaining to farm production, input usage, and other factors including socioeconomic and institutional factors during the year of 2013. In the analysis, frontier 4.1c software was used to determine the levels of technical efficiency. Thus, the mean technical efficiency was 72 percent. It was established from a stochastic frontier model that maize yield was positively influenced by seed, labor, oxen, farm size, DAP and Urea fertilizers. Tobit model revealed that factors that significantly affected the technical efficiency were age, training, membership to cooperatives, livestock, off-farm income, distance to extension centers, utilization of credit and family size of household. Thus, this study recommended policies targeting in providing trainings and education for smallholder maize producers would promote maize productivity and efficiency of smallholder maize producers.

INTRODUCTION

Maize cultivation is largely carried out by smallholders in Ethiopia. It is also the single most important crop in terms of both number of farmers engaged in cultivation and crop yield. 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. On average Ethiopia 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). 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 food supply to escape society from malnutrition and poverty (Mohammed, 2002). 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).

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. The increase in crop production in the past decade has been due to increases in area crops cultivated. 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. Given also 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 food supply to escape society from malnutrition and poverty. Hence improvements in resource usage efficiency and increasing productivity will reduce encroachment of population to marginal agricultural lands.

The agricultural sector productivity is one of the lowest and even showing a decreasing trend with causing a decline in per capita cereal consumption (Jema, 2008). Why has productivity in maize production remained low in the study area? Previous studies have not addressed such question of the low efficiency of maize production in study area. In addition to this, no studies have tried to differentiate socioeconomic factors that affect technical efficiency of smallholder maize producers. However, existing studies were related with maize varieties and technological adoption areas. Therefore, the general objective of the study was to analyze productivity in maize production and examine factors that affect technical efficiency in maize production among small holders in Boricha *Woreda* of Sidama

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Zone in SNNPR. The specific objectives of the study were to measure levels of technical efficiencies in maize production among smallholder maize producers, to identify the demographic, socio-economic and institutional factors that affect economic efficiency in maize production and to estimate the level of responsiveness of maize output to the main inputs of production; namely seed, labor, oxen and fertilizers.

Description of the Study Area

The study area, Boricha Woreda, is found in Sidama Zone, in Southern Nations Nationalities and Peoples Regions (SNNPR), which is located at 311km south of Addis Ababa. Its geographical location extends from 6º 46'N and 38º04'E to 7º01'N and 38 º24'E. 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 4.16% of its population is urban dwellers. The major crops by coverage are maize, haricot bean, coffee, horticultural crops and teff (CSA, 2007).

There are two cropping seasons in the study area, i.e., Belg (short rainy season) which runs from March to May and *Meher* (main rainy season) which occurs in the months from June to September. Belg rains are mainly used for land preparation and planting long cycle crops such as maize. The *Meher* rains are used for planting potato, green paper, haricot bean, sweet potato and to some extent *teff* (Bechaye, 2011). Farming system of the study area generally depends on rain fed agriculture and mixed farming system. Both crop production and animal husbandry are commonly practiced. The main crops grown during the two cropping seasons are maize, haricot bean, potato, green pepper, sweet potato, and in some parts sugar cane and *enset*. The main livestock species are cattle, goats, sheep and poultry. Major cash crops are maize, haricot bean, potato, green paper.

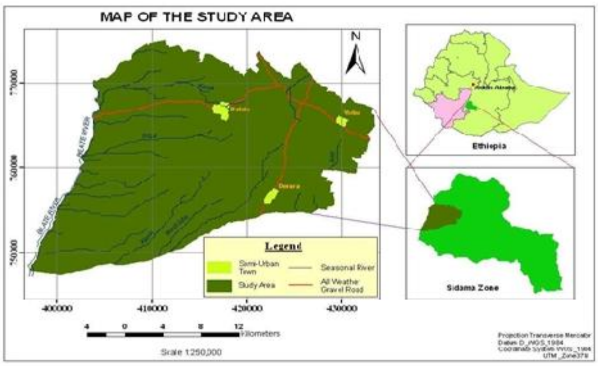

Figure 1 Administrative *map of the BorichaWoreda*
Source: Bechaye (2011)

MATERIAL AND METHODS

Efficiency is generally measured using either DEA or stochastic frontier methods. Some of the advantages of stochastic frontiers over DEA are it accounts for measurement errors and other sources of statistical noise and can be used to conduct conventional tests of hypotheses while some disadvantages are the need to specify a distributional form for the inefficiency term and the need to specify a functional form for the production function or cost function, *etc*. (Coelli *et al*., 2005). The stochastic parametric method decomposes random errors into error of farmer's uncontrollable factors, as well as farm specific inefficiencies. While deterministic and non-parametric method has drawbacks since it forces all outputs to a frontier yet sensitive to outliers if large, it distorts efficiency measurements (Ogundele and Victor, 2006; Douglas, 2008).

The specification of stochastic parametric frontier recognizes component error term as major source of deviation from the production frontier. Stochastic frontier production function is given as (Edetand Oluwatoyin, 2006; Coelli *et al*., 2005)

$$Y_i = F(X_i; \beta) \exp(V_i - U_i) \quad i = 1, 2\ldots N \qquad (1)$$

WhereYi is the output of i^{th} farm; Xi, is the corresponding (Mx2) vector of inputs; β is a vector of un-known parameterto be estimated; F denotes an appropriate functional form,V_i, is the symmetric error component that accounts forrandom effects and exogenous shock, while Ui, ≤ 0 is a onesided error component that measures technical inefficiency (Coelli*et al*., 2005; Khan and Saeed, 2011):

Productivity is seen as a measure of the efficiency of all resources put to use in any farming operation. It is defined as an indicator of the resource efficiency to its mean increase in optimal allocation and combination of these resources. Productivity could as well be measured in terms of marginal physical product (MPP) in which case, the interest is in the addition to total product resulting exclusively from a unit increase in the use of that input i.e., total factor productivity growth, which is measured using the frontier and non-frontier approaches (Edet and Oluwatoyin, 2006; Coelli*et al*., 2005; Waluse, 2011). In addition to this, Boris *et al*. (1997) described that 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:

$$Y_i = \beta_0 * \prod_{i=1}^{n} X_i^{\beta_i} * e^{(V_i - U_i)} \qquad (2)$$

By transforming it into double log-linear form:

$$\ln Y_i = \ln\beta_0 + \beta_i \sum_{i=1}^{6} \ln X_i + (V_i - U_i) \qquad (3)$$

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 $\beta_6$are the regression parameters to be estimated and ln= natural logarithm.

The major interest in efficiency study that specifies stochastic frontier is the decomposition of the component error terms (Vi - Ui) into mutually exclusive events. This is normally accomplished by estimating the mean of conditional distribution of U given V by following Amemiya (1981), Waluse (2011), Essa *et al*. (2011) Edet and Oluwatoyin, (2006); Coelli *et al*., (2005) and Endrias *et al*. (2013) and the two-limit tobit model was defined as:

E (V/ei) = μ i = σ* {f* (-μ i/σ*) [1-F(Ui/σ*)]-1} (4)

Where σ* = (σv2 σu2/σ2)½; μ = (-σu2ei)/σ2, f is the standard density function and F is the standard distributional assumptions. The values of unknown coefficients can be obtained jointly using the maximum likelihood (ML) method.

$$Y_{i\ TE}^{*} = \delta_0 + \sum_{j=1}^{12} \delta_j Z_{ij} + \mu_i \quad (5)$$

Where Y_i^* is latent variable representing the technical efficiency scores, $\delta_0, \delta_1, \ldots, \delta_{12}$ are parameters to be estimated, and TE is technical 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 $\delta^2(\mu_i \sim IN(0, \delta^2))$. 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

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

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

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

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

The coefficients of variables represented by the above equations were estimated by the STATA command using specific options. 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.

Sample Size Determination

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

$$n = \frac{N}{1 + N(e)^2} - - - - - - - - - - - - - \quad (8)$$

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,

$$n = \frac{280576}{1 + 280576(0.07)^2} = 204 - - - - - \quad (9)$$

Therefore, a total of 204 households were selected for the study. These households were selected from selected four *Kebeles* by using random sampling method.

RESULTS AND DISCUSSION

Econometric Results

Determination of elasticities is necessary for the estimation of productivity 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. 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 (Table 1).

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, J. and Oluwatoyin F., 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 elasticity about 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 show 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 return to scale in the production function at which production should normally take place because output is increasing positively at diminishing rate with an increase in inputs utilization. This is consistent with findings of Baloyi (2012) on technical efficiency in maize production in South

Africa and Hasan (2008) on economic efficiency in Northern Region of Bangladesh

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 fertilizer	0. 0652***	0.00059	110.27
Dap fertilizer	0. 1088***	0.00010	1028.77
Urea	0. 2085***	0.00007	2934.93
Farmsize	0. 2582***	0.00038	670.58
$\sigma^2 = \sigma_u^2 + \sigma_v^2$	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
Source: Model output (2013).

The result showed that technical efficiency 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 0.81to 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 were 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 similar 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 the wastage in inputs use to produce the output of the most efficient counterpart. This indicates that there was a substantial amount of technical inefficiency in maize production.

Table 2 Frequency distribution of technical efficiency of maize producers

Efficiency	Technical Efficiency	
Range	Frequency	Percentage
0.00-0.10	0	0.00
0.11-0.20	1	0.49
0.21-0.30	1	0.49
0.31-0.40	7	3.43
0.41-0.50	11	5.39
0.51-0.60	23	11.27
0.61-0.70	28	13.73
0.71-0.80	58	28.43
0.81-0.90	58	28.43
0.91-1.00	17	8.33
Total	204	100.00
Mean	0.7285	
Minimum	0.1586	
Maximum	0.9480	

Source: Model output (2013).

According to the results of Tobit regression model, important variables affecting the technical efficiency were found to be sex, age, membership to cooperatives, training, distance to extension agents and main market, credit, family size, livestock and off-farm income (Table 3). In this study, women farmers were found to be more efficient than their men counterparts. According to focus group discussion, the reason was that female farmers are more likely to attend meetings, frequent follow ups and supervisions their farms than males. This result is consistent with findings of Chiona (2011) and Dolisca and Curtis (2008) that found the negative relationship between sex and technical efficiency. Under this study, age was significant at negatively affecting the technical efficiency of smallholder maize producers.

This result is in line with findings of Simonyan *et al*. (2011) that younger farmers were more technically efficient than their aged counterparts. Boris (1997) showed also that younger and more educated farmers exhibited higher levels of technical efficiency.

Family size was also found to affect technical efficiency level negatively and significantly at 1 percent level. This was due to poor managerial ability to effectively utilize the available labor force in the family. However, there was positive relationship between technical efficiency and training. Farmers attending field days and agricultural meeting organized by extension centers had easier access to extension center services than those who do not participate in any group training. This implied that the contribution of training on maize farmers' production efficiency is very high.

Farmer's cooperatives influenced technical efficiency significantly at 5 percent level of significance and there was a positive relationship between membership to farmer's cooperatives and the technical efficiency of smallholder maize producers. Farmer's cooperatives played a significant role by disseminating agriculture information to the farmers and helped them to access extension center services easily. This result is similar to Dolisca and Curtis (2008) who found that membership to cooperatives contributed positively to technical efficiency.

The relationship between livestock and technical efficiency was positive and statistically significant at 10 percent level. Farmers were able to raise funds for the purchase of inputs especially fertilizer which was more costly. According to focus group discussion, some of livestock especially oxen were used for ploughing and weeding fields; others like donkey, horse and mule were used for transporting goods and people. And female animals provided the household with supplies of milk while animals' dung was a source of fertilizer and fire wood.

Table 3 showed that credit had a negative influence on technical efficiency and it was significant at 10 percent level. This result is similar to Essa *et al*. (2011) who found that credit contributed negatively to technical efficiency. The reason of this finding was that most of farmers did not get credit on time to purchase required inputs for production and some farmers used credit for other purpose rather than agricultural activities like food purchase, children education expenditure. Additionally, farmers that were more closer to the extension officers and main markets had more access to attend agricultural meetings, field day, demonstration plots, road and input access. Negative sign of parameter for this variable is similar to the priori expectations of the study. Thus, distance to the extension centers and markets were found to be negatively related and significantly affecting technical efficiency of small scale maize producers in the study area.

Table 3 Tobit regression estimates of factors influencing technical efficiency

Variable	Coefficient	Robust Standard error	t-value
Constant	1.350***	0.045	30.02
Sex	-0.016***	0.004	-3.39
Age	-0.007***	0.001	-10.54
Education	0.000	0.001	0.80
Training	0.045***	0.008	5.82
Membership to cooperatives	0.017**	0.007	2.33
Credit	-0.008*	0.005	-1.73
Distance to extension office	-0.014***	0.003	-4.95
Distance to market	-0.020***	0.004	-4.77
Family size	-0.021***	0.003	-6.27
Farmsize	0.000	0.002	0.13
Livestock	0.002*	0.001	1.66
Offfarm income	0.000**	0.000	2.08
Log pseudolikelihood= 478.64		F(12, 192) = Prob> F =	593.81 0.0000

***, ** and * indicate level of significance at 1, 5 and 10 percent, respectively
Source: Model output (2013).

CONCLUSION AND RECOMMENDATIONS

According to the findings, maize output was positively influenced by labor and oxen usage. A contribution of labor and oxen was positive indicating policies that motivate and mobilize the farm labor and oxen power in agricultural activities would be likely to lead to higher maize output. Urea and DAP fertilizers also appeared to be the major underlying determinants of maize output. Similarly the usage of improved maize seeds was found to be vital for increasing farmers' maize output. However, farmers' use of these inputs has been challenged by shortage of supply and high prices. Therefore, government 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. Farm size also was the important input of maize production. 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 technical efficiency level of farmers.

In this study training was major underlying determinant of technical efficiency. It was found to have positive and significant effect on technical efficiency. Providing continuous training for smallholders and follow up smallholders' farming activities about inputs usage during maize production is therefore important. As a result, extension service centers should give trainings for the farmers so as to increase their efficiencies in maize production. This will substantially help smallholder maize producers to survive and achieve food security. This requires more efforts of government and NGOs to increase farmers' trainings and education on better usage of inputs. If such knowledge is disseminated, farmers will improve their technical efficiency which result in increased maize output and higher food security

Membership to farmers' cooperatives was found to affect technical 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 cooperatives should have clear and agriculture oriented missions. Moreover, there must be active participation of farmers through giving leadership especially for those marginalized people including women that help member farmers to increase their resource use efficiency. However, distance to extension service centers and market was found to have a negative influence on technical efficiency of smallholder maize producers. Thus, 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.

The study has shown that farmers having access to credit was more technically efficient than those with no access to credit services. This means that there should be access to credit services for smallholder farmers at reasonable market interest rate, on time and in the needed amount to help farmers to acquire inputs. Furthermore, utilization of credit should be provided with continued complementary agricultural support services, including training. Additionally, improvements in farm efficiency rely on institutional capacity building for farmers. As a result, policy makers should focus on providing institutional support to farmers rather than focusing on introducing new technologies in which if the necessary technical and managerial skills are not in place, it may result in continued inefficiencies in maize production.

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