Technical Efficiency of Malt Barley Production in Malga District of Southern Ethiopia

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Abstract
This study was conducted to assess the technical efficiency of malt barley production in Malga District of southern Ethiopia using cross-sectional data. Three stages sampling technique was applied to draw 186 sample farmers randomly. The interview schedule was pre-tested before conducting the actual data collection; data gathered from the sample households with the help of trained enumerators. In addition, secondary data were collected through review of relevant documents sources. Descriptive statistical analysis such as mean, standard deviation, minimum, maximum, frequency and percentage were used to analysis basic household characteristics. Cobb-Douglas stochastic frontier production function model was used to estimate technical efficiency and determinants of technical efficiency differentials in malt barley production. Maximum likelihood estimation results implied increasing input variables (area, seed, oxen, fertilizer and labour) would increase yield of malt barley production. The coefficients of elasticity of area, seed, oxen, fertilizer and labour were 0.88, 0.056, 0.033, 0.032 and 0.0125 respectively under malt barley. Consequently, malt barley exhibits increasing returns to scale as the sums of input elasticity were greater than one which is 1.018. The discrepancy ratio, γ, was about 0.67 indicating that about 67% of variation in malt barley yield among the sampled farmers was attributed to technical efficiency effects. The mean technical efficiency of sampled farmers in the production of malt barley was 0.82. The estimated stochastic production frontier model with the inefficiency variables implies that education, experience, extension and livestock positively and significantly affected technical efficiency of malt barley production. Hence, emphasis should be give to improve technical efficiency level of those less efficient farmers by adopting the practices of relatively efficient farmers in the area. Beside this, policies and strategies of the government should be directed towards addressing the implication of statistically significant policy variables.
Keywords: Technical efficiency, Cobb-Douglas stochastic frontier, Malt barley, Malga.
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1. Introduction

Ethiopia, the country with an area of about 1.12 million square kilometres and with an estimated population of about 102.37 million is the second populous nation in Africa (CSA, 2017). This growing population requires better economic performance than ever before at least to ensure food security and sustainable livelihood. However, the major contributing factor for the country's poverty and food insecurity is degradation of natural resources. Since there is a rapid population growth in the country, especially, in rural areas, the land size per household declines, as a result, people are forced to over use the land which leads to low productivity (World Bank, 2011).

Ethiopian economy is largely dominated by subsistence agriculture and it is smallholder- based (Bishaw, B, 2009). Ethiopia, the homeland of many cereal crops, is also assumed to be the origin for barley and due to this fact; there are many indigenous barley cultivars which are adaptive to ecological situations of the country. Though barley in Ethiopia is primarily a food grain, it is also used for brewing beers and sometimes as livestock feeds. Malting barley is malted for the preparation of lager, pilsner and other beers. Currently, the major Ethiopian users of malt are the domestic breweries. Their annual demand has not so far been met by the local malt supply, and consequently, the breweries have long been dependent on heavy importation (Sultan and Adamu, 2017).

Malga *District* is one of the *District* of Sidama zone, is known by cereal production specially barley. The total area of the *District* is 32651 hectares of which 55.67% hectares cultivated. Malt barley concerned in this study, occupies 24.3% of the total cultivable land of the *District* (MWAO, 2017). Therefore, this study was tries to assess technical efficiency of malt barley producing farmers in the study area. The findings could provide information that is relevant towards strengthening the recently started malt barley production enhancing efforts and achieving sustainable level to meet growing demand.

In malt barley market only 35% of the demands were satisfied from domestic sources, while the remaining quantity is imported from abroad. However, the gap between malt barley production and demand is high. In late 2015, brewing factories, such as the Assela malt factory had to scale down their production due to the chronic shortages of malt barley in the market (Sultan and Adamu, 2017). However, many problem that contributed for low productivity of malt barley in Ethiopia are shortage of improved varieties, lack of adequate inputs(fertilizers, pesticides etc) and lack of research outputs on production techniques (Tiruneh and Geta, 2016). This is a common finding that is prevailing among smallholder farmers, which may also hold true in the Malga *District.* Therefore, this study attempted to fill the existing knowledge gap by addressing issues related to technical efficiency of smallholder malt barley production in the study area by providing empirical evidence on resource use efficiency.

2. Methodology

Descriptions of the Study Area

The study was conducted in Malga *District*, Sidama Zone of Southern Ethiopia. Barley being, one of the major crops grown in the study area, it is mostly used as staple food and as a source of income. The annual rainfall ranges from 1200mm to 1600mm with annual temperature ranging from 4.1^{0}C to 22.4^{0}C. The average altitude of the area ranges between 1500 to 3000 m.a.s.l

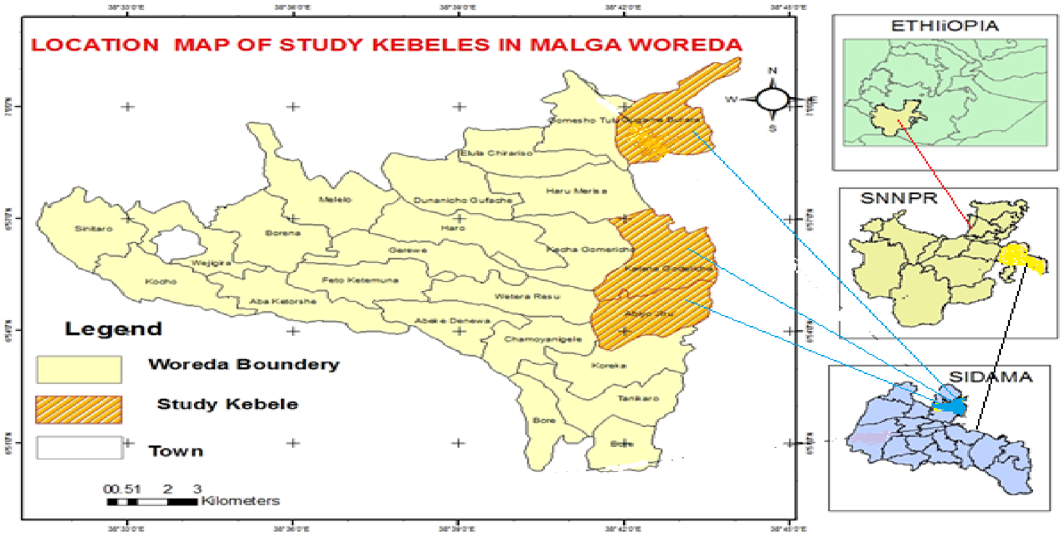

Figure 1. Location of Malga *District*

Types, Sources and *Methods of Data Collection*

In this study both primary and secondary data were used. The primary data were collected from randomly selected sample respondents using a structured questionnaire. Secondary data were collected through review of relevant documents sources Moreover; data were also collect from Agriculture offices of the study *District.*

Sampling Procedure and Sample Size

A three stage sampling procedure was employed for this study. In first stage, Malga were selected purposively. In second stage, kebele*s* were randomly selected. Finally simple random sampling method was employed to select sample farm household from selected kebeles. With this study, total 186 malt barely producing farmers was used for the study by using formula given by Yamane (1967).

Methods of Data Analysis

To achieve the study's objectives, both descriptive and econometric methods of data analysis were used. Descriptive statistics like frequency, counts means, standard deviations and percentages and Inferential Statistics like t-test. The stochastic frontier analysis (econometric) methods have generally been preferred in the empirical application of stochastic production function model in the developing countries' agriculture like Ethiopia. This may be because; SFP enables us to measure farming specific TE, the ability of the model to separate the random error and noise, such as weather and pesticide that are stochastic from deviations arising from technical inefficiency. The Cobb-Douglas stochastic frontier functional form of production function is widely used to represent the relationship of an output to inputs. The general Cobb-Douglas stochastic production frontier is estimated as:

$$\ln (Output)_i = \beta_0 + \beta_1 \ln (Area)_i + \beta_2 \ln (Oxen)_i + \beta_3 \ln (Seed)_i + \beta_4 \ln (Labor)_i + \beta_5 \ln (Frti)_i + V_i + U_i \quad (1)$$

Technical efficiency of each malt barley producer is estimated as:

$$TE_i = \frac{Y_i}{Y^*_i} \quad (2)$$

Where, TE_i = Technical efficiency of the ith farmer in malt barley production,
Y_i = Actual output of the ith farmers in malt barley production and
Y_i* = Frontier output of the ith farmer in malt barley production.

The specification of inefficiency model for individual malt barley producer is estimated as:

$$\mu_i = \delta_0 + \delta_1 Age + \delta_2 Educ + \delta_3 Fsize + \delta_4 Expr + \delta_5 Ext + \delta_6 Acredit + \delta_7 Frmsize + \delta_8 Livstock +$$

$\delta_9 Sex + \delta_{10}$ Off frmy $+\delta_{11} Frag$..(3)

The following null hypothesis for choice of frontier production function and inefficiency model was tested in this study:

1. H_0: $\Upsilon = \delta_0 = \delta_1 = \delta_2 = ... \delta_{11} = 0$, null hypothesis specifies that inefficiency is absent.
2. H_1: $\Upsilon \neq \delta_0 \neq \delta_1 \neq \delta_2 \neq ..... \delta_{11} \neq 0$, alternative hypothesis specifies that inefficiency is presence.

The approach which is used to test hypothesis associated with presence and absence technical inefficiency is specified as:

$$LR = -2ln[L(Ho) - L(H1)] \quad \text{..} (4)$$

Where, L (H_0) and L (H_1) Values of the likelihood function under the null (restricted) and alternative (unrestricted) hypothesis, H_0 and H_1 respectively.

3. Results and Discussion

Demographic factors of farm households

The average years of household head was 49.21 with standard deviation of 12.15. This implies that majority of sampled farmers found in the productive age group to achieve its works effectively and efficiency. The average numbers of family size in labour force unit was 4.36 persons per family with standard deviation of 1.76. This implies that the number of active labour force from interviewed household ranging from one to teen. To this effect, family size of sampled farmers in the study was converted into man equivalents to differentiate those who can perform agricultural activities.

Socioeconomic factors of farm households

The farmers on average involved in malt barley growing for 15.45 years with standard deviation of 8.85. It was believed as farmers experience increased, the knowledge of farmers towards using improved technologies will increase and that can enhance an increase in productivity of agricultural ventures they for livelihood making. The average year of schooling was 4.89 with standard deviation of 4.48. This implies that some of sampled farmers are not attending formal education while others attending in their education from grade one to grade twelve. This implies that the farmers are still not fully participated in formal education, which helps to prepare them to adopt new production technology and practices. The average total livestock holding in tropical livestock unit of sampled farmers was 13.40 with standard deviation of 6.94. This implies that livestock are important asset for rural households and serves multiple purposes. It contributes as draught power, sources of cash income, manure and consumption of household.

Institutional factors

The average frequency of the farmers got advices from development agents was 3.46 with standard deviation of 2.38. In this study, some sample farmers got advisory services up to sixteen-time extension workers while other sampled farmers have got no chance to be advised by extension workers. This implies that farmers addressed by extension agents to provide advices on how to manage agricultural production were less uniform among farmers. This leads to widen the efficiency variation among farmers in the study area. A sample farmer on average managed 5.49 plots with standard deviation of 0.86. Almost, all farmers allocate their land for *enset* and different cereal crops such as malt barley, food barley, maize and wheat.

Descriptive statistics for discrete variables

The study revealed that 87.10% of the sampled farmers were male headed household while the reaming 11.83% were female. This implies that malt barley production is dominated by male household head in the study area. These because male and female head household are involved in productive activities, their responsibilities and functions often differ across the agricultural calendar and seasonal activities. Off/non-farm income is very important for the production of agricultural crops. About 34% of the sampled farmers obtained off/non-farm income and the remaining 66.13% of farmers had no access to off/non-farm income in the study area. This implies that the farmers did not participate in off/non-farm income generating activities. The sources of this off/non-farm income in the study area include trading, selling local drink, selling fire wood, handicraft and tailor. Credit was provided in the form of input or in kind indicating that 87.10% of sampled farmers got fertilizer (NPS and Urea) and seed during production season and 12.90% purchased fertilizer and seed in cash. Fertilizer and seed in the form of credit was delivered by the government to farmers who need to get it in the form of credit.

Table 3. Descriptive statistics for continuous and discrete variables

Continuous Variables	Mean	Std. deviation	Minimum	Maximum
Output variable				
Output(Qt)	8.32	6.02	2.00	38.00
Input variables				
Area(ha)	0.85	0.54	0.20	3.50
Oxen (oxen-day)	3.38	8.40	0.00	62.50
Seed(kg)	82.50	52.02	15.00	350.00
Labor (man-day)	62.72	23.24	20.50	146.00
Fertilizer(kg)	110.54	73.93	20.00	450.00
Inefficiency variables				
Age (number of years)	49.22	12.15	26.00	83.00
Education (years of schooling)	4.89	4.48	0.00	12.00
Family size (man-equivalent)	4.36	1.76	1.30	9.70
Experience (number of years)	15.45	8.85	2.00	44.00
Farm size (ha)	6.17	2.95	1.00	16.00
Livestock (TLU)	13.40	6.94	2.27	44.32
Fragmentation (number of plots)	5.49	0.86	3.00	9.00
Extension (frequency)	3.47	2.38	0.00	16.00

Discrete variables		Frequency	Percent (%)
Sex of household head	Male	164	88.17
	Female	22	11.83
Off/non-farm income	Yes	63	33.87
	No	123	66.13
Credit access	Yes	162	87.10
	No	24	12.90

Results of Econometric Analysis

Hypothesis testing

One of the important features of stochastic frontier production function is to test hypothesis using traditional maximum likelihood methods which were not possible with deterministic model. It also considers noise in addition to inefficiency effects whereas all deviations from frontier model is due to inefficiency effects in OLS model. The result presented that the value of sigma square and gamma are 2.08 and 0.67 respectively and hence null hypothesis (Ho) is rejected indicating stochastic frontier production function is best fit to the data than OLS. To test this hypothesis likewise, LR or λ was calculated using the value of the log-likelihood function under the stochastic frontier model and the full frontier model. The calculated value of LR = λ= 49.91 is greater than the critical value of 24.72, thus the null hypothesis that variables in the inefficiency effects model are simultaneously equal to zero is rejected at 1% level of significance. Hence, these variables explain the difference in inefficiency among farmers.

Parameter estimates of the Stochastic Production Frontier (SPF) model

The SPF model was specified and estimated using the maximum likelihood method to analysis the efficiency of sampled farmers in the production of malt barley in study area. The model comprises of eighteen variables, five of them were the explanatory variables of the stochastic frontier function (production function) while eleven of which were the explanatory variables that are hypothesized to determine the technical efficiency scores and the remaining two being variables associated with the distribution of μ_i and v_i. The technical efficiency was estimated by using the Cobb-Douglas functional form.

Moreover, the value of gamma (0.67) was found significantly different from zero at 1% significance level. This figure reveals that 67% of the variation of observed malt barley output from frontier level is because of farmers' technical inefficiency factors. However, the remaining 33% is because of stochastic noises. In additional, sigma square (2.08) was found significant at 1% which assures the goodness of fit of the model used and the validity of the distribution assumption used for the composite error term. A one-stage estimation procedure was employed to analyze inputs and inefficiency variables simultaneously. One of the important features of single-stage estimation procedure is it guarantees that the distributional assumption of inefficiency error term is not violated. The result implies that area, ox, seed, labour and fertilizer were positive as expected and statistically significant. All input variables have positively related and statistically significant in contribution to level of malt barley produced. This implies that an increase of these inputs would increase output of malt barley. The sum of the estimated coefficients is 1.018, indicating increasing return to scale in malt barley production in the study area.

The elasticity of area has greater impact in determining production of malt barley. This implies that a 1% increase in area will lead to a 0.88% increment of malt barley output, holding all other factors constant. Consequently, malt barley farmers would need more land to possibly increase production. Coefficients of seed, oxen and fertilizer have relatively higher impacts in determining production level of farmers output as elasticity implies. Seed is an important input in increasing production and productivity level of malt barley. The result implies that a 1% increase in the use of seed will lead to a 0.056% increment of malt barley output, holding all other factors constant. This can be because of improved malt barley seed varieties used in study area. In rural area oxen are an important resource for draft power. The result indicated that a 1% increase in the usage of oxen would lead to a 0.033% increment of malt barley output, holding all other factors constant. The elasticity of fertilizer has relatively high impact in determining production of malt barley. It was found that a 1% increase use of fertilizer will lead to a 0.032% increment of malt barley output, holding all other factors constant. The elasticity of labour is very low as compared to elasticity of area, seed, oxen and fertilizer. The result implies that a 1% increase use of labour will lead to a 0.0125% increment of malt barley output, holding all other factor constant. In short, seed, oxen, fertilizer and labour were statistically significant at 1% level of significance while area was statistically significant at 5%.

Table 11 Maximum likelihood estimates of the frontier model for malt barley production

Variables	Coefficient	Standard error	Z-values	P-values
Constant	-1.19***	0.221	-5.39	0.000
lnLAND	0.88***	0.354	2.50	0.013
lnOX	0.03***	0.011	3.00	0.000
lnSEED	0.05***	0.005	11.17	0.010
lnLAB	0.01***	0.004	2.58	0.003
lnFER	0.03***	0.003	10.53	0.000
Sigma_v (α_v) = 0.8356246	Sigma u (α_u) = 1.17764		Sigma^2 ($\alpha_v^2 + \alpha_u^2$) = 2.085116	
Lambda ($\lambda = \alpha_u/\alpha_v$) = 1.409299	Number of observation= 186		Wald chi2 (5) = 5099.05	
Gamma ($\Upsilon = \lambda^2/(1+\lambda^2)$= 0.66511	Log likelihood function= -279.80347		Prob > chi2 =0.00	

Source: Own computation, 2018. * significant at levels of 0.1

Estimation of farmer specific technical efficiency

The result implies that the estimated mean technical efficiency of malt barley producing sampled farmers was about 0.82 ranging 0.0286 and 0.999 indicating that there is room to boost famer's level of technical efficiency through using input variables and currently available technology. This implies that the sampled farmers can increase the level of malt barley production on average by about 0.18% without incurring additional production inputs. Among the sample farmers, 33.87% of farmers were operating below mean of technical efficiency level, while 66.13% of sampled farmers operated above the mean level.

Determinants of technical inefficiency

Before making interpretation, understanding the sign of inefficiency parameters is very important. Negative sign of inefficiency parameters implies that the variables reduces technical inefficiency or positively affect technical efficiency, while positive sign implies increases technical inefficiency of malt barley producing sampled farmers. After noting this, it is necessary to go to discussion and interpretation of variables that affect technical inefficiency factors below. The results imply that age, education, farm experience, extension, credit, livestock, sex, off/non-farm income, were negatively related to technical inefficiency while family size, fragmentation and farm size, were positively related with technical inefficiency.

Education was hypothesized that the farmers with better education are technically more efficiency in malt barley production than those farmers with less or no education. As priori expectation, finding show that coefficient of education in years of schooling is negatively related in malt barley production technical inefficiency and statistically significance at 5% level. This implies that better educated farmer is technical more efficient than those which have lower education level. Farm experience was hypothesized that there is positive contributions of specific experiences acquired by farmers as they stay longer in the production of malt barley than less experienced ones. The finding show that coefficient of farm experience was negative and statistically significant with technical inefficiency at 10% probability level as priori expected. This implies that farmers having more years of experience are better placed to acquired knowledge and skills necessary for choosing appropriate new farm technologies over time.

The coefficient of extension contact was negative and statistically significant with technical inefficiency at 5% probability level as it was expected. This reflects the need for intensive services about best available practices and efficiency increasing technologies that would shift the productivity level of farmers from relatively lower to higher. Those farmers accessed with extension service better knowledge about the malt barley seed production and receive information about the market, which might lead to better technical efficiency. The coefficient of farm size in hectare was positively and statistically significant with technical inefficiency at 1% probability level as it was not expected. The reason for this was the farmers with more crop land difficult to manage and use their malt barley land effectively. This show that the way how to manage total land efficiently and effectively are important than simply owning without sound management practice. This show that the farmer can produce high amount of malt barley output even if the area allocated to produce is small.

The number of livestock in tropical livestock unit was hypothesized to determine technical inefficiency positively/negatively. The finding show that coefficient of livestock in tropical livestock unit is negative and statically significant with technical inefficiency at 5% probability level. This implies that livestock can support malt barley production in many ways: cash from livestock sale can improve malt barley production for input purchase, supply draft power for farming and produce manure that was used to maintain soil fertility. Fragmentation refers to the number of plots owned by the farmers and it was hypothesized to determine technical inefficiency positively. As priori expectation, the finding show that coefficient of fragmentation is positively and statically significant with technically inefficiency at 5% probability level as it was expected telling having more plots in the crops under consideration not improves the level of technical efficiency of farmers.

Table 13. Maximum likelihood estimated of the factors determining technical inefficiency

Variables	Coefficient	Standard error	Z-values	P-value
Constant	25.36**	11.53	2.20	0.028
Age	-0.10	0.06	-1.52	0.130
Educ	-0.19**	0.09	-2.10	0.036
Fsize	0.18	0.28	0.65	0.513
Expr	-0.14*	0.07	-1.89	0.058
Ext	-0.43**	0.19	-2.21	0.027
Acredit	-7.34	7.63	-0.96	0.336
Frmsize	0.93***	0.32	2.92	0.003
Livstock	-0.33**	0.14	-2.38	0.017
Sex	-3.34	3.37	-0.99	0.322
Off frmy	-1.50	1.28	-1.18	0.239
Frag	1.66**	0.69	2.40	0.016

Source: Own computation, 2018. *, * * and *** mean significant at levels of 0.1, 0.05, 0.01 respectively.

4. Conclusion

This study analyzed the technical efficiency of malt barley production in malga *District* of southern Ethiopia using farm household level data collected from 186 households in 2016/2017 production year. Cobb-Douglas stochastic frontier model was used to estimate the technical efficiency and determinants using one-stage stochastic frontier estimation procedure. SFP model incorporates 16 variables in additional to composite error term, of which 5 variables are input variables while remaining 11variables are variables associated with inefficiency effects. The estimated stochastic frontier Cobb-Douglas production function indicates that area, oxen, seed, labour and fertilizer were positively and significantly affecting of malt barley production. Area has highest elasticity which is highly affects production of malt barley, followed by seed, oxen, fertilizer and labour with the coefficients value of 0.88, 0.056, 0.033, 0.032 and 0.0125 respectively and the sum of each coefficient was 1.018, this implies that increasing returns to scale.

The mean of technical efficiency of farmer's production of malt barley was found to be 82%. This implies that there is potential to improve technical efficiency of farmers with the currently available technology and input use. The generalized likelihood-ratio test proved that variables in the inefficiency model simultaneously explained the existing technical efficiency differences among farmers. From inefficiency variables, education, experience, extension, livestock were positively and significantly affecting technical efficiency. However, age, farm size, family size, credit, sex and off/non-farm income was insignificant. The result indicates that, analysis based data from sampled farmers reveal that improved malt barley varieties supplied to farmers are the opportunity of malt barley production because improved malt barley seed is high yielder compared to local seed and it was resistant to disease and pest.

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