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Factors Affecting Technical efficiency of Smallholder coffee growing Farmers in Jimma zone: South west Ethiopia: A Stochastic Frontier Approach

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Abstract

In Ethiopia, about 15 percent of the country's population directly or indirectly deriving their livelihoods from coffee. It plays a central role in Ethiopia's economy and as the country's leading export commodity generating about 25% of Ethiopia's total export earnings. Small holder farmers' account for more than 95% of the total coffee produced in Ethiopia, but the productivity remains very low. This study aims to analysis the level of technical efficiency of coffee producing smallholder farmers. It was conducted using a cross-sectional data collected in 2019 production year from a total sample size of 149 households in Jimma zone of oromia regional state. The aim of the study was to examine the level of technical efficiency of smallholder farmers and identify the factors that influence technical efficiency in coffee production. The maximum Likelihood Estimation (MLE) result shows that farm size under coffee cultivation and labour force are the major factors that are associated with coffee output. The result of the study revealed that the mean technical efficiency was 74.27 percent, which indicates that an average smallholder farmer was producing about 25.73% below a frontier production level. The relative deviation of output from the frontier level due to inefficiency (value of gamma(γ)) was 0.999, which implied that about 99.9% of the variation in matured coffee output was due to technical inefficiency, while the remaining 0.1% variation was due to random noise. The Farmer specific efficiency factors like educational level of household head, total land holding, weeding frequency , and extension affected technical efficiency significantly and positively while total livestock unit and Off-farm income had affected technical efficiency significantly and negatively. Therefore, provision institutional service on coffee field management that would improve the production efficiency of smallholder farmers should be given priority.

Key words: *coffee production, Determinants of technical efficiency, Maximum Likelihood Estimation, Smallholder farms, and Technical Efficiency*

1. INTRODUCTION

Coffee is a primary source of income for about 10 million households throughout the world. Of these 10 million households, 95% are smallholder farmers (ICO, 2016). Two varieties of coffee beans are well-known: Robusta which is mainly used for making instant coffee, and Arabica which is used for regular coffee. Economically Coffee Arabica covers 64 % and Coffea Canephora (var. Robusta) covers 36 % of world production. Coffee (genus Coffea) is widespread throughout the tropics with more than 70 species. It is cultivated on approximately 10.3 million hectares land.

Coffee is produced and exported by more than 60 nations and ranks as one of the top cash crops in developing countries (Pohlan, H.A.J. and Janssens, M.J., 2015). Globally, yield size averages is 1 ton/hectare but varies across the world from 2.5 tones/ hectare in Vietnam, to 1.4 tones/ hectare in Brazil, and only half a ton per hectare in Uganda and Côte d'Ivoire. Much of this disparity results from differences in farming practices: less than 10 % of smallholder farmers in Africa use crop protection or fertilizers and most tend not to effectively utilize basic agronomic techniques, such as pruning and replanting (Abu and Teddy, 2013).

Africa has a largest number of coffee producing countries: 25 as opposed to 11 in Asia and Oceania, 12 in Mexico and Central America and 8 in South America. Africa's 25 coffee-producing countries are home to over 716 million people, and in some of those countries coffee is an important commodity in terms of both export earnings and generating income for smallholder farmers (ICO, CSA, 2015). About 33 million people of Africa derived their livelihoods by growing coffee on their subsistence farms on about 4.5 million square kilometers of land. Its cultivation, processing, trading, transportation, marketing provide employment for a lot of people in all producing countries (Mohammed A. B.,et al., 2013). In Africa, coffee is grown predominantly on small-scale farms with limited and fragmented land holdings, little access to inputs and low prices. It is produced in various production systems, predominantly mixed plantings with other crops and shade trees (Taye, 2010). However, its development is constrained by, among other things, deteriorating land productivity, dwindling per capita land holdings, market imperfections, and climate variability and change (Tessema, Y., et al., 2015).

Ethiopia is the origin and starting place of biodiversity of Arabica coffee seeds. More genetically diverse strains of Coffee Arabica exist in Ethiopia than anywhere else in the world, which has lead botanists and scientists to agree that Ethiopia is the center for origin, diversification and dissemination of the coffee plant (Bayetta, 2001; Taye, 2013). In the country, about 15 percent of the country's population directly or indirectly deriving their livelihoods from coffee. It plays a central role in Ethiopia's economy and as the country's leading export commodity generating about 25% of Ethiopia's total export earnings (Abu and Teddy, 2013). Ethiopia is not only a major producer and exporter of coffee, but it is also the second largest consumer of coffee among coffee producing countries in the world (next to Brazil) (Tadesse Kuma, et al., 2016). Small holder farmers' account for more than 95% of the total coffee produced in Ethiopia, but still traditional farming systems. In Ethiopia, Coffee is produced under four broad production systems, i.e. forest coffee (8-10%), semi forest coffee (30-35), cottage or garden coffee (50-57%) and modern coffee plantation (5%) which are owned by private investors or by the government (USAID, 2010; UNDP, 2012; Taye, 2013).

Despite the wealth of ecological and coffee diversities, the national average clean coffee yield around 710 kilograms per hectare is low by the world standard. Many factors are responsible for less coffee growing and yield. Among them, poor coffee farm management system, socio-economic characteristics of the farmer, types of farming system, expansions of Khat (Catapults) at the expense of coffee farm and climatic change are the major once (Taye Kufa et al., 2011 and Abu Tefera, 2016).

Agricultural productivity can be increased through the improvement in production technology by releasing improved and well adopted crop varieties and other production inputs or through enhancing the technical efficiency farmers in efficiently using and combining the available production inputs (Mechri, Lys and Cachia, 2017). In other word, productivity can be increased through dissemination of improved technologies such as fertilizer and high yielding varieties (HYV) and/or by improving the productive capacity the farmer. Technical Efficiency (TE) defined as the extent to which the maximum possible output is achieved from a given combination of available production inputs. Any deviation from the maximum output is typically considered as technical inefficiency (Coelli *et al.*, 2005).

For one to design better measures aimed at increasing productivity, understanding the current farm-level efficiency and factors that hold back the productivity of their farm is crucial. The general objective of this study was to know the level of production efficiency of smallholders' coffee farmers and factors that hold back smallholder farmers from increasing their production. This study may provide useful information for the formulation of economic policies and guide stockholders to improve producer technical efficiency.

2. RESEARCH METHODOLOGY

2.1 Description of the Study Area

Study was carried out in Jimma Zone Gomma district, located in the south western part of the Regional State of Oromia. Because it would provide a picture of the range of production and employment options available to households in a coffee producing area, with reasonably good links to the wider economy. The total area of the district is 93,657.72 hectare (936.58 km^2). Out of this; 65,921 hectare of land has been under cultivation. The district is renowned for its long history of coffee production and it is one of the main sources of coffee in Ethiopia. It is the dominant cash crop and maize is the dominant cereal crop. T'chat is the second cash crop of the area following to coffee. Other crops grown however include teff, sorghum, enset, horse bean, wheat, barley and field pea, and vegetables like potato, sweet potato, carrot, lettuce, cabbage, garlic, tomato, peppers, and beetroot. Livestock (e.g., cattle, goat, and sheep), equine (donkey, mule, horse) and poultry are common (Gomma District Agricultural and Rural Development/GDARD 2019).

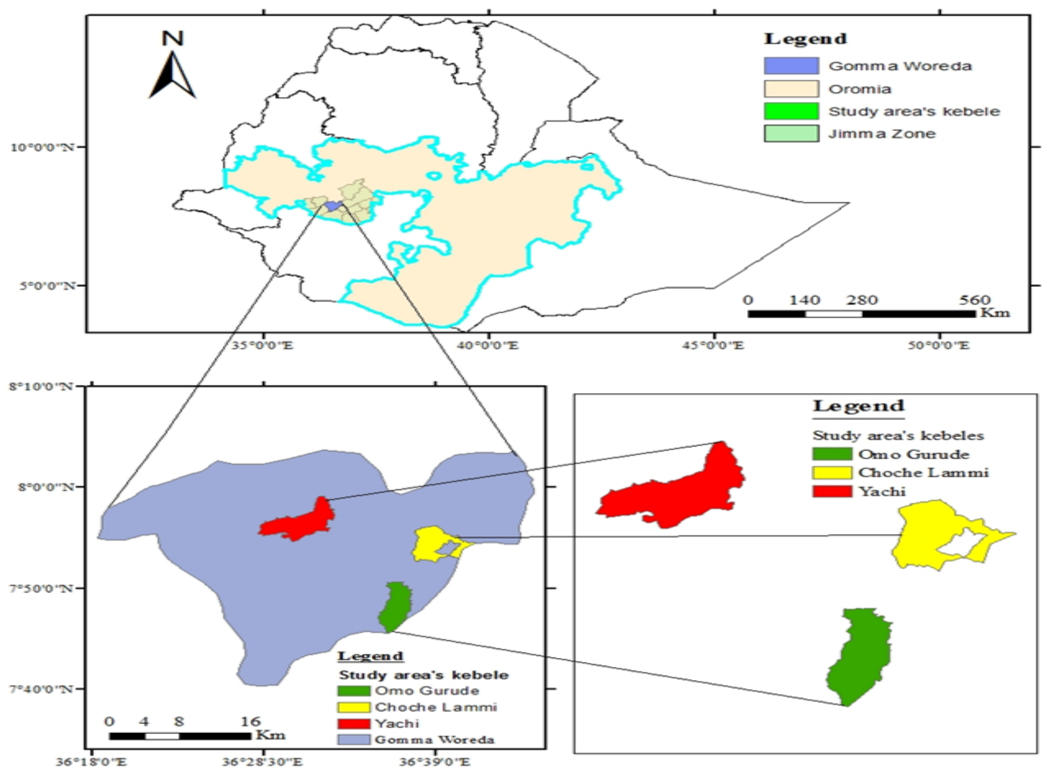

Figure 1: Location of the study area

2.2 Sampling technique and data collection

Out of the 20 districts of Jimma zone, five districts (Goma, Manna, Limmu kossa, Limmu Seka and Limmu Chekorsa) are major coffee growing areas. From those major coffee growing districts, the study area was selected purposively, because the district would provide a picture of the range of production and employment options available to households in a coffee producing area, with reasonably good links to the wider economy, and it is one of the coffee biodiversity centers in Ethiopia.

In this study, out of major coffee growing kebeles', three potential coffee growing kebeles were selected with baseline data given from GDARD. Those are: Yachi, Omogurude and Chochelammi. The total household of these kebeles are 4260. Out of these, households with matured coffee trees are 3569.The required sample size for survey was computed by using a simplified formula provided by Yamane (1967) as follows:

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

Where n is sample size to be computed, N is the households with matured coffee in the study area and e is the desired level of precision with the same unit of measure as the variance (e^2) of an attribute in the population (in this case, e= 8%; because for such studies, Sample size from ±5% up to ±10 % Precision Levels which has Confidence Level of 90-95% is acceptable (Mustefa B., et.al,, 2017). The sample size would be:

$$n = \frac{3{,}569}{1+3{,}569(0.08)^2} = 149.2 \cong 149$$

From selected household's basic information on input utilization and production levels of coffee were collected.

2.3 Methods of Data Analysis

To address the objectives of the research, the study employed both descriptive and econometric methods. The descriptive statistics such as mean, standard deviation, frequency distribution and percentage were used to summarize the socio-economic characteristics of the farmers and in the econometric analyses; a stochastic frontier approach was utilized.

Theoretical framework of measuring efficiency

The level of technical efficiency of a particular firm is characterized by the relationship between observed production and some ideal or potential production (Greene, 1993). The measurement of firm specific technical efficiency is based upon deviations of observed output from the best production or efficient production frontier. If the firm's actual production point lies on the best practice frontier, it is fully technically efficient. If it lies below the frontier, then it is technically inefficient, with the ratio of the actual to potential production defining the level of efficiency of individual firm.

There are two main analytical approaches that can be used to measure technical efficiency in production: parametric (econometric) and non-parametric (mathematical programming) approaches. Parametric approaches assume that the functional form of the production function is known ahead and apply econometric method in estimating the parameters of the function (Coelli, 1996; Coelli*et al.*, 2005). In this

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approach the Stochastic Frontier Approach (SFA) is the most popular. This method has the advantage of taking into account the measurement errors or random effects and the inefficiency component specific to every plantation, it does not attribute all deviations from the frontier to inefficiency and it allows statistical hypotheses testing regarding the nature and magnitude of inefficiency.

The stochastic production function can be specified as Cobb-Douglas, constant elasticity of substitution, Tran's log, and other functional forms. From these empirical models, stochastic frontier production function model of Cobb-Douglas functional form was employed to estimate the farm level technical efficiencies of the farmer in the study area. Because, Cobb- Douglas functional form has the advantage of ease of estimation and interpretation of coefficients, it assumes constant elasticity of scale and unitary elasticity of substitution and thus variation the elasticity of scale or substitution may be erroneously attributed to inefficiency, the functional form has been widely used in farm efficiency for the developing and developed countries. The model has the advantage of allowing simultaneous estimation of the farmers as well as the determinants of technical efficiency (Battese, 1992).

Model specification

The stochastic frontier production function model which is expressed in Cobb-Douglas functional form used to estimate technical efficiency of the farmers is express in the following form:

$$Yi = f(Xi, \beta) + \varepsilon \ldots\ldots (1)$$

Thus, to estimate Cobb-Douglas production function, all the input and output must log before the data is analyzed (Coelli, 1995). The estimating equation for the stochastic function is given as:

$$\ln Y_i = \beta_0 + \ln \sum_{j=1}^{n} \beta_j x_{ij} + \varepsilon_i \ldots\ldots (2)$$

The linear form of Cobb-Douglas production function for this study was represented in as:

$$\ln(Y) = \beta_0 + \beta_1 \ln(x_1) + \beta_2 \ln(x_2) + \beta_3 \ln(x_3) + \varepsilon_i \ldots\ldots (3)$$

Where:

Y= clean coffee yield of i[th] farmer (Kg/ha),

X_1 = area under matured coffee trees of i[th] farmer (ha),

X_2 = total labor used (man-days/crop season),

X_3 = the amount of organic fertilizer applied (Kg/ha),

β_1, β_2 and β_3 are the parameters to be estimated; and

ε_i = error term equal to (v_i - u_i). Vi is a two-sided random error accounts for random variation in output due to statistical noise (arises from the omission of relevant variable from the vector X_i as well as from measurement errors and approximation errors associated with the choice of function form) and identically distributed as N (0, ~σ_v^2); U_i is a one-sided inefficiency component (representing management factors and are assumed to be independent of V_i). U_i captures the stochastic effects outside the farmer's control (for example: weather, natural disasters, and luck, measurement errors in production, and other statistical noise).

Technical efficiency of an individual firm is defined in terms of the ratio of the observed output (Y) to the corresponding frontier output (Y*), given the available technology, conditional on the levels of input used by the firm.

$$TE_i = \frac{Y_i}{Y_i^*} = \frac{\exp(x_i\beta + v_{i_i} - u_i)}{\exp(x_i\beta + v_i)} \quad \ldots\ldots (4)$$

$$TE_i = \exp(-u_i)$$

Based on the individual farm's technical efficiency, the mean technical efficiency for the sample is obtained (Rahji, 2005). TE takes values within the interval (0, 1), where $0 \leq TE \leq 1$ with 1 indicates a fully efficient farm; Y_i is the observed output and Y_i^* is the frontier output.

Technically efficient farms are those operate on the production frontier, which implies that Y_i / Y_i^* equals one in value. The level of u_i is zero if the production unit produces the potential output (full TE or TE equals one) and is less than zero when production is below the frontier (less than full TE). Technical efficiency of the i^{th} farm is therefore a relative measure of its output as a proportion of the corresponding frontier output.

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Estimation of the determinants of coffee technical efficiency

Some hypothesized socio-economic, institutional, and technological factors that affect efficiency levels were regressed on the technical inefficiency derived from stochastic frontier. The linear regression model (Sharma et al., 1999; Arega, 2003) on the farm specific explanatory variables that explain variation in efficiency across farmers was adopted. The model takes the following form:

$$U_k^* = Z_i\delta + w_i \quad \ldots\ldots (5)$$

Where: $U_k^* =$ is represents the inefficiency effect of k^{th} farm obtained (1-TE); $Z_i =$ is the vector of independent variables which have been postulated to affect efficiency. The vector δ comprises the unknown parameters associated with the independent variables for the k^{th} farm and w_i is an independently distributed error term assumed to be normally distributed with zero mean and constant. The variables with a negative (positive) coefficient will have a positive (negative) effect on efficiency levels.

The explanatory variables hypothesized to explain differences in technical efficiency among farmers are:

F_1= Age of household head in years

F_2= education level of household head in years of formal schooling

F_3=Family size (persons)

F_4= the total livestock available in TLU

F_5=Total land holding (total area of cultivated and grazing land) in hectares

Z_6=Experience of coffee cultivation (year)

F_7= Weeding frequency per year (number)

F_8= Age of matured coffee (year) is biological life cycle of coffee

F_9 = Extension contact or training on coffee production (1= if farmer had access to the extension service, 0=otherwise)

F_{10}= Land fragmentation (number): it is the number of plots managed by the farmer during the production year (all crops)

F_{11}= Income from non/off-farm activities (1= yes, 0= otherwise).

3. RESULTS AND DISCUSSION

3.1 Demographic and Socio-economic Characteristics of Sample Households

The survey results revealed that out of total respondents, 93.96% of them were male headed house hold and 6.04% of them are females, who are divorced or widowed; and more than 88% of the respondents were married, 4.7% respondents were divorced, and the remaining were single and widow/ers at the time of survey. The average age of the sample households during the survey period, was about 44.5 years with maximum and minimum of 70 and 27 years, respectively. The family size was ranged from 1 to 11 with mean of 6 persons per household.

Table 1: Demographic and socio-economic characteristics of the sampled households

Variable	N	Mean	Std. Dev.	Minimum	Maximum
Age of household head (years)	149	44.53	9.437	27	70
Education (number of grade)	149	3.05	3.444	0	12
Family size (persons)	149	6.04	1.750	1	11
Total Land holding (ha)	149	1.74	0.786	0.38	4.5
Livestock (TLU)	149	5.56	3.675	0	12.5
Experience of coffee cultivation (year)	149	19.8	8.368199	6	45
Age of matured coffee (year)	149	12.8	6.066	3	29
Weeding frequency per year (number)	149	1.8	0.416641	1	2
Extension contact per year (Frequency)	149	2.0	0.873144	0	8
Land fragmentation (number)	149	1.65	0.869344	1	4
Income from coffee yield per year (birr)	149	25,199.36	12,715.49	2,318.1	83,830.5
Off/non-farm income (birr)	149	3,345.5	7,331.153	0	3,7800

Source: Own computation (2019)

The study also showed that 51.01% have attained formal education with grade level of 1 to 12, 27.52% of them can read and wrote (religious education, adult education, etc) and 21.48% were Illiterate. The average formal education level of the sample household heads during survey period was about 3.05 years with the minimum of 1 year and maximum of 12 years. The households had an average land holding/farm size of 1.74 ha, 5.56 TLU of livestock, 3345.5 birr income from off/non-farm, and 25199.36 birr income from coffee yield per year. The average age of matured coffee was 12.8 years with minimum and maximum of 3 and 29 years respectively. The young coffee plant grows for three to four years before bearing fruit. Full production starts in the ninth year and lasts until the sixty years, when a progressive decline begins (Alemayehu, 2010). This indicates that after reaching maturity at certain age, the productive capacity of coffee trees decline.

Regarding main occupation; about 12.75% of respondents were growing crops, 71.81% of them were growing crops and rearing animals, 12.08% of them occupied crop production, livestock rearing and off-farming. Only 3.36 % of them had adopts crop production and off-farming. Among others, oxen power is a major input in crop production process serving as a source of draft power. Given a mixed farming system in the study area, livestock has considerable contribution for household income and food security.

The extension workers visit households on different intervals, some households are being visited more frequently per year while others have got less chance at all to be visited by extension workers. Accordingly, sample households were being visited by extension workers on average 2.49 times with the minimum of 0 and maximum of 8 times (table 1). The major sources of non/off-farm income in the study area were remittance, petty trade, salary, daily laborer and guard. The mean off- farm income of the sample households was 3345.5 birr. Generally, the variables (demographic, socio-economic, and institutional variables) which were expected to affect technical efficiency levels of smallholder households were summarized and presented in table 1.

3.2 Major Coffee production and marketing constraints in the study area

The survey result showed that diseases, climatic change and poor soil fertility were the major production problems that farmers were facing in the study areas (Table 2). Moreover, about 45.64%, 21.48% and 18.12 % of the sampled households were ranked; coffee disease, climatic change and poor soil fertility as 1st, 2nd and 3rd problems respectively.

Table 2: Major coffee production constraints

Major coffee production constraints	Freq.	Percent	Cum.

Disease	68	45.64	45.64
Climatic change	32	21.48	67.12
Poor soil fertility	27	18.12	85.24
Weed infestation	12	8.05	93.29
Lack of processing	5	3.36	96.65
Storage problem	3	2.01	98.66
Shortage of labor	2	1.34	100
Total	**149**	**100**	

Source: Own computation, 2019

Weed infestation, lack of processing, shortage of labor during pick time and storage were another constraint in the study areas. The major coffee marketing constraints that farmers facing in study area were; low price, absence of certification, lack of quality sampling and quality based price, and lack of market information. The problems covered 62.42%, 20.13%, 14.09% and 3.36% respectively.

3.2 Econometric analysis

3.2.1 Estimation of production function

The summery statistic of the variables used for the stochastic production function analysis is presented in the table 2. The area allocated for coffee production, by sample households during the survey period, ranged from 0.13 to 2.75 ha with an average of 0.77 ha and standard deviation of 0.38.

Table 3: Summary of statistics of production function

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Yield (Kg/Ha)	149	482.530	138.235	229.267	968.720
Area (Ha)	149	0.770	0.376	0.13	2.750
Organic fertilizer (Kg/Ha)	149	464.161	284.551	30	1500
Labour (Man days/Ha)	149	12.977	4.954	3.333	33.333

Source: Own computation, 2019

The average clean coffee yield was 482.52 Kg/ha, which is below the national average of 710 Kg/ha. The output, moreover, has large standard deviation (138.24). This reflects the wide variability of farmers output from the average. Similarly, sample households used from 3.33 to 33.33 with the mean of 12.98 man days. Based on the standard deviation (4.95), there is low variability of labour utilization among the farmer from the estimated mean. Table 3 also shows that utilization of organic fertilizer among the farmers ranged between 30kg and 1500kg with the mean of 464.16 kg/ha.

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The ordinary least square (OLS) and maximum likelihood (ML) estimates of the parameters of the stochastic production frontier were obtained by using the program frontier 4.1. Estimated OLS results (table 4) obtained from the study revealed that out of three variables included in the model, the coefficient of organic fertilizer was significant at 5% level of significance.

Table 4. Econometric result of the stochastic frontier production function (SFPF)

Common variables	Parameter	OLS estimates			MLE estimates		
		coefficient	standard-error	t-ratio	coefficient	standard-error	t-ratio
Constant	β_0	5.636	0.208	27.133***	6.014	8.043	74.774***
lnfarm size	$\ln\beta_1$	6.136	5.527	1.110	4.836	2.133	2.267**
lnlabour	$\ln\beta_2$	7.007	7.190	0.975	7.109	2.363	3.008***
lnorganic lnfertilizer	$\ln\beta_3$	5.073	2.702	1.874*	3.547	2.475	1.433
Variance	sigma-squared (σ^2)	9.516***			0.190	3.128	6.080***
parameters	gamma (γ)	0.950			0.999	363.319	275.239
log likelihood function		-0.003			-0.001		

Source: Computed from frontier 4.1 MLE/Survey data, 2009. *, ** and *** = Significant at 10%, 5% and 1% respectively.

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The sigma squared ($\sigma^2 = 9.516$) was statistically significant at 1% indicating goodness of fit, and the correctness of the distributional form assumed for the composite error term. In addition, the estimated value of gamma (γ) was 0.999, which implies that, about 99.9 % of the total variation in coffee output was due to technical inefficiency(v_i), while the remaining 0.1% variation was due to random noise (u_i) that are beyond the control of the farmers, also the value represented the gap between maximum production and production reached. This variation was also confirmed by the value of gamma (γ) that was 0.95.

Input elasticity and return to scale

As indicated in the table 4 above, estimated MLH result showed that farm size and labour were found to be important variables in increasing the productivity of coffee. Coefficient for farm size was significant for production with elasticity of 4.836. This implies that, at ceteris paribus, a 1% increase in area allocated to increase the coffee output by 4.84 percent. Also the coefficient of labour was significant for coffee production with elasticity of 7.109 which implies that a 1% increase of labour increase coffee output by 7.1 percent. The result showed that coffee farm management needs large number of labour force. In general, results showed that the variables specified in the model had elastic effect on the output of coffee production.

3.2.2 Efficiency scores and distribution

The result of stochastic frontier analysis shows that the technical efficiency scores of sample farmers varies from 40.92% to 98.1%, with the mean efficiency of 74.27% (table 5). This indicated that if resources were efficiently utilized, the smallholder farmer in the study area could increase current output by 25.73% using the existing resources and level of technology.

Table 5: Summery of technical efficiency

Variable	Obs	Mean	Std. Dev.	Min	Max
TE	149	.7426917	.1825263	.4092651	.9806856

The distribution of the TE scores in table 6 bellow showed that the majority (57.7%) of the sample households had TE score of greater than 81-90 %.

Table 6. Distribution of efficiency score.

	TE	
Efficiency Range	**Frequency**	**%**
<30	0	0
31-40	1	0.67
41-50	40	26.85
51-60	4	2.68
61-70	0	0
71-80	7	4.7
81-90	86	57.72
>90	11	7.38
Mean = 74.27		

Source: Own computation (2019)

But there were also some households whose TE levels were limited to the range 41 to 50%. On average, households in this cluster have a room to enhance their coffee production at least by 50%. Out of the total sample, only 7.4% of the farmers have TE of greater than 90% and 27.5% was operating below 50% of technical efficiency level.

3.3 Determinants of technical efficiency of coffee production

After measuring levels of farmers' efficiency in coffee production, determining the factors that influence the efficiency within study area is important. This would add more value to such studies by giving guidance on formulation of policies that would alleviate the shortfalls in the efficiency. To see this, the technical efficiency levels derived from stochastic frontier were regressed on factors that were hypothesized to affect efficiency levels.

The results of the regression model showed that among the eleven hypothesized variables, five variables (education, total land holding, weeding frequency, extension frequency and land fragmentation) were found to be statistically significant in affecting the level of technical efficiency (Table 6).

Table 6: Marginal effects of variables after regression

Variable	Coefficient	Std. Error	P>|t|
Constant	.469757***	.077042	0.000
Age of household head (year)	-.000798	.0014483	0.583
Educational level (number)	.019119***	.0056952	0.001
Size of family (number)	.005383	.0071629	0.454
Total land holding (ha)	.032031**	.0156266	0.042
Livestock (TLU)	-.0004	.0031912	0.527
Experience of coffee production (year)	-.000615	.0026056	0.814
Weeding frequency per year (number)	.133431***	.0293585	0.000
Extension contact per year (number)	.030808**	.013597	0.025
Land fragmentation (number)	-.073771***	.0157151	0.000
Age of coffee (year)	.0020554	.0033063	0.535
Off-farm income (Birr)	-.000001	0.000001	0.162

Source: Model output (2019). * p<.1; ** p<.05; *** p<.01 refers to level of significance at 10, 5 and 1% respectively.

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The educational level of the household head had a positive and significant effect on TE. This is because education can increase their information acquisition and adjustment abilities, thereby-increasing their decision making capacity. In addition to this, it will help them to adopt modern agricultural technologies and be able to produce higher output using the existing recourses more efficiently. Moreover, educated households have relatively better capacity for optimal allocation of inputs, and this forced to the higher technical efficiencies. Furthermore, the model result shows, a one unit increase in the formal year of schooling of the household head increases the expected values of TE of the smallholder coffee producers by 0.19%. In line with this study, research done by Alemayehu (2010); Beyan*et al.* (2013) and Mustefa (2014) explains that the more educated the farmer, the more technically, allocatively and economically efficient s/he becomes.

The finding of the study shows that total land holding affected TE positively at significance level of 5%. The model result shows, a one unit increase in size of land increases the expected values of TE by 3.2%. The survey result indicated that 22.15% of the sample farmers' weeds their coffee field once per crop season and 77.85% of respondents' weeds twice per crop season.

The coefficient of weeding frequency was positive and statistically significant at significance level of 1%. The result shows that, a unit increases in weeding increases the value of technical efficiency of a farmer by 13.3%. This shows that one of the major factor that affect the coffee yield of small holder farmers' was weed. The result is in line with finding of P.J.A. van Asten , *et al*. (2011); Ogundari and Ojo (2006) and IWMI (2011).

The frequency of extension contact had significant and positive effect on technical efficiency at 5% significance level. This indicates farmers who had more number of contacts with extension worker during the production year were technically more efficient than those who had less number of extension contact. Furthermore, the model result shows that, a unit increases in the number of extension contact with the smallholder coffee farmers' increase the expected values of technical efficiency of a farmer by 3 %. This result is similar with the findings of Beyan*et al.* (2013); Getachew and Bamlak (2014); Chilot*et al* (1996); Freeman *et al*, 1996; Asfaw*et al* (1997)**;**Kedir, 1998 who found that farmers who had more number of visits with development agents enhanced their access to improved inputs and farming management practices thereby increased their production efficiencies.

The coefficient of land fragmentation is negative and statistically significant at 1%. The result showed that fragmented land leads to inefficiency by creating shortage of family labor, wastage of time and other resources that should been available at the same time. Moreover, as the number of plots operated by the farmer increases, it may be difficult to manage these plots. In the study area land is fragmented and scattered over different places. The result is in line with the finding made by Mustefa (2014) and Fikadu (2004).

4. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

4.1 Summary and Conclusions

This study was undertaken with the objective of assessing the efficiency of small scale coffee producers in Gomma district of Oromia National State of Ethiopia. The study area was selected purposively based on the level of coffee production in the region. The study employed the stochastic frontier approach and both primary and secondary data were used. Primary data were collected through household survey from a sample of 149 households using structured questionnaire. Secondary data were collected from relevant sources to supplement the primary data. Data analysis was carried out using descriptive statistics and econometric techniques.

The results from the production function showed that only organic fertilizer was positive and statistically significant. The study also indicated that the mean level of TE was 74%. This in turn implies that farmers can increase their coffee production on average by 26% when they were technically efficient.

In the second step of the analysis, relationships between TE and various variables on coffee farm efficiency were examined. Among 12 regressed variables, education level of household head, family size and weeding frequency per crop season were found to be statistically significant to affect the level of technical efficiency of smallholders in the study area.

4.2 Recommendations

The result of the analysis showed that coffee producers in the study area are not operating at full technical efficiency level and the result indicated that there is ample opportunity for coffee producers to increase output at existing levels of inputs without compromising yield with present technologies available at the hand of producers. An intervention aiming to improve efficiency of farmers in the study area has to give due attention for resource allocation in line with output maximization as there is big opportunities to increase output.

A positive and significant impact of education level to technical efficiency in the study area implied that more educated farmers were achieved a higher level of technical efficiency than farmers with less education. Therefore it is better if policy makers aware in order to prevent output lost due to technical inefficiency, and give attention for training farmers through strengthening and establishing both formal and informal type of framers' education, farmers' training centers, technical and vocational schools. Similarly, extension contact has positive and significant contribution to technical efficiency. Since extension services are the main instrument used in the promotion of demand for modern technologies, appropriate and adequate extension services should be provide. This could be done by designing appropriate capacity building program to development agents.

The negative influence of land fragmentation on technical efficiency shows the difficulty of widely scattered plots for farmers to practice the improved technologies on all their fields at the same time. Therefore, it is better if farmers have small plot numbers of coffee in order to perform basic agronomic practice on time.

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