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Technical, Allocative and Economic Efficiencies and Sources of Inefficiencies among Large-scale Sesame Producers in Kafta Humera District, Western Zone of Tigray, Ethiopia: Non-parametric approach

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ABSTRACT

This study analyzed production efficiency and sources of inefficiency differentials of sesame in Kafta Humera district of Tigray region, Ethiopia. It was specifically aimed to address the research gaps by measuring technical, allocative and economic efficiencies and their sources of inefficiency differentials of sesame in Kafta Humera District. For addressing these objectives this study used primary and secondary data obtained from field survey and desk review. Multistage random sampling technique was used to draw 126 large-scale sesame producers. Applying the Cobb-Douglas functional form the average technical, allocative and economic efficiencies found were 71%, 90% and 64% for large-scale producers. Regarding these producers; education level, frequency of farm visit, experience in sesame production, type of road and credited amount obtained were significant sources of technical, allocative and economic inefficiencies. Distance of farm from residence, ownership of living home and livestock and cooperative membership were also significant sources of technical and economic inefficiencies. Depending on the results found, this study recommend strengthening the introduction of improved seed, mechanized labor substituting technologies and fertility enhancing inputs for improving production level. For improving sesame production efficiency this study recommend; capacitating large-scale producers through strengthening education, strengthening the credit access at affordable interest rate, nearby sesame farm follow up and frequently visiting of their farm with effective farm management will be better. For improving the farm level efficiency of large-scale producers, it is also important to initiate producers to hire certified experts, strengthening the productive utilization of their livestock and their house to earn cash.

Key words: Efficiency, inefficiency sources, Kafta Humera, Large-Scale and Sesame

INTRODUCTION

Background of the Study

Agriculture is the most important sector of Ethiopia's economy where about 95% of total arable area is cultivated by small-scale that produce more than 95% of total output obtained from the sector (CSA, 2015; Mahelet, 2007; Seyoum *et al.*, 2007; MoARD, 2010). It has contributed to livelihoods of about 85%, employing about 85% labor force, accounts about 45% of GDP and for foreign exchange currency of about 86% (FDRE, 2016). Accordingly, the government of Ethiopia has taken initiatives that meant to support successful achievement which can assure by improving efficiency through reducing losses and improving market performance.

Sesame is one of the important oilseed crops adapted to semi-arid tropical regions that best performs on well drained, moderately fertile soils with temperature between 20-35°C (Wijnands *et al.*, 2007). Sesame is one of the six priority crops in the AGP of Ethiopia (SBN, 2013_b). In Ethiopia, sesame is being produced as cash crop by small-scale who cultivate 0.42 million ha and produce 0.29 million tone and by large-scale who cultivate 0.28 million ha and produced more than 0.22 million tones (CAS, 2015). Nationally, sesame accounts for 3.35% of total area and 1.1% of total grain production (CSA, 2015). It is produced in North Gondar and Western Tigray lowlands, Welega, Benishangul Gumuz and South-Omo; which North Gondar and Western Tigray contributed more than 68% of the national product (CSA, 2015).

Over the past years, sesame production has shown greater increase in area and production but decreasing in yield. Looking at its trend, nationally sesame covered 0.14 million ha area where 0.12 million tons was produced in 2004/5 (Kindie, 2007) increased to 0.29 million tone production on 0.42 million ha in 2014/15 (CSA, 2015). But, its productivity declined from 8.47 Qt/ha in 2004/5 (Kindie, 2007) to 7.35 Qt/ha in 2013/14 (CSA, 2014) and to 6.87 Qt/ha in 2014/15 (CSA, 2015).

In Tigray region, about 176,030 small-scale (CSA, 2015) and about 1130 large-scale (KHLAdO, 2015) were engaged in sesame production that supplied 88.7% of their production (CSA, 2014). According to CSA (2014), Tigray region ranked second in area and production. Western zone took the lion share in the region's sesame area (76.33%) and total production (76%) for the average productivity of 7 Qt/ha (CSA, 2015).

Given agriculture as backbone of the nation's food security and as sesame is the second agricultural product that earns foreign exchange; it is imperative to conduct study on measuring production efficiency and inefficiency; so, large-scale producers in the study area were fail to earn profit. Similarly, sesame suffers lower productivity than the FAO estimated potential (Wijnands *et al.*, 2007). Also, through farmer's practice productivity ranges from 2 to 13.75 Qt/ha (WTZAO, 2014; HuARC, 2014) which shows wider gap. So, this study was aimed to measure production efficiency and inefficiency sources. Achievements of these objectives have significance contributions on making an informed decision for optimum input allocation and providing scientific information for decision makers, planners, policy makers, input suppliers, supporting institutions, and other actors. This study would also help as reference for other studies.

METHODOLOGY

Description of the Study Area: The study was conducted in Kafta-Humera district, Ethiopia; bordered by Eritrea, Sudan, Tsegedie district, Welkayt district and North western zone in the north, west, South, East and north east, respectively. The study area has 24 kebeles with total population of 103,692 having 26,352 households covering 4,542.33Km^2 with 396,852ha cultivable land (KHARDO, 2013). There are also 1,130 large-scale producers who cultivate sesame (KHLAdO, 2015). The study area is known for cultivation of sesame and sorghum (KHARDO, 2013; HuARC, 2014).

Data Types, Sources and Methods of Data Collection: Both primary and secondary data types were collected for this study where primary data sources were collected using semi-structured questionnaires of formal survey procedures from large-scale producers in four kebeles. Secondary data sources are also collected from office of agriculture and rural development, HuARC, different books and published and unpublished reports.

Sampling Procedure and Sample Size: This study used multi-stage sampling technique for selecting sample producers. First, large-scale producers in the district were selected purposively. Secondly, four kebeles (Mai Cadra, Baeker, Adebay and Rawyian) were selected randomly. Then depending on probability proportional to size of large-scale producers from each sample kebeles, specified numbers of respondents were obtained based on the formula developed by Yamane (1967) considering confidence level of 90% and accepting the error (e) of 9%,

$$n = \frac{N}{1 + N(e^2)} \qquad (3.1)$$

Where n = sample size, N= total large-scale household equal to 1,130. Based on the calculation, 126 large-scale sesame producers were sampled using random sampling technique (Table 1).

Table 1. Number of sampled producers from each kebele

Kebele	Total pop.	Sample
Adebay	98	16
Baeker	149	25
Mai Cadra	409	68
Rawyian	107	17
Total	763	126

Source: KHLAdO, 2015

Methods of Data Analysis

Production Efficiency and Sources of Inefficiency Differentials

In estimating technical, allocative and economic efficiencies and inefficiencies, SFA of Cobb-Douglas function was applied; because, it allows segregating of external effects from inefficiency. From Aigner *et al*. (1968) and Meeusen and Broeck (1977), SPF in Cobb-Douglas form is defined as:

$$\ln Y_i = \beta_0 + \ln \sum_{j=1}^{k} \beta_j x_{ij} + \varepsilon_i \qquad (3.\ 2)$$

$$\varepsilon_i = v_i - u_i \qquad (3.\ 3)$$

Where j= 1… k inputs; i= ith producer; Y_i= sesame yield, X_{ij}= jth input used, β_i= vector of unknown parameters, ε_i= disturbance term composed of v_i (error) and u_i (inefficiency).

Production function could be either Cobb-Douglas or translog that requires specification by likelihood ratio test. As it was developed by Battese and Coelli (1995) Cobb-Douglass production function of dual cost used to specify cost function with its inefficiency where cost function represents dual approach (Chambers, 1988). The stochastic nature of cost frontier would still imply the theoretically minimum cost frontier; stochastic in nature, given as:

$$C = C\left(P, Y^*, \alpha\right) \qquad (3.\ 4)$$

Or,

$$\ln C_i = \alpha_0 + \left(\sum_{j=1}^{k} p_{ij} \cdot \alpha_i\right) + \alpha_j Y_i^* \qquad (3.\ 5)$$

Where i = ith household; C_i = minimum cost; j= 1…k, inputs used; P_{ij}= input price; Y_i* = farm revenue adjusted for noise v_i, and α's= parameters to be estimated.

Variables of sesame production efficiency: These variables are inputs in sesame production efficiency which could be production or cost inputs that combined to determine the overall production efficiency.

Production function: This uses the Cobb-Douglas form that shows the relation of dependent variable with its inputs. The dependent variable is given by the following equation.

$$\ln Y_i = \beta_0 + \beta_i \ln ld_i + \beta_i \ln sd_i + \beta_i \ln lb_i + \beta_i \ln pw_i + \beta_i \ln fq_i + (v_{i-} u_i) \quad (3.6)$$

Where ld= land, sd = seed, lb= Labor, pw = Oxen/tractor power, fq = fertilizer

Estimation of cost functions for sesame production

This refers to production cost incurred by producer's calculated taking price of inputs give as follows:

$$\ln c_j = \partial_{0j} + \partial_{1j} \ln cld_{j1} + \partial_{2j} \ln csd_{j2} + \partial_{3j} \ln clb_{3j} + \partial_{4j} \ln cft_{4j} + \partial_{5j} \ln cpw_{5j} + \partial_{6j} \ln cmt_{6j} + \partial_{7j} \ln cop_{7j} + (v_j - u_j) \quad (3.7)$$

Where j= jth producer; c_j = actual cost; i= 1…7, $_i{}^{th}$ input cost; β_j= coefficients to be determined; v-u = error; cld= land cost; csd= seed cost; clb= wage; cft= fertilizer cost; cpw= plough cost; cmt= material cost and cop= operation cost.

The minimum cost input equation can be expressed as:

$$\Delta c_i / \Delta p_i = \chi_{ie}\left(p_i, Y_i^*, \alpha\right) \quad (3.8)$$

So, optimization profit principle is to minimize cost subject to optimum output. Minimum cost is derived using the methodology used in Arega and Rashid (2006), Ogundari *et al*. (2006), Zalkuwi *et al.* (2010) and Ermiyas *et al*. (2015). Given input oriented function, the efficient cost function is written as:

$$Min \sum C = \sum_{j=i}^{k} (x_j, p_j) \quad (3.9)$$

Subject to

$$Y_i^* = \hat{A} \prod Xj^{\beta j} \quad (3.10)$$

$$\hat{A} = Exp\, \beta_0 \quad (3.11)$$

By substituting the expenditure function and the adjusted yield for stochastic error in to the above minimization function to derive the following:

$$C\left(Y_i^*, Y_i\right) = H \quad Y_i^{*u} \prod_i P_i^{\alpha j} \quad (3.12)$$

According to (Sharma *et al*., 1999), the explained cost measures enable to estimate AE and further EE.

Generally from the above explained concepts TE can be defined in the ratio of observed outputs (Y_i) to the corresponding frontier output (Y_i*).

$$TE_i = Y_i / Y_i^* = \sum\nolimits_i^{`} \chi_{it}, P_i / \sum\nolimits_i^{`} \chi_i, P_{ip} \quad (3.13)$$

Also economic efficiency (EE) is the ratio of the minimum costs adjusted or expenditure (C*) to the actual total production cost or expenditure (C).

$$EE = c_i^* / c = \sum \chi_{ie} P_i / \sum \chi_i P_i \quad (3.14)$$

From these two equations the AE can be derived as the ratio of EE to TE.

$$AE = EE / TE = \sum x_{ie} P_i / \sum x_{it} P_i \quad (3.15)$$

Sources of sesame production inefficiency

After measuring TE, AE, and EE, it is important to identify the major sources of inefficiency derived from different variables. Following the adoption of Battese and Coelli (1995) for analysis inefficiency using Cobb Douglas functional form, estimation of inefficiency is specified as:

$$U_i = \sigma_0 + \sigma_{1i} w_{1i} + \sigma_{2i} w_{2i} + \sigma_{3i} w_{3i} + ... + \sigma_{15i} w_{15i} \quad (3.16)$$

Where U_i= inefficiency of i^{th} producer; w_1-w_{15}= inefficiency variables.

Estimation of best production function

Selecting the best function relative to other functions is based on tests of fitness to the data generated. In specifying the best production function this study conducted hypothesis tests for the parameters of SFA using likelihood ratio statistic defined by eq.3.17, that H_0 is for Cobb-Douglas and H_1 is for translog.

Likelihood ratio test: This is used to compare the goodness of fit of two hypotheses given as in eq. 3.17.

$$LR = \lambda = -2 \ln[L(H_0) / L(H_1)] = -2[\ln L(H_0) - \ln L(H_1)] \quad (3.17)$$

Where, L[Ho] is value of H_0, $L[H_1]$ is value of H_1. This also enables to detect either there is error or not; through comparison of χ2 by obtaining λ, γ and δ^2.

$$\lambda = \delta_u^2 / \delta_v^2 ...or.... \delta_u / \delta_v, \quad (3.18)$$

$$\gamma = \delta_u^{\ 2} / \delta^{\ 2} \quad (3.19)$$

$$\delta^2 = \delta_u^{\ 2} + \delta_v^{\ 2} \quad (3.20)$$

Given the specification of SFA, inefficiency is present is defined by H_a:$\gamma \neq 0$. In selecting the best fitting model; so further the level of TE, AE and EE and inefficiencies, the studies conducted by Chimai (2011), Abu *et al.* (2012), Hidayah *et al.* (2013), Asad *et al.* (2014), Getahun (2014), Berhan (2015), Chakwera (2015) and Ermiyas *et al.* (2015), similarly used likelihood ratio test.

RESULTS AND DISCUSSION

Demographic Features and Availability of Production Resources

On average there were six persons in each family with the composition of three by three for male and female members (Table 2).

Table 2. Household characteristics of large-scale sesame producers

Variables	Mean
Age (years)	48.4
Experience (years)	19.8
Family size (No)	6.50
Male members (No)	3.30
Female members (No)	3.20
Active family (No)	3.90
Non-active family (No)	2.50
Dependency ratio	0.38
Education level (years of school)	4.88
Extension contact (No)	1.34
Training obtained (No)	0.91
TLU	12.73
Off-sesame income (Birr)	61,361.27
Borrowed money (Birr)	347,960.30
Own income (Birr)	192,245.10
Labor hired /ha	23.17
Total land	159.86
Sesame land	128.60

Source: Survey result, 2016

The sampled sesame producers used hired labor at different production activities that were 23 man-days/year per-ha owning the average land holding size of 159.86 ha (Table 2). 98.67% of the sesame produced in 2015/16 production year was sold (Table 3).

Table 3. Amount of sesame allocated for different purposes

Purpose	Mean (Qt.)	%
Sold	295.91	98.67
Seed	3.6	1.2
Consumption	0.38	0.13

Source: Survey result, 2016

Summary Statistics of Sesame Production Inputs and Costs

The average sesame produced by the sampled producers was 299.43 Qt/household with cost of birr 854469.84 (Table 4).

Table 4. Summary of total production inputs and costs

Variable	Unit	Mean
Sesame produced	Qt	299.43
Production cost	Birr	854469.84
Labor used	No	2979.44
Labor cost	Birr	445387.67
Land size	Ha	128.59
Land cost	Birr	178981.01
Plough power hour	Hr	64.30
Plough cost	Birr	63530.04
Operating cost	Birr	53458.69
Material cost	Birr	7657.32
Seed amount	Kg	436.98
Seed cost	Birr	12681.64
Fertilizer cost	Birr	92773.63
Fertilizer used	Qt	72.24
Average sesame yield	Qt/ha	2.46
Average production cost/ha	Birr/ha	6644.43

Source: Survey result, 2016

Estimation of Production Function parameters

Specification tests: Different types of tests were applied for model validity checking such as multi-collinearity, heteroskedasticity, and adjusted R-square. Multicollinearity test using VIF for all variables was less than ten (i.e., 5.21), indicating no severe problem (Table 5). Heteroskedasticity test using the Breusch-Pagan test also show that there is no heteroskedasticity problem (Table 5). Adjusted R-squared also was 0.92 indicating the variables explain 92% of the variability in sesame output (Table 5).

Table 5. SFA parameter coefficient for sesame production by large-scale producers

Ln sesame production	unit	Coefficients	P>|t|
Ln land	Ha	-1.15***	0.007
Ln fertilizer	Qt	0.024	0.276
Ln labor	Man day	0.021	0.352
Ln plow power	Tractor hr	2.31***	0.00
Ln seed	Kg	-0.279**	0.025
Total (elasticity)		0.926	
Constant		3.60***	0.00
Wald chi^2 (5)		2746.57	P= 0.00
Sigma_U		0.482	P= 0.00
Sigma_V		0.117	P= 0.00
gamma(γ)		0.944	
$sigma^2$		0.246	
MLR		-24.32	
Adj. R-squared		0.9156	
hettest. Prob. > chi2		0.217	
VIF		5.21	

*, **, ***, significant at 10%, 5% and 1%, significance level respectively

The study indicated that variables such as land size and plough power were significant at 1%; while improved seed at 5% for determining large-scale sesame production; however, variables such as fertilizer and labor become insignificant (Table 5). The studies conducted by Baten *et al.* (2009), Ibrahim *et al.* (2014), Wassie (2014), Chakwera (2015) and Ermiyas *et al. (*2015) found farm size was significant in determining production. Moreover, Rahman and Umar (2009), Zalkuwi *et al.* (2010), Abu *et al*. (2012), Abba (2012), Getachew and Beneberu (2014), Ibrahim *et al.* (2014), Wassie (2014), Berhan (2015) and Ermiyas *et al. (*2015) found seed as significant variable. So, it is observable that the result found by this study is similar with the results obtained by the listed former studies. The inverse relationship between farm size and yield was similar with the results of Chand *et al.* (2011), Maqbool *et al.* (2012), Wutyi *et al.* (2013) and Berhan (2015). The coefficients in Table 5 could be interpreted that, one percent increment in sesame land size leads to 1.15% decline in yield. Similarly one percent increment in seed results to 0.28% reduction of total production. However, one percent increase in plough power hour leads to 2.31% increment of production.

Elasticity of sesame production: The summation of production inputs' coefficients was 0.93 (Table 5), indicating the one percent increase in inputs simultaneously leads to 0.93% increment of production. This has consistency with the result of Ogundari and Ojo (2005), Ibrahim *et al.* (2014) and Ermiyas *et al*. (2015); found the scale ranging from 0.84 to 1.2105%.

Cost efficiency: This study found that both error terms (u and v) for sesame producers were statistically significant at 1% (Table 7). Further, value of gamma ($\gamma = \delta_u^2 / (\delta_u^2 + \delta_v^2)$); is $\gamma = 0.9257$ that implies 92.57% variability is contributed by differences in decision maker's inefficiencies (Table 6). Regarding the cost function inputs, all variables have statistically significant with positive sign; except operation and material costs that were insignificant (Table 7).

Table 6. Tests of cost function model validity

Null hypothesis	LR value calculated	Critical value (5%)	decision
H_0: γ=0	92.57	11.07	Reject H_0
H_0: $\delta_1 = ... \delta_{10}$=0	77.27	9.39	Reject H_0

Source: STATA.13, output

Material cost includes cost of: agricultural materials, sack, harvesting and threshing materials and tractor material and tools. Whereas operating cost includes cost of; fuel and lubricants, tractor repairing, medical service and feed expense for draft animals, transportation and loan. This study shares similarities on cost parameters with the formerly conducted studies by Ogundari and Ojo (2007), Berhan (2015) and Ermiyas *et al.* (2015), in which cost efficiency inputs were wage, seed cost, agro-chemical costs, and amount produced. But also, cost of farm tools by Ogundari and Ojo (2007) and land rental cost by Berhan (2015) in addition to the above explained once.

Table 7. Sesame production cost parameters

Total sesame Production cost	Coefficient	P>|z|
Ln Operation cost	0.006	0.44
Ln seed cost	0.033**	0.023
Ln fertilizer cost	0.007***	0.001
Ln material cost	-0.009	0.471
Ln plough cost	0.039***	0.006
Ln labor cost	0.242***	0.00
Ln land cost	0.083***	0.004
Ln production	0.62***	0.00
Elasticity	1.0155	
Constant	5.22***	0.00
MLR	127.98	
Sigma_v	0.0395***	0.00
Sigma_u	0.1393***	0.00
Sigma2	0.021***	0.00
gamma (γ)	0.9257	

*, **, *** significance at 10%, 5%, and 1%, respectively

Estimation of technical, allocative and economic efficiencies of large-scale sesame producers

Technical efficiency: The mean TE level found in this study was 71.46% (25.6 - 96.03) (Table 8). This implies that if the average producer wants to achieve the TE of his/her most efficient counterpart, he/she could realize 25.59% input saving [i.e., 1-(71.46/96.03) x100]. Similar the most inefficient farmer reveals cost saving of about 73.34% [i.e., 1-(25.6/96.03) x100]. The mean level of TE shows that there is an opportunity to increase efficiency on average by 28.64% if inputs allocated properly.

Table 8. Category of sampled sesame producers based on their TE

Category	Number of respondents	Percent
TE≤20	0	0.00
20<TE≤30	2	1.59
30<TE≤40	5	3.97
40<TE≤50	9	7.143
50<TE≤60	15	11.9
60<TE≤70	20	15.87
70<TE≤80	24	19.05
80<TE≤90	37	29.37
TE>90	14	11.11
Mean TE	71.46	

Source: Survey results, 2016

The average and range of TE in this study is consistent with the result of Ibrahim (2007), Amaza *et al.* (2010), Chimai (2011), Abba (2012), Dawit *et al* (2013), Endrias *et al*. (2013), Getahun (2014), Evaline *et al.* (2014), Getachew and Bamlak (2014), Hussain, *et al.* (2014), Wassie (2014), Chakwera (2015) and Ermiyas *et al.* (2015); ranging in 34-77%.

To give a better picture about TE distributions, a frequency distribution is categorized by 10% interval; here, 40.48% of the producers were operating blow mean (Table 8). This imply that in the long run there is a room for improving the existing TE level of sesame producers providing a special attention to introduce best alternative farming practices and improved technologies.

Allocative efficiency: The average AE of large-scale sesame producers was 89.88% (56.94 - 98.16) (Table 9). With this deviation, if the average producer wants to operate his/her AE to the most efficient, he/she could obtain cost saving of 8.44% [i.e., 1-(89.88/98.16) x100], however the most allocatively inefficient could save 42% [i.e., 1-(56.94/98.16) x100]. About 38% of the sampled producers were operating below mean AE (Table 9). The result obtained in this study is complementary with the results of Ogundari and Ojo (2005, 2007), Alboghdady (2014), Mburu (2014) and Chakwera (2015) who found AE from 57 to 96%. Generally, AE of large-scale sesame producers in Kafta Humera district show that most of the producers have relatively similar allocation of resources with the unit prices attached to each input, so leads higher AE.

Table 9. Distribution of AE of sesame producer categories

Category	Number of respondents	Percent
AE≤ 20	0	0.00
20< AE≤30	0	0.00
30<AE≤40	0	0.00
40<AE≤50	0	0.00
50<AE≤60	1	0.79
60<AE≤70	0	0.00
70<AE≤80	8	6.35
80<AE≤90	43	34.13
AE>90	74	58.73
Mean	89.88	

Source: Survey result, 2016

Economic efficiency (EE): Following the relative ratio of actual cost to the hypothetical minimum cost, EE could be obtained which is the multiplication of TE and AE. Applying this procedure this study found mean EE of 64.58 percent (22.37 - 92.76) (Table 10). Taking this range, if the average producer wants to reach his/her EE to the most efficient counterpart, he/she could experience the cost saving of

30.38% ([i.e., 1-(64.58/92.76) x100]. Similarly, the most inefficient producer could save his/her cost by 75.88% [i.e., 1-(22.37/92.76) x100]. The mean EE found in this study is similar with the results of Endrias *et al*. (2013), Abu *et al*. (2012), Myo *et al*. (2012) Hidayah *et al*. (2013), Abba (2012), Dawit *et al.* (2013), Asad *et al*. (2014), Evaline *et al.* (2014), Getachew and Bamlak (2014), Berhan (2015), Chakwera (2015) and Ermiyas *et al*. (2015).

Table 10. Distribution of EE by large-scale sesame producers

Category	Frequency	Percent
EE≤20	--	--
20<EE≤30	6	7.14
30<EE≤40	6	7.14
40<EE≤50	13	15.88
50<EE≤60	21	16.67
60<EE≤70	27	28.57
70<EE≤80	26	19.84
80<EE≤90	25	3.17
EE>90	2	1.59
Mean	64.58	

Source: Survey data, 2016

As presented in Table 10, about 45% of the sampled producers' EE was below mean which is an indication that producers were unfairly efficient; meaning there was greater variability in their achievement.

Sources of technical, allocative and economic inefficiency of large-scale sesame producers

Having information about TE, AE and EE, identifying the major sources of inefficiency is the next important part of this study. Before using all the proposed socio-economic and institutional variables into the model a test for multi-collinearity using VIF is important. Accordingly, the VIF result of each variable is below ten (i.e., 2.73) (Table 11), indicating no severe multicollinearity problem. Based on the Breusch-Pagan test result of heteroskedasticity also, the null hypothesis could not be rejected (Table 11). The test for cost inefficiency model validity also indicated the result of VIF for each variable in the model and the mean value of all variables is below 10 (i.e., VIF= 3.59) (Table 11). Based on the Breusch-Pagan test result of heteroskedasticity also, the null hypothesis could not be rejected (Table 11). The adjusted R-squared in both production and cost inefficiency also show the variables explained 69% and 91.46%, respectively (Table 11). As a result all the variables hypothesized are entered in to their respective models. The significant sources of technical, allocative and economic inefficiencies (Table 11) are discussed as follows.

Education level of household head (eduhhd): The result of this study shows that education level of household head significantly and negatively affect to technical, allocative and economic inefficiency at 1%. If education level in years of schooling becomes one year higher relative to others, one's technical, allocative and economic inefficiency decreases by 1.4%, 0.6% and 1.6%, respectively. This may be, education enables producers to have greater ability to understand, adopt and correlate inputs with lower cost and misuse.

According to Huffman (1980) and Lockheed, *et al*. (1980), the relationship between education level and efficiency is theoretically justified as education increases performing capacity and so best match of resources; because education is proxy for managerial ability. The result of this study is similar with the results found by Shumet (2011), Rahman *et al*. (2012), Abba (2012), Getachew and Bamlak (2014), Hussain *et al.* (2014), Shalma (2014) and Wassie (2014); but, in conducted to Abu *et al.* (2012). The result of allocative and economic inefficiencies obtained in this study is in line with results of Arega and Reshid (2006), Aye and Mungatana (2010), Otitoju and Arene (2010), Shehu *et al* (2010), Shumet (2011), Myo *et al*. (2012), Chakwera (2015) and Sisay *et al.* (2015).

Experience in sesame production (exp): It is found that experience of sesame producers is significantly and negatively affected to technical, allocative and economic inefficiency of sesame production at 5%, 10% and 5%, respectively. This could be; because experience is a proxy for managerial aspects and improves the skill and technical capacity that enables to best match inputs and in cost saving aspect so attain higher productivity at minimum cost. The relationship implied that, there is a reduction in technical, allocative and economic inefficiencies by 0.6%, 0.37% and 0.5%, respectively as one's experience increases by one year. The technical inefficiency result is consistent with the results of Abdukadir (2010), Myo *et al*. (2012), Hidayah *et al*. (2013), Berhan (2015) and Ermiyas *et al.* (2015); but contradicts with result found by Adeyemo *et al.* (2010). Taking allocative and economic inefficiency the result found is similar with results of Zalkuwi *et al. (*2010), Abu *et al.* (2012, 2011), Myo *et al*. (2012), Hidayah *et al*. (2013) and Biam *et al*. (2016). However, it is in contrast to the result of Dawit *et al*. (2013) and Ermiyas *et al.* (2015).

Membership in cooperatives (memb): The technical and economic inefficiency of large-scale producers were significantly and positively determined by being a membership in cooperative at 1%. Theoretically, membership in social organizations helps producers in achieving efficiency; but, this unexpected result could be that members might not discuss related to sesame production while meeting and they may spend more time while discussing other issues which compute time of sesame farm operation. Besides, while producers want to take loan from their cooperative it takes more time; so, they did not get their credit on its time, spending of time until getting loan which computed sesame farm operating time. Depending on the result of this study, as sesame producer's become members of cooperative one's technical and economic inefficiencies raises by ten and 10.3%, respectively.

Distance of sesame farm from residence (distfh): It is found that farm distance is significant and negatively related to technical and economic inefficiencies at 1% and 5%. Accordingly, as farm distance increases by 01Km, their technical and economic inefficiencies decreases by 0.3% and 0.2%, respectively. This relation may be because there is high probability of family members or manager to live in production site; so, whole day follow up is observed that enables to better manage farms which lead to better efficiency achievement.

Frequency of sesame farm visit (freqgo): It is found that this variable significantly and negatively determines technical, allocative and economic inefficiencies at 1%, 10% and 1%, respectively. So, according to the study result as large-scale sesame producer increases his/her farm visit by one time, his/her technical, allocative and economic inefficiencies decrease by 0.4%, 0.6% and 0.4%, respectively. Theoretically, the relation could be interlinked, as there is nearby farm follow up that enables understanding of real happening so solutions could be emanated.

Ownership of standardized home (ownhom): It is found that this variable significantly and negatively determined technical and economic inefficiencies of large-scale sesame producers at 1%. According to the result found, as large-scale producer owns standard home that could hold as collateral their technical and economic inefficiencies decreases by 23% and 22% relative to the one who did not own. This may be as producers had their own house, they do not pay house rent rather they may allocate the money for sesame production. Also it can be used as collateral for obtaining loan. Thus, improves their efficiency. This result matches with the result of Jema (2008).

Ownership of livestock (ownliv): This study found that TLU significantly and negatively affected to technical and economic inefficiencies of the sampled producers at 10%. This relationship implies that as large-scale producer's TLU increases by one, one's technical and economic inefficiencies decreases by 5.1% and 0.56%, respectively. This could be as livestock enables to obtain off-sesame farm income. Regarding, the relationship of TLU and TE, the result in this study is similar with the result of Wassie (2012), but in contradiction with the result revealed by Wondimu and Hassen (2014). In relation of TLU and EE the result found is similar with the reports of Amos *et al.* (2007), Idiong *et al.* (2009), Otitoju and Arene (2010), Shehu *et al.* (2010), Chakwera (2015) and Sisay *et al*. (2015).

Amount of credit obtained for sesame production (loan): It is significantly and positively related to technical, allocative and economic inefficiencies of large-scale producers at 10%, 10% and 5%, respectively. According to this result, as one obtains one percent of the amount he/she expected and invested at sesame production one's technical, allocative and economic inefficiencies increases by 0.011, 0.003 and 0.01%, respectively. This may be that they spent the loan obtained in payment of laborers and fertilizer purchase which did not have significance contribution in TE achievement. It may also due to as loan is obtained from informal money lenders, who were most familiar in the area that requires higher interest rate.

Availability of road facility from farm to home (road): It is also found that road facility is significantly and negatively related to technical, allocative and economic inefficiencies of large-scale producers at 1%, 5% and 1%, respectively. This is implying that as large-scale producer obtained access to normal road, one's technical, allocative and economic inefficiencies decreases by 0.033%, 0.008% and 0.033%, respectively. It is because accessible road enables to timely reach so manage farm activities timely and reduced amount of grain loss while transporting.

Table 11. Sources of technical, allocative and economic inefficiencies

Variables	Technical inefficiency	Allocative inefficiency	Economic inefficiency	VIF production function	VIF cost function
Age household head (years)	0.001	-0.001	0.001	1.99	2.40
Education level (schooling years)	-0.014***	-0.006***	-0.016***	1.69	1.92
Experience (years)	-0.006**	-0.0037*	-0.005**	1.67	2.08
Dependency ratio (No)	0.004	0.004	0.006	1.9	2.06
Distance of farm (Km)	-0.003***	0.0002	-0.002**	1.88	2.03
No of extension contact (No)	-0.01	0.005	-0.007	2.09	2.84
Frequency farm visit (No)	-0.004***	-0.006*	-0.004***	1.93	2.21
Home ownership (Dummy)	-0.23***	-0.022	-0.22***	1.68	2.44
Livestock ownership (TLU)	-0.051*	-0.017	-0.056*	1.90	2.29
Number of training obtained (No)	-0.003	0.001	-0.001	1.76	1.75
cooperative member (Dummy)	0.10***	0.0204	0.103***	1.92	2.07
Road type (Dummy)	-0.033***	-0.008**	-0.033***	1.48	1.95
Ln Off sesame income (Birr)	0.003	0.0027	0.004	2.48	2.48
Ln loan obtained (Birr)	0.011*	0.003*	0.01**	1.53	2.25
Constant	-0.6***	-0.87***	-0.54***		
Mean				2.73	3.59
Adjusted R^2				0.91	0.69
Chi^2				$P(X^2 = 0.19)=0.12$	$P(X^2 = 0.78)=0.38$

*, **, *** significance at 10%, 5%, and 1% respectively

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