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Economic Efficiency of Smallholder Farmers in Maize Production in West Harerghe Zone, Oromia National Regional State, Ethiopia

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Abstract: The aim of the study was to measure the levels of technical, allocative and economic efficiencies and identify factors affecting efficiency levels of maize production in west Hararghe zone. The study was based on cross-sectional data collected from 160 randomly selected respondents. Stochastic frontier production model was used to estimate technical, allocative and economic efficiency levels, whereas Tobit model was used to identify factors affecting efficiency levels. Accordingly, the mean technical, allocative and economic efficiencies of sample households were 77%, 64% and 51%, respectively. The results indicated that there was substantial amount of efficiency variation in maize production in the study area. Land, seed and NPS were the variables that positively affected the production of maize. Results of the Tobit model revealed that education, number of livestock owned and social participation significantly affected technical efficiency. On the other hand, household size, proximity to maize farm, number of maize plot, landholding size, credit and social participation significantly affected allocative efficiency. The result of the study also showed that, proximity, landholding size, livestock and credit affected economic efficiency significantly. Results also indicate that there is a room to increase the efficiency in maize production of the study area. Therefore, government authorities, policy makers and other concerned bodies should take into consideration the above mentioned socioeconomic and institutional factors to improve the productivity of maize in the study area.

Keywords: Maize Production, Efficiency, Stochastic Frontier, Tobit

1. Introduction

Ethiopian agriculture is characterized by low productivity due to technical and socio-economic factors. Mostly the farmers with the same resources are producing different per hectare output, because of management inefficiency inputs, limited use of modern agricultural technologies; obsolete farming techniques, poor complementary services such as extension, credit, marketing, and infrastructure, poor and biased agricultural policies in developing countries like as Ethiopia [9].

Agriculture in Ethiopia can help in bringing down poverty. Nevertheless, vulnerability of returning to poverty remains high, particularly for rural livelihoods dependent on rained agriculture. However, in spite of its poor performance the Ethiopian agriculture shoulders the major responsibility in the supply of cereals which makes analyzing cereal production systems in Ethiopia of paramount importance. In addition, in Ethiopian context, where agriculture derives the highest share of gross domestic product any concern for poverty alleviation would place substantial weight on the generation of rural income, which is mainly generated from its agricultural operations [8, 9, 28].

Ethiopia, one of the world's centers of genetic diversity in crop germplasm and produces more of maize than any other crop. Among the crops grown in Ethiopia, maize (Zea mays L.) is the most important cereal crop in terms of production, area coverage and better availability and utilization of new production technologies. Nationally, the area under maize cultivation in 2019/20 was 2.52 million hectares from which 100.68 million quintals of maize were produced. From the country's total grain production, maize shares more than 27%). It is the highly demanded food crop in different parts of Ethiopia. However, the levels of productivity of the crop have remained to be low. Production inefficiency of smallholder farmers representing major supply of agricultural production in Ethiopia has been one of the key factors limiting agricultural productivity. High productivity and efficiency in maize production is critical to improve food security, reduce the level of poverty and achieve or maintain agricultural growth [4, 7, 8, 16, 18].

In order to improve maize production and productivity, an efficient use of production inputs has to be adopted by small holder farmers. An understanding of the relationships between efficiency, policy indicators and farm specific practices would provide policy makers with information to design programs that can contribute to increasing food production potential among smallholder farmers [22].

Maize is major food crop in West Hararghe zone. It ranks first among cereal crops produced in area coverage. However, the average yield of the crop was 23.5 quintal per hectare in west Hararghe zone; which is very lower than the national average yield (i.e., 39.44 qt/ha) of maize. The main reasons for the low productivity of maize include extensive use of unimproved maize seeds, depletion of soil fertility, erratic rainfall, prevalence of pests and diseases, little improvement in agronomic technologies, limited use of yield-enhancing purchased inputs such as fertilizers and agrochemicals. In addition, previous survey works shown that there is a yield gap in production among maize producer farmers in the study area. In the study area, similar survey studies and information on the levels of economic efficiency of small-holder farm households in maize production is lacking [15].

Therefore, this study attempted to determine and assess the economic efficiency levels of maize producer farmers and identify its determinant factors in West Hararghe zone.

2. Objectives of the Study

The specific objectives of the study were as follows:

1) To determine the technical, allocative and economic efficiency levels of smallholder farmers in maize production.
2) To identify factors that determine efficiency of smallholder farmers in the study area.

3. Methodology

3.1. Description of the Study Area

The study was conducted in Habro, Tullo and Boke districts of West Harerghe Zone which have potential in production of maize.

3.1.1. Habro District

Habro district is one of the fifteen districts of West Hararghe administrative zone of the Oromia National Regional State. It is located 404 km to East of Addis Ababa, which is capital city of Ethiopia and 75 km to South of Chiro. The district is boarded by Guba Koricha district in West, Boke district in East, Daro Lebu in South and Oda Bultum in North. Gelemso town is the administrative seat of the district. The population of the district is estimated to be 244,444 of which women account for 118,268 (48.4%) and men account for 126,176 (51.6%) of the population. The altitude of the district ranges from 1600 to 2400 masl. The annual average rainfall the district is 1010 mm & the mean temperature ranges between 16 and 32°C. There are two cropping seasons in the area, Belg (short rainy season) from March to June and Meher (main rainy season) 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 of cereal crops like barley, teff, wheat and vegetable crops. Meher rains are also the major source of moisture for the growth and development of perennial crops such as mango, coffee and chat. Haricot bean is grown in both of the cropping seasons [14].

3.1.2. Tullo District

Tullo is located at 370km southeast of Addis Ababa and about 40 km South of Chiro, which is capital town of the Zone. Hirna town is the administrative seat of the district. Tullo district has a total population of 178,245 out of which 90,746 and 87,499 are male and female, respectively. The district is found at an average altitude of 1750 meters above sea level with mean annual rainfall of 1850ml and mean annual temperature of 23°C. Agro-ecologically, the district has three sub-climatic zone highland, midland and lowland. The production system is mixed type in which extensive husbandry management of livestock have been practiced [25].

3.1.3. Boke District

Boke district is found at a distance of 70 km to the South West direction of Chiro town. It bordered by district of Oda Bultum in North East, Daro Lebu in South West, Habro in North and Burka Dimtu in South having an area of 123,188.06 hectares. Boke Tiko town is its administrative seat. The district has a total population of 134,687 of whom 66,671 were males and 68,016 were females among 23,914 are households whereas 18,134 are males and 5,780 are females' households. The topography of the district is mainly midland (80%) while the rest is lowland (20%) zones. The district receive annual rain fall minimum of 600mm and maximum of 800mm per year having bimodal rainfall in Summer during mid of June to mid of September and in Belg February up to April. Its altitude stretches between 1100 and 1980 m.a.s.l. The major economic activity of the district was depends on agricultural activity among production of Maize, Sorghum and Teff for food; Coffee and Khat for cash crops [6].

3.2. Sampling Technique and Sample Size

Multistage sampling technique was applied for this study. Firstly, three (3) districts were selected purposively based on their potential in maize production. Secondly, depending on their potential in maize production three (3) kebeles were randomly selected from each district. Accordingly, a total of nine (9) kebeles were selected among/out of the three districts.

Namely, ReketaFura, Buraksa and Kirakufiskebeles from Tulo; Chebi, Mildhab and Kiltu-ilala kebeles from Boke; Abdi Gudina, Lagabera and Haro-chercher kebeles from Habro district were selected. Finally, a total of 160 maize producer farmers were randomly selected based on probability proportional to size. For the drawn sample respondents, the simplified formula provided was employed to determine the required sample size at 95% confidence level with degree of variability = 0.5 and level of precision (e) = 7.5% [29].

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

Where *n* is the sample size, N is the population size (total household size), and e-is the level of precision.

Table 1. *Total number of sample households.*

Districts	Number of sample households
Tullo	45
Habro	75
Boke	40
Total	160

3.3. Data Source and METHOD of Data Collection

Both primary and secondary data sources were employed. Secondary data source was collected from published and unpublished documents of district Agricultural Office to support the primary data. The primary data was collected from the selected sample representative households through direct interview. Both qualitative and quantitative primary data were collected by using structured questionnaire administered through personal interviews with the selected respondents. Prior to the administration of the questionnaire, enumerators were informed about the objectives of the study.

3.4. Method of Data Analysis

The collected data were analyzed with STATA 13.1 software. In this study, descriptive statistics such as mean, standard deviation, frequency distribution and percentage were used for the analysis.

Stochastic Frontier Production (SFP) and tobit model were also used to estimate level of efficiencies and identify factors that determine efficiency of maize producer farmers, respectively.

Econometric Model

For this study stochastic frontier production model was used to estimate efficiency levels. Following the [1] and [18] method of estimating a stochastic frontier production function, with a Cobb-Douglas type production function specification can be represented as:

$$\ln Y_i = \beta_0 + \beta_1\ln(land) + \beta_2\ln(oxen) + \beta_3\ln(labor) + \beta_4\ln(seed) + \beta_5\ln(NPS) + \beta_6\ln(UREA) + \beta_7\ln(chemicals) + v_i - u_i \quad (2)$$

Where, Y_i -measures the quantity of output of the i^{th} farmer, X_{ij} -refers to the farm inputs of the i^{th} farmer, β is a vector of parameters, V_i is the symmetric error term, accounts for factors outside the control of the farmer U_i is the technical inefficiency, accounting for random variations in output due to inefficiency.

Tobit model was also used to identify factors that affect efficiency of smallholder farmers in maize production in the study area. As the distribution of the estimated efficiencies is censored from above at the value 1, Tobit model [26] is specified as:

$$E = E^* = \beta0 + \beta1X1 + \beta2X2 + \beta3X3 + \ldots + \beta14X14 + v \quad (3)$$

$$E = 1 \text{ if } E^* \geq 1, \text{ and } E = E^* \text{ if } E^* < 1$$

Where: E is the efficiency measures representing technical, allocative and economic efficiency, E* is the latent variable, β's are unknown parameters to be estimated, v is a disturbance term and X is explanatory variables used in the model.

Table 2. *Summary of variables and hypotheses.*

Variables	Measurement	Expected sign
Dependent variables		
Technical Efficiency (TE)	Continuous	
Allocative Efficiency (AE)	Continuous	
Economic Efficiency (EE)	Continuous	
Explanatory variables		
Experience (years)	Continuous	+
Sex (1=male, 0=female)	Dummy	±
Household size (number)	Continuous	±
Education level (years)	Continuous	+
Landholding size (ha)	Continuous	+
Access to training (1=yes, 0=no)	Dummy	+
Off/non-farm occupation (1=yes, 0=No)	Dummy	+
Livestock holding (TLU)	Continuous	+
Proximity of maize farm (km)	Continuous	+
Extension contact (1=yes, 0=No)	Dummy	+
Access to credit (1=yes, 0=No)	Dummy	+
Number of maize plot (number)	Continuous	-
Irrigation use (1=yes, 0=No)	Dummy	+
Social participation (1=yes, 0=No)	Dummy	-

4. Results and Discussion

4.1. Descriptive Analysis Results

4.1.1. Age, land Holding Size, Household Size and Experience of the Respondents

The mean age of sample households was 39.84 years with standard deviation of 11.46, while the average family size was 6.49. The maximum age for the sample farmers was 73 years while the minimum was 20 years. On average, the sampled respondents have 16.32 years of experience in maize cultivation with a range of 2 to 50 years. The result of the study also shows that, average land holding size of households in the study area was 0.80 hectares with standard deviation of ± 0.608. The result of one way ANOVA test (which is depicted in table 3) has indicated that there was significant mean difference (F-value =14.711, p-value = .000) in total landholding size among the three districts, whereas there is no significant mean difference (F-value = 1.206, p-value = 0.302) in experience of maize producers across the three districts.

Table 3. *Age, land holding size, household size and experience of the respondents.*

Variable	Min	Max	Mean	St. dev	F-value
Age (year)	20	73	39.84	11.468	
Experience in maize production (year)	2	50	16.32	10.440	1.206
Land holding size (ha)	0.125	4	0.80	0.607	14.711***
Household size (number)	1	13	6.49	2.384	

4.1.2. Sex and Educational Status of the Respondent

The result of the study shows that, out of the total sample households about 143 (89.4%) were male while 17 (10.6%) were female. From the sample households, 42 (26.3%) of the respondents were illiterate, 13 (8.1%) of them can read and write whereas 105 (65.6%) respondents attended formal education in the study area. Education is expected to sharpen managerial capacity and lead to a better assessment of the importance and complexities of good decisions in farming.

Table 4. *Sex and Educational status of the respondent.*

Variables	Category	Frequency	Percentage
Sex	Male	143	89.4
	Female	17	10.6
Total		160	100
Education	Illiterate	42	26.3
	Read and write	13	8.1
	Formal education	105	65.6
Total		160	100

4.1.3. Estimation of the Cobb-Douglas Production Function

Technical, allocative and economic efficiency levels of smallholder farmers in maize production were estimated using stochastic frontier production function (SFP). Input variables such land (hectares), oxen labor (number), human labor (man-equivalent), amount of seed (kilogram), inorganic fertilizers (NPS and UREA in kilogram) and chemicals (liters) were used in the model for estimating technical efficiency, while price of each inputs in birr were used for estimating allocative efficiency.

From the total of seven variables considered in the production function; land, seed and NPS had positive and significant effect in explaining the variation in maize output among farmers and are significant variables in shifting the frontier output to the right or moving along the frontier. This indicated that a unit increase of these variables; increase the level of maize production. As a result, 1% increase in size of land, seed and NPS will increase maize production by 0.569%, 0.212% and 0.447%, respectively in the study area. This result is in line with the finding of the study of Analysis of Maize Production Efficiency in Maize Production in Ethiopia in the Low Land of Gudeya Bila district [27].

Table 5. *Estimation of the Cobb-Douglas frontier production function.*

Variable	Coefficient	Standard error
Constant	1.624	0.713
Land	0.569 ***	0.126
Oxen	0.047	0.088
Labor	0.048	0.115
Seed	0.212 *	0.121
NPS	0.447***	0.135
UREA	0.028	0.110
Chemicals	0.078	0.114
Sigma square (σ^2)	1.016***	0.181
Gamma (γ)	0.848***	
Log likelihood	62.021	

4.1.4. Technical, Allocate and Economic Efficiency Scores

The result of mean efficiency scores indicated that farmers in the study area were relatively good in TE than in AE or EE. Generally, there is a considerable amount of efficiency variation among maize producer farmers.

Table 6. *Summary statistics of efficiency scores.*

Type of efficiency	Minimum	Maximum	Mean	Std. dev.
EE	0.23	0.72	0.51	0.106
TE	0.40	0.98	0.77	0.195
AE	0.26	0.99	0.64	0.196

The mean technical efficiency level of 77% indicated that maize producing farmers have a chance to efficiently utilize resources and hence they could increase the current maize output by 23% using the existing technology. The TE among farmers varies from 40% to 98%, with standard deviation of 0.195. This shows that there is a wide disparity among maize producer farmers in their level of technical efficiency. This result is in line with the finding of the study of Economic Efficiency of Sorghum Production for Smallholder Farmers in Eastern Ethiopia [12].

The mean allocative efficiency of farmers in the study area was 64% indicating that on average, maize producer farmers can save 36% of their current cost of inputs if resources are efficiently utilized. In other words, maize producer farmers increased their cost of production by 36% because of allocative inefficiency. This implies that there is a great opportunity to increase the efficiency of maize producers by reallocation of resources in cost minimizing way. This result is in line with the finding of the study of Economic Efficiency of Smallholder Farmers in Maize Production in Bako Tibe District, Ethiopia [16].

As designated in the above table, mean economic efficiency level of sample households was 51% with minimum and maximum efficiency scores of 23% and 72%, respectively. This result shows that on average, an economically efficient farmer can reduce his/her cost by 49% in maize production.

4.2. Determinants of Efficiency in Maize Production

The estimates of the Tobit regression model showed that among the fourteen 14 variables used in the model; education, livestock and social participation were found to be statistically significant in affecting the level of technical efficiency of farmers. The result also revealed that, household size, proximity, number of maize plot, landholding size, credit and social participation were found to be significantly influence allocative efficiency of maize producer farmers. The result also indicated that, proximity, landholding size, livestock and credit were important factors influencing economic efficiency of smallholder farmers in the study area. This result is in line with the finding of the study of Economic Efficiency of Groundnut Production in Gursum District [19].

Table 7. *Determinants of Efficiency in Maize Production.*

Variables	TE		AE		EE	
	ME	P-value	ME	P-value	ME	P-value
Sex	-0.0002	0.951	-0.0005	0.852	0.0004	0.755
Education	0.0066*	0.095	-0.0057	0.406	0.0003	0.938
Experience	0.0039	0.250	-0.0045	0.154	-0.0013	0.421
Household size	-0.0084	0.440	0.0255***	0.010	0.0064	0.209
Proximity	0.0174	0.339	-0.0324**	0.050	-0.0136*	0.100
Off/non-farm	0.0391	0.305	0.0246	0.480	0.0243	0.173
Maizeplot	-0.0129	0.621	-0.0385*	0.100	0.0193	0.114
Land size	0.0055	0.871	0.0727**	0.022	0.0645***	0.000
Irrigation	-0.0592	0.274	0.0530	0.284	0.0162	0.520
Livestock	0.0280***	0.000	-0.0094	0.161	0.0070**	0.044
Extension	0.0400	0.367	-0.0247	0.541	-0.0086	0.675
Credit	0.0462	0.596	0.2252***	0.006	0.1153***	0.006
Training	0.0044	0.916	0.0097	0.800	0.0132	0.500
Socialparticipation	-0.1327**	0.020	0.0009	0.580	0.0006	0.980
Constant	0.7876***	0.000	0.7309***	0.000	0.4756***	0.000

*, ** and *** imply 10%, 5% and 1% significance levels, respectively.
Source: Model output

(1) *Education*: Education of the household head has a positive and significant effect on technical efficiency of maize production at 10% level of significance, suggesting that better educated household head can understand agricultural instructions easily, have higher tendency to adopt improved agricultural technologies, have better access to information, good use of production inputs, improve the efficient use of inputs and able to apply technical skills than uneducated ones. Marginal effect of education can be interpreted as a one year increase in educational level of the household head increases their technical efficiency on average by 0.66%. This result is in conformity with the findings of [13, 21, 27].

(2) *Household size*: The coefficient of family size has a positive and significant effect on allocative efficiency at 1% probability levels. The 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. This might be because farmers with large family size had better capacity for optimal allocation of resources. This suggests that larger households may utilize family labor and reduce cost incurred in hiring labor. This result was consistent with the findings of [5, 23].

(3) *Proximity of maize farm*: The coefficient of the distance of maize farm from the home of household head was negatively and significant effect on both allocative and economic efficiencies at 5% and 10% probability level. This might be due to, the sample household that near maize farm were delivery input timely, reduction of transport cost of inputs and easily disposal of output compared to his counter-parts. Thus, leads to maximum output at least cost. The marginal effect of proximity to homestead indicates a unit change in distance of maize farm from farmer's home by one kilometer would decrease his allocative and

economic efficiencies on average by 2% on each. The result was consistence with the findings made by [2].

(4) *Number of maize plot*: The result of the study also shows number of maize plot is one among the explanatory variables which affected allocative efficiency negatively and it is significant at 10% level. The increasing number of plots leads to increased inefficiency or decreased efficiency by creating shortage of family labour, wastage of time and other resources that should have been available at the same time. Additionally, having large number of plots may lead to wastage of time resource and cost inefficiency than having less number of plots. The result agreed with the previous research works [10].

(5) *Land size*: The result also shows that farm size have a significant and positive impact on AE and EE, at 5% and 1% level of significance, respectively. This positive relationship was also observed in several other studies [3]. This could probably be because of farmers with larger area of cultivated land have the capacity to use compatible technologies that could increase the efficiency of the farmer. On the other hand, the smaller-sized farms are populated heavily by young and inexperienced people and therefore, they are expected to have lower average efficiency levels than large and more experienced farmers. Moreover, farmers who have large farm size would have an opportunity to use and allocate the maximum available resources efficiently because they do not have land size limitation. Additionally, farmers with large farm size may also have an easier access to new improved agricultural technologies introduced in to the area. Generally, large farm size owners are more efficient as compared to small land size owners.

(6) *Livestock (TLU)*: The amount of livestock owned, which is a proxy for estimating wealth status of a farmer, has a positive and significant effect on both technical and economic efficiencies at 1% and 5% levels of significance. Farmers who owned more number of livestock were more efficient than those who owned a few number of livestock in the production of maize. This might be due to that livestock provides traction, manure and is a source of cash that can be used to purchase consumption goods and production inputs. Others also argue that when all types of animals, poultry and beehive production are considered, its supplementary effect could diminish and it is likely to become competitive. This result was consistent with the finding of [20, 24].

(7) *Credit*: The coefficient of access to credit had a positive and significant effect on both allocative and economic efficiencies at 1% significance level. It is an important element in agricultural production systems. Credit availability shifts the cash constraint outwards and enables farmers to make timely purchases of those inputs that they cannot provide from their own sources. In other words, credit utilized permits a household to enhance efficiency by removing money constraints which may affect their ability to apply inputs, implements and farm management decisions on time. The finding is consistent by [11, 13].

(8) *Social participation*: The study also indicated that social participation had a significant and negative impact on technical efficiency at 5% probability level.

5. Conclusion and Recommendation

The study concluded as that it was aimed at estimating the technical, allocative and economic efficiency levels and identifying factors affecting efficiency levels of maize production in west Hararghe zone. The study was based on cross-sectional data collected from 160 randomly selected respondents using semi-structured interview schedule. Out of the total sample households about 143 were male while the rest 17 were female maize producer farmers. The descriptive statistics result showed that mean age of sample households was 39.84 years, while the average family size was 6.49. The result also showed that on average, the sampled respondents have 16.32 years of experience in maize cultivation. The result of the study also shows that, average land holding size of households in the study area was 0.80 hectares.

The stochastic production frontier model output showed that among input variables land, NPS and seed were significant variables that significantly affect the production of maize. This indicates that increased use of these inputs will increase the production level to a greater extent. Technical efficiency scores range from 40% to 98% while allocative and economic efficiency scores range from 26% to 99% and from 23% to 72%, respectively. This shows that there is efficiency variation among sample farmers in the study area. Average technical efficiency stands at 77% while the average allocative and economic efficiency stands at 64% and 51%, respectively.

Tobit model results showed that education, livestock and social participation are significant determinants of technical efficiency. Furthermore, the results revealed that household size, proximity, number of maize plot, landholding size, credit and social participation significantly influence allocative efficiency of smallholder farmers in the study area. The result also showed that proximity, landholding size, livestock and credit are important factors that significantly affect economic efficiency of the smallholder farmers in the area. Such farm, socioeconomic and farmer characteristics should be encouraged to enhance efficiency among smallholder maize producing farmers.

The study recommended that:

1) The concerned body should have to give more attention to provide educational service for all to attain educated farmers in order to increase efficiency and agricultural productivity.
2) The above significant variables related to farm, socioeconomic and farmer characteristics should have to be encouraged to enhance efficiency among

smallholder maize producing farmers in the study areas.

3) Policies and strategies designed and implemented to increase the efficiency of smallholder farmers in maize production in the study area should focus on the above mentioned factors.

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