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Research paper

Technical Efficiency of Maize Production in MeskanWoreda of Gurage Zone

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The study empirically examined the current levels of technical efficiency of maize farmers in the study area using cross sectional data collected from 150 households by employing multistage sampling technique. Cobb-Douglass stochastic production frontier model was used to predict farm level efficiency using Maximum Likelihood Method for technical efficiency estimation. Furthermore, the effects of some socio-economic variables on efficiency were estimated and compared based on the results obtained from the analysis. Besides this, Descriptive statistics were used in analysing the socio economic variables of the study. The study revealed that inefficiency in the maize production system exists. The mean technical efficiency of the pooled sample is 49%. The result shows that Seed used, and Extension contact were positively related to technical efficiency and significant at less than 1% level of significance. Education and good soil was positively related to technical efficiency and significant at 5%. Gender and family size was positively related to technical efficiency and significant at 10%. Results of the stochastic frontier production function showed that variance parameters gamma (γ) and sigma (δ2) are both significant at 1% level. The study showed that technical efficiency in farm production among the farmers could be increased by through better use of available resources. Therefore, it is recommended that government should do the intensive on-farm training since farmers mainly depend on trial and error method of production and farmers` should have access to enough arable land, if possible and the advantage of using full packaged recommendations. Hence, farmers need to be trained on matters relating to fertilizer application, on the amount of seed rate that farmers should apply per ha and the importance of using hybrid seed.

Key words: Technical Efficiency, cobb-douglass, production function.

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INTRODUCTION

Ethiopia's economy in respect of total production is dominated by agriculture. Hence, with 85% of the population living in the rural areas and depending on agriculture for livelihood. The economic importance of the agricultural sector for sustainable development and poverty reduction in Ethiopia is beyond doubt. The role of the agricultural sector and its impact on the different aspects of socio-economic life is signified by its contribution to GDP (46%), source of livelihood for the overwhelming majority of the population (80%), food supply, and export trade and foreign exchange earnings (84%). Ethiopian agriculture is dominated by smallholder farms that produce the bulk (over 90 percent) of outputs for consumption and the market (Zenebe et al., 2005).

Moreover, agriculture has a considerable potential for boosting the country's socio-economic development endeavours given its varied endowments (Dessalegn et al., 2010). Agriculture has a considerable potential for boosting the country's socio-economic development endeavours given its varied endowments (Dessalegn et al., 2010). Due to the fact that aiming the potential merits of the agricultural sector, the Ethiopian government made substantial efforts in agricultural development as a priority area of intervention by devising various policies and strategies to this end. A better performed agricultural sector has provided growth to the overall economy, improved the food security and reduced poverty in the recent years (Xinshen et al., 2010).

As far as agricultural production concerned in Ethiopia, cereal crops becomes in front line in its production as well as getting emphasis by the government and other important stakeholders of the sector. Among the cereal crops, Maize is one of the most valuable staple crops in Ethiopia, especially in Southern Nations Nationalities and people's Regional state that we have considered as a study area is found in this region.

Maize (Zea mays L.) originated from Latin America and its cultivation is considered to have begun by 3000 BC. It was introduced to West and East Africa in the 16th century (JAICAF 2008). Maize covers a wider area in its production and it is found the most productive crop in Ethiopia. In 2007/08 Cultivated crop area (13 million hectares) accounts for a relatively small share of the total area of Ethiopia as most land is not suited for cultivation. From the average area and production levels of the main crops cultivated for the period 2004/05-2007/08, Cereals dominate Ethiopian crop production. Cereals were grown on 73.4 percent of the total area cultivated, by a total of 11.2 million farmers. Together, these holders produce a yearly average of 12 million ton of cereals, which is 68 percent of total agricultural production. The five major cereals are teff, wheat, maize, sorghum and barley. Teff accounts for 28 percent of total cereal area, while maize stands for 27 percent of total annual cereal production. Smallholder cereal production in the Meher season dominates cereal production in Ethiopia and accounted for 93 percent of national cereal production in 2007/08. While 8.9 percent of total cereal area was cultivated during Belg season, only 4.5 percent of national cereal production was produced in the Belg season, a reflection of the significantly lower yields in the Belg season. The most important contribution of the Belg season to total production is found for the maize crop: 22.0 percent of total maize area was cultivated in the Belg season and this resulted in 9.5 percent of total maize production (Alemayehu 2011).

In accordance with Shahidur and Solomon (2010), while maize already plays a critical role in smallholder livelihood and food security in Ethiopia, this role can be expanded. Maize is the staple cereal crop with the highest current and potential yield from available inputs, at 2.2 tons per hectare in 2008/09 with a potential for 4.7 tons per hectare according to on-farm field trials, when cultivated with fertilizer, hybrid seed, and farm management practices. It is estimated that, by bridging this yield gap and tapping into latent demand sinks, smallholders could increase their income.

Maize, wheat and Teff are the major top crops in the study area and efforts have been made by the respective bodies by giving advice on better agronomic practices and input use to raise maize output. These technologies are all incentives known for increased production efficiency. However, according to the Agricultural development Office of the study area, the average maize productivity of smallholder farmers is 3.5 metric tons per hectare against the potential. According to Alemayehu et al., (2011), there has been substantial growth in cereals, in terms of area cultivated, yields and production since 2000, but a yield are low by international standards and overall production is highly susceptible to weather shocks, particularly draught. This shows that smallholder farmers are technically inefficient since they are producing below potential output using the existing technologies.

The role of efficient use of resources in fostering agricultural growth has long been recognized and has motivated considerable research in to the extent and sources of efficiency differentials in smallholder farmers (Susan, 2011).

Increasing population pressure and low levels of agricultural productivity have been critical problems of Sub-Saharan Africa and that of Ethiopia in particular. These have aggravated the food insecurity situation by widening the gap between demand for and supply of food. Increasing productivity and efficiency in maize production could be taken as an important step towards attaining food security as maize widely grown in Ethiopia. Production inefficiency of smallholder farmers is representing major factors limiting agricultural productivity (Endrias et al., 2011).

For smallholder farmers, variations in productivity due to differences in efficiency may be affected by various regional and farm specific socio-economic factors. In order to identify these factors, there is need to find a way of measuring the performance of the farmers (Bernadette, 2011).

Hence, in order to realize increased production and efficiency, small-scale farmers in developing countries need to efficiently utilize the limited resources accessed for improved food security and farm income generation (Amos, 2007).

Owing to this reality, in order to boost productivity, the GOs and NGOs provided material and technical services to farmers in Meskan Woreda. Though farmers applied the production techniques given by development practitioners and realized a slight increase in production, it is not clear evidence that asserts whether they were relatively more efficient technically.

Accordingly, there is knowledge gap in technical efficiency of maize farmers in Meskan Woreda. Thus, this study was carried out in order to establish technical efficiency and factors affecting technical efficiency of maize farmers in this Woreda. Results from this study were used to enhance the services delivered for maize farmers in Meskan Woreda to boost production and productivity.

OBJECTIVES OF THE STUDY

- To describe the socio-economic characteristics of maize farmers in the study area.
- To determine the level of technical efficiency in maize growing farmers.
- To identify the factors that affecting the technical efficiency of Farmers in maize production.

METHODOLOGY

Description of the Study Area

Meskan is one of the Woredas that found in the Gurage zone of Southern Regional state of Ethiopia. It is located between 38.26-38.57' N and 7.99'-8.27' E. The Woreda encompasses one city administration (Butajira), 40 kebele administrations and 34,219 households. The average household size of the woreda is about 5 persons. Ithas an altitude range of 1700 m to 3500 m above sea level. It comprises a total area of 50177 ha of land; of which, 23234 ha is cultivated land, 10093 ha is forest land area, 1801 ha is fallow land, 3346 ha is waste land and 11703 ha covered by others. The Woreda bordered by Sodo Woreda in the Northern side, by Southern part withSilte zone, by Eestern area with Marejo and Sodo Woredas and by West with Muher Ajilil, Essza, Kokiregdabeno and Gutazer Woredas. On average, the Woreda receives about 1150 mm of rainfall annually. The woreda gets 24 ^{0}c maximum and 10.3^{0}c annual temperature. In the Woreda, 47% of the soil is sandy clay loam, 15 % clay and 38% clay loam.

Sampling Procedure and Sample Size

Meskanworeda was purposively selected for this study. A multi-stage sampling technique was employed in this study. First based on maize crop area (ha) coverage Kebele administration (KAs) were randomly selected. From these potential kebeles, four KAs were randomly selected. Based on the number of households contained in each four sampled KAs, sample size of each KA allocated proportionally. Then from each and among these a total of 150 households were randomly selected from the sampling frame and get interviewed.

Methods and Type of Data Collection

In order to analyse the level of technical efficiency and factors affecting the technical efficiency of maize producers in Gurage zone of Meskanworeda, primary as well as secondary sources of data have been used. Primary data was collected from farmers using a survey method involving a structured questionnaire. The socio-economic information and farm specific maize Production data was collected. Market information was also collected which including prices of seeds, seasonal quantities produced, incomes earned from maize farm sales. Moreover, data about constraints faced by maize farmers and suggestions to increase their outputs was collected. As far as secondary sources of data are concerned, the data from Agriculture department of Gurge zone, reports, journals and other published literatures have been used.

Analytical Methods

Estimation of Technical Efficiency (T.E)

In this study, Cobb-Douglas stochastic frontier production function was assumed to be appropriate model for the analysis of the technical efficiency of the maize farmers. This study assumed that maize production is dependent on human labour, fertilizers applied, amount of seed planted and the size of land allocated for maize production.

Therefore, technical efficiency was estimated following physical production relationships derived from the Cobb – Douglas production function of Equation Thus, the specific model estimated as defined by Seyoum et al., (1998) is given by:

$$(1).\ \ln Y_i = b_o + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + E_j$$

Where:-

In represents natural logarithm, the subscript i represents i-th sample farmer,

Y = Amount of maize produced per farm household (kg)
X₁= Land allocated to maize production (ha) by a given household
X₂ = Human labour used by a given household in maize production (person days).

X_3= Amount of fertilizers (DAP and Urea) applied in maize by a household
X_4= Amount of seed planted (kg) by a given household

(2) $E_j = V_j - U_j$is the composed error tem and $V_{j\ is}$ two sided error term $_{while}U_j$is the one sided error term.

Accordingly, individual farmer technical efficiency was predicted from estimated stochastic production frontiers. The measure of production efficiency relative to the production frontier was the ratio of the observed output to the corresponding maximum output given the available technology and it is defined as:

$$(3)\quad \mathrm{TE} = \frac{Yi}{Yi*} = exp\ (U_i)$$

Where: - Y_i is the observed output represents the actual output and Yi^* is the minimum output and represents the frontier output. TEtakes the value with in interval (0,1) and 1 indicates fully efficient farmer.

Estimation of Factors Affecting Technical Efficiency

Determining factors that affect the level of technical inefficiency attained by establishing the relationship between farm/farmer characteristics and the computed technical efficiency indices. It was done in one step maximum likelihood estimation approach with a stochastic frontier production function. In which the inefficiency effects would be expressed as an explicit function of a vector of socio-economic variables. For the reason that one step approach has an advantage of being less open to criticism at the statistical level that would have been occurred if two step approach is being under taken. Moreover, this approach enables us to test hypothesis on structure of production function and output of final efficiency score without additional programming simultaneously.

The inefficiency model U_i was defined as:

(6). $U_i = \delta + \delta1Z_1 + \delta1Z_2 + \delta1Z_3 + \delta1Z_4 + \delta1Z_5 + \delta1Z_6 + \delta1Z_7 + \delta1Z_8 + \delta1Z_9 + \delta1Z_{10} + \delta1Z_{11} + \delta1Z_{12} + \delta1Z_{13} + \delta1Z_{14}$

Where:-

Z was a vector of explanatory variables that include:
Z_1= Hired labour; a dummy variable having the value of 1, if a farmer hires labor and 0 otherwise.
Z_2= Variety of maize planted; A dummy variable having the value of 1 if the farmer has used improved maize seed (purchased hybrid) and 0 otherwise
Z_3= Age of household head (in years)
Z_4= Sex of house hold head; dummy variable having a value of 1 for female and 0 otherwise
Z_5= Family size; total number of household members.
Z_6= Level of education of farmer (years spend in school)
Z_7= Farming experience; years of active farming
Z_8= Extension visits; A dummy variable having the value of 1 if the farmer had extension visit and 0 otherwise.
Z_9= Credit received; A dummy variable having the value of 1 if the farmer has access to credit and 0 otherwise
Z_{10}= Proximity to market; the distance of plot from the nearest market in kilo meter (km)
Z_{11}= Soil fertility; A categorical variable having the value of 1, 2 and 3 if the soil fertility is reported to be poor, medium and fertile respectively.
Z_{13} = access to off-farm income; A dummy variable having the value of 1 if the household head had access of off-farm income and 0 otherwise.
Z_{14} = Method of production; A dummy variable having the value of 1 if the farmer produces Inter-cropped maize with other crops and 0 otherwise.
δi = is a (Mx1) vector of unknown parameter to be estimated

Hypothesis test

A series of tests can be conducted to test the specification of the models. These are tested through imposing restrictions on the model and using the generalized likelihood ratio statistic (*l*) to determine the significance of the restriction. The generalized likelihood ratio statistic (also known as the LR test) is given by:-

$$\lambda = -2[\ln\{L(H_0)\} - \ln\{L(H_1)\}]$$

Where ln{$L(H_o)$} and ln{$L(H_1)$} are the values of the log-likelihood function under the null (H_o) and alternative (H_1) hypotheses. The restrictions form the basis of the null hypothesis, with the unrestricted model being the alternative hypothesis. The value of *l* has a c^2 distribution with the degrees of freedom given by the number of restrictions imposed

RESULTS AND DISCUSSION

The technical efficiency and factors that affect the level efficiency of small holder farmers of the study area was estimated using the Frontier 4.1 version and the descriptive statistics have been analysed via SPSS version 20. The results of the software employed for the analysis of the hypothesized research is depicted hereafter accordingly.

Socio-economic Characteristics of the Farmers

The descriptive statistics of maize farmers' characteristics is shown in Table 1 below. Such characteristics include, sex, age, marital status, and household size, level of formal education in years spent in school, farm experience in years, size of farm land used for maize production, spouse age and education level and other variables indicated in table 1 are statistically highly significant among the maize farmers that contributes a lot for the presence of inefficiency in the study area.

Table 1. Descriptive statistics of Variables

	N	Min	Max	Mean	Std. Dev	t	Sig.
Age	150	20.00	80.00	44.3200	12.79436	42.425	.000
Family size	150	2.00	14.00	6.4067	2.20158	35.641	.000
Education	150	0.00	9.00	2.7667	2.78398	12.171	.000
Maize farming experience	150	3.00	57.00	23.4800	10.47703	27.448	.000
Extension contact	150	0.00	6.00	1.9867	1.56723	15.525	.000
Proximity for market	150	0.00	15.00	2.9467	2.31362	15.599	.000
Total land holding	150	0.13	4.00	0.7071	.46868	18.477	.000
Maize yield	150	600.0	7400.0	2955.467	1687.175	21.454	.000
Land holding for maize	150	0.13	2.00	0.4314	.25402	20.800	.000
Labour used	150	28.75	336.00	107.1668	49.97740	26.262	.000
Maize Seed rate	150	9.60	50.00	23.5562	7.21917	39.964	.000
Fertilizer used	150	1.00	400.00	114.6877	77.38451	18.151	.000
Manure used	150	1.00	2600.0	77.7933	279.0871	3.414	.001

Source: own data, 2013

Table 2. Cross tabulation Farm size and Source of labour

Farm size	**source of labour**			
	Family labour	**Hired labour**	**Both**	**Total**
< 0.5ha	69	2	5	76
0.5 - 1ha	59	5	7	71
> 1ha	1	0	2	3
Total	129	7	14	150

Chi-Square: 14.117, Asymp. Sig. (2-sided): 0.007

About 46% of the family labour was used to cultivate the maize land below 0.5 hectare and 39% of family labour was used to cultivate the maize land ranges between 0.5 and 1 hectare. However, in the study area, the use of hired labour and a combination of both family and hired labour was very minimal. There is a strong relationship between the farm size and source of labour used for maize production (Chi-Square sig. 0. 007).

Table 3. Cross tabulation Gender and Access of off -farm income

Gender	Access of off -farm income		Total
	N0	yes	
Male	96	29	125
Female	15	10	25
Total	111	39	150

Chi-Square: 3.056, Asymp. Sig. (2-sided): 0 .08

Based figures from table 3, only 19.33% of the male farmers have got access of off-farm income While 6.67% of the female farmers were engaged in off-farm activities. According to the chi-square test, there is a relationship between the gender and access of off -farm income (Chi-Square sig. 0.080)

Table 4. Cross tabulation Gender and Access of fertilizer

Gender	Access of fertilizer		
	N0	yes	Total
Male	7	118	125
Female	4	21	25
Total	11	139	150

Chi-Square: 3.316, Asymp. Sig. (2-sided): .069

According to table 4, about 78.67% of the male farmers have got access of fertilizer. However, only 14% of the female farmers were having accesses of fertilizer during the course of maize production in the study area. According to the chi-square test, there is a relationship between the gender and access of fertilizer (Chi-Square sig. 0.069).

Cobb-Douglas Production Function Model Results

Table 14 presents the ordinary least square estimates of the log linear Cobb-Douglass production function. Estimated Ols results obtained from the study revealed that except labour all of the coefficients of factors of production involved in maize production of Meskanworeda maize farmers were statistically significant at 1% level of significance.

Table 5. Table OLS Estimates of Maize Production using Cobb-Douglas frontier production Function.

Variables		coefficient	standard-error	t-ratio
Constant	β_0	4.8270608	0.43924387	10.989478***
Ln (land)	β_1	0.93108050	0.072761353	12.796360***
Ln (labour)	β_2	0.027485036	0.085394842	0.32185827
Ln (fertilizer)	β_3	0.35399096	0.024058561	14.713721***
Ln (seed)	β_4	0.40492806	0.097005218	4.1742915***

*, **, *** Significant at 10%, 5% and 1% respectively.

The preceding Paragraphs below interpreted the Cobb-Douglas estimate of the frontier model results. The results indicated that out of four variables/inputs used in the Cobb-Douglas production function, 2 of the variables were found to be significant at 1% and one variable (with being negative) at 10% level of significance. In this result, one variable was not found significant. In general, this result implies that there is an input output relationship in this production function.

Table 2. Maximum likelihood Estimates for Parameters of Stochastic Frontier Production Function and Inefficiency Model for Maize Farmers of Meskan Woreda.

Variables	Parameters	Coefficients	Standard - error	t-ratio
General model				
Constant	β_0	8.3026384	0.19889467	41.743895***
Ln (land)	β_1	0.94057450	0.029059416	32.367288***
Ln (labour)	β_2	-0.049128455	0.031089988	-1.5802018*
Ln (fertilizer)	β_3	0.10971704	0.013381466	8.1991794***
Ln (seed)	β_4	0.012967924	0.038877885	0.33355529
Inefficiency model				
Constant	δ_0	1.6254126	0.096866017	16.780008***
Hired labour	δ_1	0.0078283400	0.041087011	0.19053078
Seed used	δ_2	-0.10487318	0.043902047	-2.388799***
Age	δ_3	0.00079138079	0.0014383695	0.55019296
Sex	δ_4	-0.051491856	0.035030403	-1.4699190*
Family size	δ_5	-0.0086901152	0.0063811105	-1.3618500*
Education	δ_6	-0.013122195	0.0062501810	-2.0994904**
Maize Farming experience	δ_7	0.00050637684	0.0017795586	0.28455193
Extension contact	δ_8	-0.33012893	0.023035253	-14.33146***
Access of Credit	δ_9	-0.0007851855	0.046303150	-0.016957498
Proximity to market	δ_{10}	-0.0007754507	0.0054147636	-0.14321045
Poor soil	δ_{11}	0.037834907	0.032349769	1.1695572
Good soil	δ_{12}	-0.073519781	0.039645381	-1.8544350**
Off-farm income	δ_{13}	0.030149811	0.030676541	0.98282954
Method of production	δ_{14}	-0.0066689229	0.026893565	-0.24797467
Variance Parameters				
sigma-squared	δ^2	0.017926029	0.0021108364	8.492382***
gamma	γ	0.75634199	0.12707734	5.51824***
log likelihood function		101.90386		
LR test		324.00342		

*, **, *** Significant at 10%, 5% and 1% respectively.

From the Cobb-Douglas stochastic frontier production function output presented in the above table, the estimate of the variance ratio (γ) is significant. The value is 0.7563.This implies that about 75.63% of the variation in maize output is attributable to technical efficiency differences among production units. The high value of γ suggests that there are differences in technical efficiency among the production units considered in this study.

By implication about 24.37 % of the variation in output among producers is due to random factors such as unfavorable weather, effect of pest and diseases, errors in data collection and aggregation and the like. The γ parameter is very important because it shows the relative magnitude of the inefficiency variance associated with the frontier model which assumes that there is no room for inefficiency in the model. The sigma squared (δ2) on the other hand is -0.0186 and is statistically highly significant at 1% level. Since the figure statistically different from zero, it indicates a good fit and correctness of the distributional form assumed for the composite error term.

Elasticity of Production

The Cobb-Douglas production function was estimated using maximum likelihood estimates (MLE) and the coefficients estimated represented individual elasticity. The elasticity associated with all inputs were greater than one which was involved under maize production used by Meskan Woreda maize farmers. While, elasticity of each individual variables was less than one. Thus, for inputs with elasticity less than one, a unit increase in the respective input would result in less than a unit increase in maize output. Among the input variables, the elasticity for the land (0.94) was highest. This means that, maize land was the most essential input in maize production. The second most important elasticity was 0.11 for fertilizer in maize production. The third most important elasticity (0.0119) was related to seed.

Estimation of Technical Efficiency

The results of the technical efficiency level of each production unit indicates a great difference in efficiency levels among production units The table below shows the distribution of the efficiency estimates of maize producers in the study area using Jondrow et al (1982) conditional expectation predictor.

Table 3. Frequency distribution of Technical Efficiency estimates

Category of Technical Efficiency (%)	Frequency	Relative efficiency	Percentage	Cumulative %
0 - 19	14		9.34	9.33
20 - 29	27		18	27.34
30 - 39	17		11.33	38.67
40 – 49	29		19.33	58
50 – 59	19		12.67	70.67
60 – 69	12		8	78.67
70 – 79	6		4	82.67
80 – 89	12		8	90.67
90 - 100	14		9.33	100
Total	**150**		**100**	
Mean		**49.11**		
Min		**18.00**		
Max		**99.00**		

Source: Own data, survey 2013

Technical efficiency was obtained using the estimated parameters from the log linear Cobb Douglas stochastic production frontier. The study showed that technical efficiency ranges between 18% - 99%. The lowest level of efficiency is 18 % which is far below the efficient frontier by 99%. Hence, such lowest production units, the lowest level, are technically inefficient. The highest level of efficiency is 99% which is only 1 % away from the frontier. Such production units can be classified as being technically efficient since in reality production units hardly operate at 100% level of efficiency. The mean technical efficiency of the pooled sample is 49.11%. This compares favorably with other efficiency studies conducted in other areas of agriculture. For instance, previous studies in rice had 65% (Kalirajan and Shand, 1986); 75% (Kumbhakar, 1994); 50% (Kalirajan and Flinn, 1983); 59% (Bravo-ureta and Evenson, 1993) and 66% (Pierani and Rizzi, 2002).

The 49.11% mean technical efficiency implies that on the average, 50.89% more output would have been produced with the same level of inputs if producers were to produce on the most efficient frontier following best practices. A greater proportion of the production units (19.33%) are concentrated in the efficiency class of 40 – 49%. The next highest concentration of producers in the efficiency class 20 – 29 % which contains 18 % of the pooled sampled households and the least concentration of producers in the efficiency class of 70 – 79% which contains 4% pooled sampled maize producers of Meskan Woreda.

The wide variation in technical efficiency estimates is an indication that most of the farmers are still using their resources inefficiently in the production process and there still exists opportunities for improving on their current level of technical efficiency. This result suggests that the farmers were not utilizing their production resources efficiently in dictating that they were not obtaining maximum output from their given quantum of inputs. In other words, technical efficiency among the respondents could be increased by 50.89 % through better use of available production resources given the current state of technology. This would enable the farmers obtaining maximum output from their given quantum of inputs and hence increase their farm income thereby reducing poverty.

Factors Affecting the Level of Technical Efficiency

In the analysis of technical inefficiency effects model, the sign of coefficients of the model is taken in to account based on the analysis of (Coelli, 1996). If the coefficient of the parameter in the model is positive, it means that the variable is increasing the level of technical inefficiency of the farmers. Whereas, if the sign of the coefficient of the parameter is negative, it shows that the variable under consideration is decreasing the level of technical inefficiency or increasing the level of technical efficiency of farmers who engaged in maize production of the study area.

Table 15 shows variables that explain technical inefficiency of maize producers in the Meskan Woreda of Gurage zone. The results indicated that out of fourteen variables that were included in the model, six of them are found being significant which are: Sex of household head, level of education, family size, farmer`s farming experience, purchased hybrid maize seeds and Number of extension contact. This showed that these are the most major factors influencing technical efficiency of small-scale maize producers of Meskan Woreda. Next, the variables which were found to be in the model are explained accordingly.

Seed

As expected that variety or type of maize seeds planted by the farmers had a positive and significant effect on the technical efficiency of farmers at 1 % level. It means that if a farmer buys certified seeds instead of using the recycled seeds, a farmer may tend to maximize output with increased efficiency. In line with this, purchased hybrid maize seeds can still influence efficiency positively, since the use of improved seed in crop production is one way of increasing productivity in terms of quantity and quality (Kiplan`at, 2003).

Sex

Even though, it was not, Sex of household head was found to be negatively influence technical inefficiency and statistically significant at 10% level of significance. It opens good opportunity for female headed farmers to carry out frequent follow up and supervision of their farm. Accordingly, it is hypothesized that female headed household head is more technically efficient than male.

Family size

Household size was found to be positively and significantly affecting technical efficiency of maize farmers at 10% level. This means that, as household members increase, there will be a more equitable labour distribution among farming activities especially during peak periods. Improved farm labour distribution will lead to higher concentration on the given task and thus improving production efficiency. Therefore, it eases the labour constraint faced by most smallholder farms. In most African rural settings, increased household size means increasing labour force. Results of this study match with Amos (2007) findings where family size was also found to have a positive and significant effect on technical efficiency among cocoa producing households in Nigeria. A study carried out by Jema (2006) also indicated a positive and significant effect of family size among small-scale vegetable farming households in Ethiopia.

Education

Education levels of farmers were significant at 5% and positively affect the level of technical efficiency of farmers operating in Meskan Woreda of Gurge zone. This implies that it has a positive relationship with technical efficiency. Education of the farmer is expected to have an effect on farm resources use and the ability to adopt new technology and hence have a positive impact on technical efficiency (Ogolla and Mugabe, 1996). Such results support findings of this study since education is believed to have a positive relationship with adoption of new technologies and advisory services resulting into improved efficiency (Amos, 2007).

Extension contact

Another important factor considered in this analysis was access to extension services. The results of the analysis in Table 15 revealed that there was a positive relationship between extension contact and technical efficiency of farmers and it is significant at 1%. This could be due to the fact that development agents tried to reaching the farmer and that the training packages that may fit with the agro-ecological settings of the study area.

Hypothesis Testing

Is there significant technical inefficiency?
H_0: γ=0 versus**H_1: γ>0** the LR statistic = 319.94, and Kodde and Palm critical value at 5% = 2.71 => reject H_0 .The LR statistic has mixed Chi-square distribution.

The models also can be compared the distributional assumptions using the LR test. The half-normal is a restricted form of the truncated normal with the restriction that*m* (*mu*) = *0*. The value of the generalized likelihood ratio statistic in this case is = -2(13.01- 13.24) = 0.4. Since the value is less than the critical c^2 value, we cannot reject the hypothesis that *Ho: m = 0* and accept the model which assumes the half-normal distribution.

There are no socio-economic characteristics influencing the technical efficiency of small-scale maize producers in Meskan Woreda. The hypothesis is rejected as the empirical results shown a positive influence of socio-economic factors in technical efficiency.

CONCLUSIONS AND COMMENDATONS

Cobb-Douglas production function results indicated that some of the variables were found to be positively significant, while others were negative but significant, and some were positive but non-significant. Even though some variables were not significant, it still shows that the variables used in the analysis have a positive effect on the output (the total quantity of maize produced) which simply means that there is a good inputs-output relationship, and the small-scale maize producers in Meskan Woreda are experiencing a increasing returns to scale for production function.

Results from the stochastic frontier analysis showed that 75.63% of the variation in maize production output is attributable to technical efficiency differences among producers. About 24.24% of technical efficiency of the variation in output among producers is due to random shocks such as unfavorable weather, water scarcity, pest and disease attacks and other factors outside the control of producers including errors in data collection and aggregation. The mean technical efficiency of the pooled sample is 49%. Therefore, there is a 51 percent scope for increasing maize production by using the present technology for technical efficiency to avoid resource wastage by improving their efficiency.

The main socio-economic factors which were assumed to have an influence on the technical efficiency of small-scale maize producers in Meskan Woreda included in one stage ML estimation. The findings from the MLS indicated that there are socioeconomic factors influencing the technical efficiency of small-scale maize producers.

In general the study concludes that farmers are technically inefficient since they are under and over-utilizing resources at farm level and that farmers` technical efficiency can be determined through the influence of certain socio-economic factors.

Given the empirical findings of the study, some recommendations are suggested to be addressed both at government as well as at firm levels. To avoid technical inefficiency amongst small-scale maize producers, the study recommends the need to adopt modern agricultural technology usage that should be governed by a complex set of factors such as human capital improvement and institutional support. The study also recommends that the government should design capacity building programme for agricultural development project for the maize farming community by training and giving them skills on how to allocate resources efficiently such as fertilizer and seed during the production periods. Farmers also need to have access to enough arable land. Since land was the first important input in the study area, which has a positive relationship and having a major stake in boosting maize yield among the inputs used in maize production. Education has also a positive impact in terms of farmers' efficiency. Therefore government should intensify its efforts to expand education to the rural sector. The fact that households where there is increasing education level made them more efficient further justifies the need for expanding education.

More effort should also be intensified on the part of extension agent in educating the farmers so as to boost their efficiencies in maize production. These extension gents should have to get on job trainings based on the gap analysis made to build their capacity. They are being used to inform the farmers in the rural areas about the improvement of farm practices. Hence, there should have strong participatory planning, monitoring and evaluation of development activities being implemented in the study area.

The farmers should be encouraged to keep records and get intensive practical trainings on how to plan and monitor their farm activities by using profitable and recommended quantities of agricultural practices on their farms, in order to achieve optimum yield. This will help the farmers to make better farm strategies in the future so as to increase output as well as profit.

The useful policy recommendations made by agricultural researchers should be implemented by the government. This should be done by filling the gaps between the respective stakeholders of agricultural development and thereby creating strong linkage and coordination between them that enable to complement each other. This will go a long way in contributing the achievement of self sufficiency in the study area.

Finally, it may be interesting to look at technical efficiency using panel data collected from maize producing farmers to see and evaluate how technical efficiency has changed over time.

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