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Economies of Scale and Cost Efficiency of Maize Production in Meskan Woreda of Gurage Zone.

Muluken Philipos*

Ethiopian Institute of Agricultural Research, Agricultural Economics Research Directory.
P. O. Box 2003, Addis Ababa. *Corresponding Author's E-mail: mulphinat@yahoo.com; telephone: +251911977934

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The study examined empirically the current levels of efficiency of some selected maize Farmers in the Meskan Woreda using cross section data from 150 by employing multistage sampling technique. Cobb-Douglass stochastic cost frontier model was used to predict farm level efficiency using Maximum Likelihood Method for the allocative efficiency. The study revealed that cost inefficiency in the maize production system exists. The allocative efficiency indices indicated that, the mean efficiency was 1.13 of the sampled households of this study. Accordingly, the study discovered that, Seed used, age, Education and method of production were positively related to allocative efficiency and significant at 1%, 5%, 1%, and 5% respectively. Hired labour, Extension contact and Proximity to market were negatively related to allocative efficiency and significant at 1%. There was no significant relationship between allocative efficiency and sex, family size, maize farming experience, Off-farm income, and credit access. Results of the stochastic frontier cost function showed that variance parameters gamma (γ) and sigma (δ^2) are both significant at 1% level. Therefore, it is recommended that government should do the intensive on-farm training since farmers mainly depend on trial and error, if possible and the advantage of using optimum utilization of inputs with respect to its cost incurred for the production of maize. Moreover, farmers need to focus on related to factors of Seed used, age, Education and method of production in order to get more opportunity that enables creating an opportunity for the improvement of allocative efficiency by the maize farmers.

Keywords: Economics of scale, stochastic frontier cost function, Cost efficiency.

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INTRODUCTION

Maize (Zea mays L.) originated from Latin America and its cultivation is considered to have begun by 3000 BC at the latest. It was introduced to West and East Africa in the 16th century (JAICAF, 2008). Maize is the largest and most productive crop in Ethiopia. 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 With an average yield of 1.74 tons per hectare (equal to 3.2 million tons grown over 1.8 million hectares) from 1995 to 2008. Maize has been the leading cereal crop in Ethiopia since the mid-1990s in terms of both crop yield and production. Wheat and sorghum yields have averaged 1.39 and 1.36 tons per hectare, respectively (Shahidur and Solomon, 2010).

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 can able to get 2.2 tons per hectare in 2008/09 with a potential for 4.7 tons per hectare according to on-farm field trials, which cultivated with the recommended 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 from approximately USD 60 per hectare today to USD 350 to USD 4501.

Despite the economic and food security importance of these crops, data and opinion suggest a yield gap: actual smallholder farm yields do not achieve estimated potential yields for wheat, sorghum, maize, lentils and peas. Furthermore, cereal prices in Ethiopia fall between import and export parity prices, limiting their international trading prospects. Although there are significant wheat imports, these reflect the influx of food aid and not competitive trade on the international market (Kate and Leigh, 2010).

Meskan is one of the woreda in Gurage zone of Southern Nations Nationalities and Peoples Regional State of Ethiopia. Maize, wheat and Teff are the major top crops of the area respectively and efforts have been made by the respective bodies by giving advice on better agronomic practices and input use to raise maize output in the Woreda. However, according to the Agricultural development Office of the Woreda, 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 the yield is low in terms of international standards and overall production is highly susceptible to weather shocks, particularly draught.

This showed that, evaluating the mean and plot specific efficiency of smallholder farmers and their determinants of farmer and farm characteristics will able to contribute a lot to the performance of maize profitability in Meskan Woreda.

The role of efficient use of resources in fostering agricultural production 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 an important step towards attaining food security. Production inefficiency of smallholder farmers representing major supply of agricultural production in Ethiopia has been one of the key factors limiting agricultural productivity especially that of cereal crops including maize (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 representing 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 maize Farmers were relatively cost efficient or not in the study area. Accordingly, as there was no studies conducted to determine the cost efficiency of maize farmers in Meskan Woreda. Thus, this study was carried out in order to establish cost efficiency and factors affecting the allocative efficiency of maize farmers in Meskan Woreda.

OBJECTIVES

The broad objective of the study is to analyse the allocative efficiency Maize Farmers in the study area. The specific objectives of the study are:

- To determine the level of allocative efficiency in maize growing farmers.
- To identify the factors affecting the allocative efficiency in maize production.

METHODOLOGY

Description of the Study Area

Meskan is one of the Woredas in Gurage zone of SNNPRS. Which is located in the Southern Region of Ethiopia between 38.26-38.57' N and 7.99'-8.27' E. The Woreda has 1 city administration (Butajira), 40 PAs and 34,219 households. The average household size is about 5 persons. The Woreda lies at an altitude range of 1700 m to 3500 m above sea level. It comprises a total area of 50177 ha, of which 23234 ha is cultivated land, 10093 ha forest land area, 1801 ha hallow land, 3346 ha waste land, and 11703 ha covered by others. 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

Meskan woreda was purposively selected for this study. A multi-stage sampling technique was employed in this study. For this study, a head of the Woreda average maize crop area (ha) coverage of maize growing Kebele Administrations (KAs) were randomly selected. From these potential four KAs was 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 was selected randomly from the sampling frame and get interviewed.

Data Collection and Type of Data

Primary data was collected from farmers using a survey method involving a structured questionnaire. Production information collected included size of farmland owned, size of land under maize production, type of labour used in production, varieties of seed planted, amount of seed planted and fertilizer application. Amount of credit, access to extension services were also among production information. Market information was also collected which included prices of inputs, seasonal quantities produced, incomes earned from maize farm sales. Data about constraints faced by maize farmers and suggestions to increase their outputs was collected.

Data Analysis

The data obtained from the field was subjected to analysis using the program FRONTIER (Version 4.1c). Analysis of cost efficiency and its determinants are described below.

Model Specification

In this study, Cobb-Douglas stochastic frontier cost function was assumed to be appropriate model for the analysis of the cost efficiency and the inefficiency of the maize farmers of the study area. In line with this, the specification of a stochastic frontier cost function with the inefficiency component expressed as an explicit function of a vector of socio-economic variables were estimated in one step maximum likelihood. Thus, the specific model estimated as follows according to Battese and Coeli (1995):

(4). $\ln C_i = b_o + b_1 \ln Y_i + b_2 \ln P_1 + b_3 \ln P_2 + b_4 \ln P_3 + b_5 \ln P_4 + V_i + U_i$

Where: In represents natural logarithm, the subscript i represents i-th sample farmer,C_i = Total cost of production per unit farm (birr), Y_i= Amount of maize produced per farm household (kg), P_1= Labour cost (birr), P_2= Fertilizer cost (birr), P_3= Seed cost(birr), P_4= transportation cost (birr), V_i = the systemic component which represents random disturbance cost due to factors outside the scope of the farmer, U_i = the one sided disturbance farm used to represent cost efficiency and in dependent of $V_{i,}$

Moreover, in this study, individual farmer cost efficiency was predicted from estimated stochastic cost frontiers. The measure of cost efficiency relative to the cost frontier is the ratio of the observed cost to the corresponding minimum cost given the available technology and it was defined as:

(5). $\mathrm{CEE} = \frac{C^b}{C^{min}} = \exp(\mathrm{Ui})$

Where: C^b is the observed cost represents the actual total production cost and C^{min} is the minimum cost and represents the frontier total production cost or least cost total production level. C_{EE} takes the value of 1 or higher with 1defining cost efficient farm.

The inefficiency model U_i was defined as:

(6). $U_i = \delta + \delta 1Z_1 + \delta 1Z_2 + \delta 1Z_3 + \delta 1Z_4 + \delta 1Z_5 + \delta 1Z_6 + \delta 1Z_7 + \delta 1Z_8 + \delta 1Z_9 + \delta 1Z_{10} + \delta 1Z_{11} + \delta 1Z_{12} + \delta 1Z_{13} + \delta 1Z_{14}$

Where Z was a vector of explanatory variables that include:

Z_1= Hired labour, Z_2= Seed Used , Z_3= Age of household head (in years) , Z_4= Sex of house hold head, Z_5= Family size, Z_6= Level of education of farmer (years spend in school), Z_7= Farming experience; years of active farming, Z_8= Extension Contact , Z_9= Access of Credit, Z_{10}= Proximity to market (km) Soil fertility, Z_{11}= Medium Soil Fertility, Z_{12} = Fertile Soil, Z_{13} = Access to off-farm income, Z_{14} = Method of production, δ i = 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:

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

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.

RESULT AND DISCUSSION

Cobb-Douglas cost function model results

The stochastic cost frontier estimations were done using maximum likelihood methods. The dependent variable of the estimated model was maize total cost in the main season of 2012 cropping season and the independent variables include; maize output, labour cost, fertilizer cost, seed cost and cost of transportation.

Maximum likelihood estimates of the stochastic cost frontier model as presented in table 1 from the Cobb-Douglas stochastic frontier cost function output, the variance ratio (γ) were highly significant at 1% level its value is 0.704. The total variance (δ^2) on the other hand is 0.007659 and is statistically highly significant at 1% level. Total variance estimates goodness of fit and the correctness the specified distributional assumption of the composite error term. The variance error of .704 implies that 70.40% of disturbance is due to inefficiency one sided error and therefore 29.60% is due to stochastic disturbance with two sided error, supported by high t-value. Hence, 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.

Cost Elasticity

The elasticity of maize output is negative and not significant in the cost function of maize. The result also indicated that 1 % increase the maize output will decrease the total production cost by 0.001%. The negative sign implies that an increase in the amount of this output leads to a decrease in the level of total cost of maize production. The elasticity of cost of labour, fertilizer, seeds and transportation were positive and significant at 1 % significance level. The implication is that labour, fertilizer, seeds and transportation cost contributes positively to the total cost of production of maize in Meskan Woreda. The result implies that a one percent increase in the cost of labour, fertilizer, seeds and transportation will lead to 0.65%, 0.15%, and 0.048 % and in 0.029% increase in the total cost of maize.

This result suggests that the farmers were not minimizing production costs dictating that, they were utilizing the inputs in the wrong proportion given the input prices. In other words, 13% of the resources are wasted or inefficiently allocated relative to the best practiced farmes producing the same output and facing the same technology. This implies that, cost efficiency among the respondents could be increased by 13% through better utilization of resources in optimal proportions given their respective prices and the current state of technology.

This would enable the farmers equate the Marginal Revenue Product (MRP) of inputs to the marginal cost of the input thereby improving farm income and consequently reduction of poverty. However, there are farmers producing a given level of output using cost minimizing input ratio, which reflects the farmers' tendency to minimize resource wastage associated with production process from cost perspective.

Estimation of Cost Efficiency

The cost efficiency was estimated for each sampled households and the summery of cost efficiency scores presented in the table 2. According to the result, the minimum, the maximum and the mean cost efficiency of the farmers was estimated 1.01, 1.64 and1.13respectively. The distribution of cost efficiency in table 2 shows that the cost efficiency concentrated in the 1.03 and 1.05 range, representing 32.67% of the sample farmers. The wide variation of allocative efficiency estimates is an indication that most of the farmers have not yet achieved optimal resource mix in their production process and there still exists opportunities for improving on their current level of allocative efficiency.

Determinants of Cost Efficiency

The determinants of the cost efficiency were modeled using socio economic factors that affects farm operations and also has policy implications. The main socio-economic factors which were assumed to have an influence on the cost efficiency of farmers and hence included in the model were the age of the farmer, availability of off-farm income, access to credit, access to extension services, educational level of farmer, sex, Soil fertility, Method of production, Hired labour, seed used, Family size, Proximity to marketing and years of experience in the production of maize. These variables were regressed on the inefficiency due to production scores.

In the analysis of cost inefficiency effects model, the sign of coefficients of the model is taken in to account

Table 1. MLE for Parameters of Stochastic Frontier Cost Function and Inefficiency Model for Maize Farmers of Meskan Woreda.

Variables	Parameters	Coefficients	Standard - error	t-ratio
General model				
Constant	β_0	1.932474	0.201667	9.582517***
Ln (output)	β_1	-0.00126	0.013355	-0.09438
Ln (cost of labor)	β_2	0.646113	0.01738	37.17468***
Ln (cost of fertilizer)	β_3	0.154516	0.015096	10.23558***
Ln (cost of seed)	β_4	0.047816	0.003951	12.10173***
Ln (cost of transportation)	β_5	0.029426	0.005374	5.475331***
Inefficiency model				
Constant	δ_0	0.260381	0.086449	3.01196***
Hired labour	δ_1	0.079794	0.033872	2.35576***
Seed used	δ_2	-0.24758	0.063585	-3.89361***
Age	δ_3	-0.004	0.001999	-1.99985**
Sex	δ_4	-0.04515	0.036635	-1.23248
Family size	δ_5	0.001957	0.007335	0.266808
Education	δ_6	-0.02575	0.006713	-3.83564***
Maize Farming experience	δ_7	0.001498	0.002468	0.607064
Extension contact	δ_8	0.102701	0.016755	6.129636***
Access of Credit	δ_9	-0.00425	0.048787	-0.08707
Proximity to market	δ_{10}	0.016096	0.005579	2.885019***
Medium soil	δ_{11}	-0.04063	0.030515	-1.33153
Fertile soil	δ_{12}	0.012143	0.055199	0.219991**
Off-farm income	δ_{13}	-0.00296	0.026314	-0.11248
Method of production	δ_{14}	-0.05748	0.026395	-2.17773**
Variance Parameters				
sigma-squared	δ^2	0.007659	0.001996	3.837956***
gamma	γ	0.703582	0.153552	4.582051***
log likelihood function		187.3304		

Source: Own data, Survey2013

based on the analysis of Coelli T.J, 1996. If the coefficient of the parameter in the model is positive, it means that the variable is increasing the level of cost inefficiency of the farmer and whereas, if the sign of the coefficient of the parameter is negative, it shows that the variable under consideration is decreasing the level of cost inefficiency or increasing the level of cost efficiency of maize farmers.

According to the result, the dummy variable representing the use of hired labour on maize plots to control for variations on cost efficiency due to its application was significant at 1% level and negatively related to the cost efficiency. A purchased hybrid maize seeds planted by the farmers had a positive and

Table 2. Distributionof respondents by cost efficiency estimates

Efficiency level	Frequency	Relative Efficiency	Percentage (%)
1.00 - 1.02	21		14.00
1.03 - 1.05	49		32.67
1.06 - 1.08	12		8.00
1.09 - 1.11	11		7.33
1.12 - 1.14	5		3.33
1.15 - 1.17	7		4.67
1.18 - 1.2	7		4.67
1.21 - 1.23	10		6.67
1.24 - 1.26	8		5.33
1.27 - 1.29	6		4.00
1.30 - 1.32	4		2.67
1.33 -1.39	5		3.33
1.40 - 1.64	5		3.33
Total	150		100.00
mean		1.13	
minimum		1.01	
maximum		1.64	

Source: Field survey, 2013

significant effect on the cost efficiency of farmers at 1% significance level. The dummy variable for age was also positive and it was significant at 5% level, Education levels of farmers was significant at 1% and positively affected the level of cost efficiency of farmers operating in Meskan Woreda of Gurge zone. Another important factor considered in this analysis was access to extension services. The dummy variable for age was also positive and it was significant at 5% level, Education levels of farmers was significant at 1% and positively affected the level of cost efficiency of farmers The results of the analysis also revealed that there was a negative relationship between extension contact and cost efficiency of farmers and it was significant at 1% level. Another factor affecting technical inefficiency of farmers producing maize in Meskan Woreda had proximity to the market places. It was measured by the distance between plot and the most nearest market centre in kilometres. According to this study, there was a negative relationship between proximity to market and cost efficiency. The other important variable affecting cost inefficiency of maize producers was soil fertility. The measure of soil fertility is based on farmers' personal opinions on the quality of the soil. Accordingly, fertility of soil significantly influences cost inefficiency of farmers. Farmers' operating on high quality of soil fertility is cost efficient than others who were producing maize on poor and good soil fertility type. The last explanatory variable for this study was method of maize production. It had a positive effect on cost efficiency of maize farmers in the study area and significant at 5% level. However, Sex of household head, Household size, the variable farmer`s farming experience, acess of Credit and the off-farm income variables were not found significant in this study even though the variables had their own implication in accordance with their signs positively and negatively.

The result of this study revealed that, plots on which hired labour was used to supplement family labour tend to produce maize less efficient than those that exclusively used family labour. Hence, those farmers used purchased improved hybrid seeds were also able to increase their cost efficiency. Suggesting that younger farmers were less efficient than the older ones with respect to the cost efficiency of maize farmers in the study area. The reason for this is probably that as a farmer gets older his level of cost efficiency increases due to increase in wealth of experience. This implies that it had a positive relationship with cost efficiency. Hence, the negative coefficient of education level is implying that more educated farmers allocated their resources better than their less educated counter parts. Extension contact had a positive coefficient, implying that increased in extension visits lead to reduction in cost efficiency level. Hence, nearness to the market will have decreased cost efficiency. Therefore, those farmers who were practiced method of production, intercropping maize crop with legume ones, found to be increasing their level of cost efficiency.

Hypothesis Testing

Is there significant cost inefficiency?

H_0: γ=0 versus H1: γ>0
the LR statistic = 74.83 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.

CONCLUSION

Empirical studies suggest that farmers in developing countries fail to exploit fully the potential of a technology making inefficient decisions. Hence, this study attempts to measure cost efficiency and identifying its determinants of maize producers in Meskan Woreda of Gurage zone.

The findings from the MLS indicated that there are socioeconomic factors influencing the cost efficiency of small-scale maize producers.

These are: level of education, household size, farmer`s farming experience, access of credit, extension contact, off-farm income, gender of household head, sex of household head, seed used, soil fertility, proximity to market, hired labour and method of production. Some of these factors were found to be significant and showing positive and/or negative relationship. However, some of the variables were not significant and showing a negative and/or positive relationship to small-scale maize producers` allocative efficiency.

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

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