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Research Paper

Factors Affecting Technical Efficiency of Coffee Producers: The Case Dale Woreda, Sidama Region, Ethiopia

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Abstract
Coffee is the major source of income for smallholder farmers and is a leading export crop for Ethiopia. Even though a great proportion of coffee production comes from smallholder farmers with farm sizes below two hectares, productivity in these farms remained very low. To identify the causes of low productivity this study identified the technical efficiency level of smallholder coffee farmers and the factors that influence technical efficiency in coffee production in Dale Woreda, Sidama Region, Ethiopia using the stochastic frontier approach. In addition, this study attempts to determine whether the agricultural and some of the socio-economic characteristics of farmers can influence the efficiency of their technical efficiency coffee production. By exploiting the information that was gathered in a survey of 150 farmers selected randomly from three kebeles using stratified random sampling in the woreda, these farmers' technical efficiency was estimated using a trans-long-type stochastic frontier model and two-limit Tobit model. The mean technical efficiency of the study area is 65.43%. The results suggest that, factors like the land cover, labor in hours, compost used as well as their cross product and the interaction effects of labor with sufficient compost used, labor with proper capital-labor force, and minimum cost for agricultural equipment and composite with proper capital significant determinants of coffee technical efficiency in the area. Furthermore, variables like educational status, age of the coffee tree, membership of cooperative associations, size of livestock holding, presence of additional off-farm incomes, and age of household head are significant predictors of the technical efficiency of farmers in the study area. Thus, by improving their education, improving the frequency of extension service, increasing livestock holdings, improving membership in cooperative associations, and replacing the aged coffee tree, someone can improve his/her technical efficiency directly and coffee production indirectly.

Keywords*: Maximum Likelihood Estimation, Stochastic Frontier Analysis, Technical Efficiency.*

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I. INTRODUCTION

Agriculture plays a decisive role in the economic development of Ethiopia and other developing countries. It is a source of employment, income, and food for more than 85% of Ethiopians (KPMG, 2014). Agriculture services as a main source of employment for the majority of Ethiopians because industry and service sectors aren't able to generate enough employment and also contribute 43% to the national GDP of the country (UNDP, 2014, FRDE, 2013). United Nations Development Program (2014) also forwarded the main reasons for the increase in the agricultural productivity and production in the country among others are favorable weather and good rainfall, strengthened agricultural extension services, better access to agricultural inputs, improved access to market and pursue enhanced policy and advocacy. However, the Ethiopian government is attempting to increase agricultural productivity through increased use of improved technologies. Moreover, it is proved not to bring about the expected productivity gains in the short run. Similarly, Getahun (2014) stated that agricultural production in Ethiopia is dominated by subsistence-based smallholder farmers, whose production and incomes from the sector are constrained by socio-economic, institutional, resource, and environmental factors.

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The agriculture sector is the primary foreign exchange source of Ethiopia, particularly coffee exports. Ethiopia produces and exports one of the best highland coffees in the world. Coffee is the number one source of export revenue generating about 25-30% of the country's total export earnings (Gray *et al*., 2014). It is a very important cash crop deserving particular attention. Ethiopia is the leading Arabica coffee producer in Africa, the fifth largest worldwide, and the tenth in coffee exports worldwide. The average annual production amounts to about 229, 351.3 metric tons the average production is about 0.71 tons/ha. Ethiopian coffee is intrinsically organic and renowned for its superior quality. Smallholder farmers account for more than 95% of the total coffee produced in Ethiopia, but still traditional farming systems. Ethiopia has a huge potential to increase coffee production as it is endowed with suitable elevation, temperature, soil fertility, indigenous quality planting materials, and sufficient rainfall in the coffee growing belts of the country (Taye, 2013). This study aims to analyze factors influencing technical efficiency of coffee producers Sidama Region *Dale Woreda* which consists a total of 36,236 coffee producers of which 2,087 are females and 34,149 are males. In terms of land coverage 15,215.3 ha in 36 *Kebeles* produced 284,184 quintals and on average 16.5 quintals of unprocessed coffee per ha (DWAOS, 2015).

Coffee production is vital to the Ethiopian economy with about 15 million people directly or indirectly deriving their livelihoods from it (Gray *et al*., 2014). It is mainly produced in the southwestern and southeastern parts of the country. It is predominantly produced by small holder farmers on average farms of less than 2 hectares. Around 95% of the country's total production comes from these small holder farmers. Even though coffee is vital for the economy of the country and the income of small holder farmers' various factors have been constraining its production and productivity. GTP I of Ethiopia targeted to increase coffee production in tones from 341000 in 2009/2010 to 831000 in 2014/2015; coffee export in tones from 172, 210 in 2009/2010 to 600,970 in 2014/2015; and coffee export earnings from 528,000 million USD to 2.037 billion USD in 2014/2015 (FDRE, 2010).

Technical and allocative efficiency level of coffee is relatively lower, as compared to other countries. As Gray *et al*. (2014) identified reasons for the low coffee production (in quality and quantity) are the coffee farm management system, agronomic practices, inadequate extension services, inadequate use of improved seeds, and lack of specialized coffee institutions. From these two prime coffee growing regions the study was conducted in Sidama Region, which is known for its coffee production. This study aims to analyze factors influencing the technical efficiency of coffee producers in Sidama Region *Dale Woreda* which consists of a total of 36,236 coffee producers of which 2087 are females and 34,149 are males. In terms of land coverage, 15,215.3 ha in 36 *Kebeles* produced 284,184 quintals. Dale Woreda is one of the woredas in the Sidama Region renowned for its coffee production.

coffee brands producing and enabling farmers to get the right value for their produce and improve their lives. Coffee is a very important crop deserving particular attention in the context of development policies concerning agricultural exports and domestic resource allocation. Nevertheless, Ethiopian has not yet exploited its comparative advantage in coffee production although coffee plays a significant role in the Ethiopian economy (Nicolas Petit, 2007).

By improving the technical efficiency of producers, it is possible to attain the greatest amount of output from a fixed quantity of inputs. The presence of shortfalls of inefficiency means that output can be increased without requiring additional conventional inputs or new technologies. If this is the case, then empirical measures of efficiency are necessary to determine the magnitude of the gain that could be obtained by improving performance in production with a given technology. Consequently, it is necessary to analyze the technical efficiency of coffee producers and to identify its determinants. According to the Dale Woreda Agriculture Office (2015) model farmers are producing 22 quintals of coffee yield per hectare on average. However, other (non-model coffee producers are producing 12 quintals of coffee yield per hectare on average. From this, we can infer that there is a half gap between model coffee producers and other on –model producers. To that end, the research problem of this study can be stated in the following manner: how do we improve the productive performance of coffee producers in order to increase their production and enable *Dale woreda* to regain its market shares in international markets in a context of land saturation and financial resource scarcity? This study is based on this main question.

Therefore, this study attempts to identify factors affecting coffee production efficiency in the Dale Woreda Sidama Region. To the researcher's knowledge, there was no study in Dale Woreda on coffee production technical efficiency. However, the researcher believes and is familiar that there is a production efficiency problem.
Objective of the study

1. To estimate the level of farmer-specific technical efficiency of coffee producers in Dale Woreda; and
2. To identify factors affecting the technical efficiency of coffee producers in the study area.

II. Conceptual Framework

A production process involves the transformation of inputs into outputs. In coffee production, technical inputs such as land, labor fertilizer/manure/ and the price of agricultural equipment are combined to produce the coffee yield. The transformation process depends not only on the levels of inputs used but also on the management practices that the farmers use to combine these inputs. Management practices used in production represent an amalgam of knowledge and skills that the farmer has or acquires overtime and characteristics of the farm. The technical inputs and the management practices jointly determine the output produced.

Thecoffeeproductionprocessissummarized

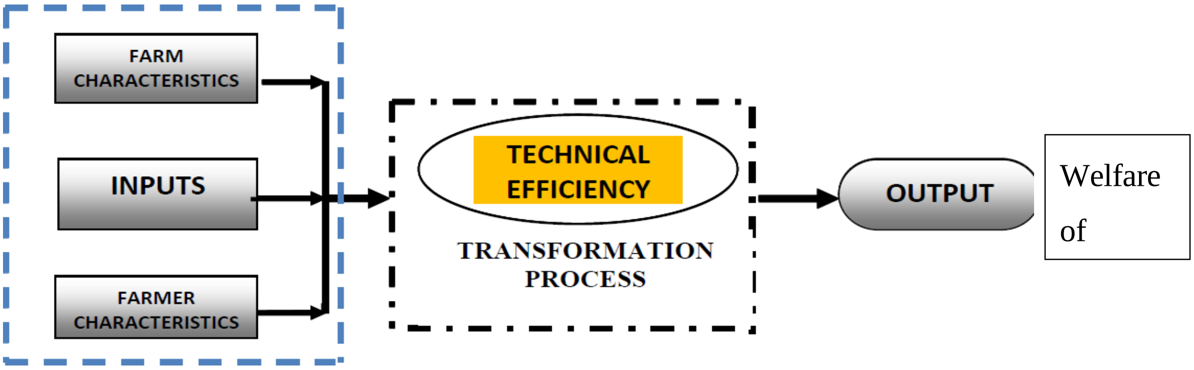

Figure 1: coffee production process

Farm characteristics: distance home to coffee farm, variety of coffee trees,
Inputs: land covered by matured coffee, labor hours; capital used, and compost (fertilizer)
Farmer characteristics: educational status, sex of household, age, farming experience, household size, marital status, extension service, market access, livestock ownership, member of cooperative association, and off-farm income.

III. Research methodology

3.1. Description of the Study Area

Dale woreda is located in the Sidama Region and is geographically located between $6^027'$- $6^051'$N latitude and 38^0– 38^037"E longitude. Its capital city, Yirgalem, is located 317 km south east of Addis Ababa and 42 km south east of Hawassa, capital of the region. The woreda is bordered by Wonsho woreda in the North, Aleta Wondo in the South, Shabedino woreda in the East, and Loka Abaya in the West. It comprises 35 *Kebeles*. According to 2014 the report of the Sidama Region administration socioeconomic profile, the total population of Woreda is 237,107 out of which 119,894 are male and the remaining 117,213 are female.

This study aims to analyze factors influencing the technical efficiency of coffee producers in Sidama Region *Dale Woreda* it consists of a total of 36,236 coffee producers of which 2,087 are females and 34,149 are males. In terms of land coverage223.04km^2. agriculture is the dominant economic sector by growing plants and rearing animals. The major agricultural products produced in the woreda are "Enset", banana, wheat, and barley and in addition, livestock like cattle, sheep, goats, hens, horses, mules, and donkeys are products that in general produced in study area. In Dale woreda coffee is remembered and high competent in international and national trade activities.

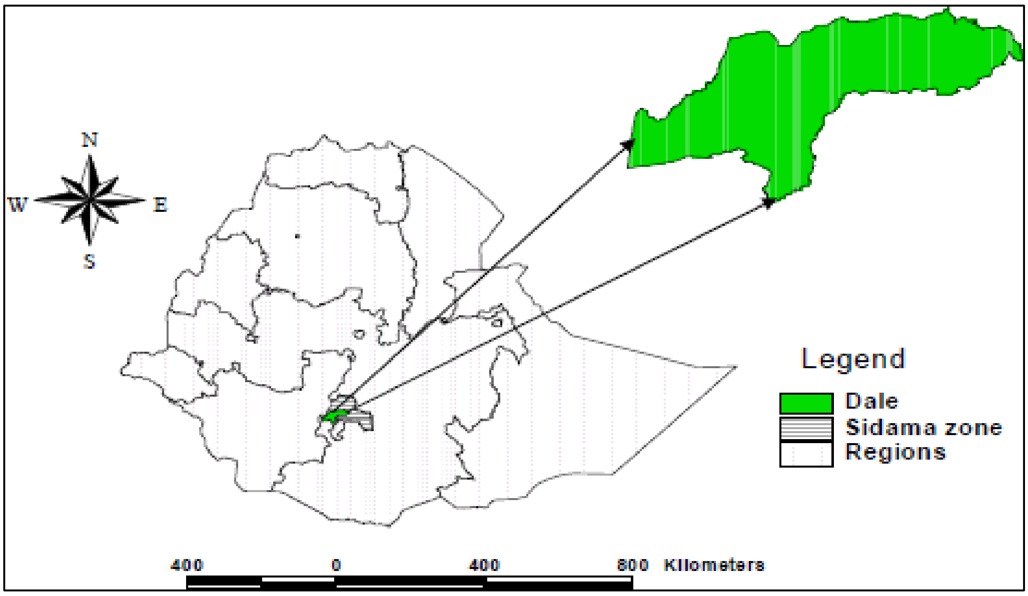

Figure2:Mapof Study Area

3.2. Research Design

Cross-sectional survey research design will be used which is among the most commonly used non-experimental designs (Graziano and Raulin, 2004). In cross-sectional field surveys, independent and dependent variables are measured at the same point in time (Bhattacherjee, 2012). However, it may be subject to respondent biases. It also does not control for or manipulate independent variables or treatments, but measures the variables and tests their effects using statistical methods (Bhattacherjee, 2012).

3.3.Sample size and sampling procedures

All coffee-producing households especially households in three sample kebeles in Dale woreda were considered as sampling frames when selecting the sample in the study. The researcher selected these three kebele purposes because in those kebeles there is high coffee production in the first kebele, medium coffee production in the second kebele, and low production in the third kebele. Thus, when studying the technical efficiency of farmers, we have considered high, medium as well low production areas to get representative samples from theworeda. Why, the researcher selected these three kebeles purposively due to cost and time reasons in addition to the above factors.

A multistage sampling procedure was considered during study time. Here, the combination of a two-stage sampling process consisting of purposive and stratified random sampling methods by considering the three kebeles as strata was used. Firstly, three sampleKebeles (Halile, Shifa, and Megara) have been selected purposively based on their high, medium, and low coffee production patterns which have been expressed by the total coffee coverage, and production. Then sample size was estimated using the stratified random sampling method. A stratified random sampling technique is a method of sampling that involves the division of the population into smaller groups, known as strata in such a way that individuals in the same strata are assumed to be homogenous relative to some characteristics. For instance, residents in one stratum are expected to share the same common social and economic connectedness and provide the same or similar services. Therefore, the stratified random sampling technique is adopted as an appropriate sampling design for selecting ar a representative sample, because the coffee production levels in these three kebeles are different i.e. in the first kebele (high coffee production), in the second kebele (high coffee production) and the third kebele (low coffee production). By considering the three kebeles as stata, samples from each stratum were selected using simple random sampling after proportion allocation was made for each kebele‟s.

The sample size was determined by using the proportional formula proposed by (Cochran, 1997) as illustrated:-

Where:n=required sample size

N=Total number ofpopulationinthreekebele‟s K= number of strata‟s, number of kebele‟s (3)

N_i=Thenumberofindividualineachkebele(Totalnumberofhouseholdswithinthei^{th}strata),

∕Stratumweight, e =Thelevelofprecision(marginoferror).

Z=confidence level required (95%) z=1.96; $e$is the level of precision required. Sample variance = 0.459 (which was taken from the study by, Amaechi E. C. C. and J. E. Ewuziem (2014) on “Estimation of technical efficiency in the translog stochastic frontier production function model: An application to the oil palm produce mills industry in Nigeria". Therefore sample households will be determined as **150** households. Proportionally allocating the selected samples to each kebeles as follows:

Table 1. Number of Farmers Taken from the Selected PSU at Dale woreda

Kebele"s	Ni	wi=Ni/N	Ni/N*150=wi*150	Approximate
Halile	2085	0.539038263	80.8557394	**81**
Shifa	835	0.215873837	32.38107549	**32**
Megara	948	0.245087901	36.76318511	**37**
Total	**3868**	**1**	**150**	**150**

3.4. Data type, source, and method of data collection

To achieve objectives data will be collected from both primary and secondary sources. Primary data will be collected by using pre-tested and then refined structured interviews from sampled coffee-producing households in the study area

Data Analysis

Both descriptive and Econometric methods were employed to analyze data collected form households. Descriptive statistics (mean, percentage, frequency, minimum, and maximum values will be used to summarize the variables used in the model and describe the study area. The econometric model stochastic frontier model will be employed to estimate the elasticity of production function, determine the determinants of inefficiency, and estimate the level of efficiency.

3.5. Model specification

A large body of theoretical and empirical literature has investigated the measurement of the efficiency of farm enterprises, using various methods. Many studies have emphasized that the focus in analyzing economic efficiency should be the performance of the whole production system, including farmers and institutional support systems. These results can be used to pinpoint the factors that impede the capacity of farmers to reach their productivity potential. Technical efficiency (TE) can be estimated using one- or two-step approaches.

The stochastic production function can be specified as Cobb-Douglas, constant elasticity of substitution, Trans log, and other functional forms. Moreover, evidence from Krishna and Sahota (1991) shows that if the interest rests in technical efficiency measurement not the analysis of the general structure of stochastic frontier, then the functional form would have a very small impact on the measurement of efficiency. Given the above arguments, the study used a likelihood ratio test to select among the different functional forms that could fit the data well. In this study, we assume that the frontier technology of matured coffee production of the sample can be represented by the trans-log production function and tested against the restrictive Cobb-Douglas production function.

To address the research question raised in the introductory part of this study and in light of the designed analytical framework, the appropriate empirical model specifications are made in the following two sections.

3.5.1. The Empirical stochastic frontier model

Following Coelli(1995) and Aigner*et al.* (1977) technical efficiency and their determinants used in this study for the analytical purpose were estimated using a one-step maximum likelihood estimate (MLE) procedure. The choice of functional form is of prime importance in the stochastic production frontier estimation. The more flexible functional form (Trans log specification) is generally preferred over (the Cobb-Douglas specification) since it does not impose general restrictions on the parameters nor the technical relationships among inputs. Consequently, the trans-log functional form is supposed to fit the data under the study adequately. This is done by incorporating the model for technical efficiency effects in the Trans log production function which is specified by relating yield as a function of farm input as follows.

$Yi=\beta o\sum \beta iXij/\sum\sum \beta ikijXkjVjUj$

Where design atesanatural logarithm and subscripts and j, respectively, represent the inputs i used by farm j.

Y=istheobservedoutput of the i^{th} farmer on the j^{th} farm in kg

$\mathbf{X_1}$=Area of land covered by matured coffee tree (ha).

$\mathbf{X_2}$=Fertilizer (quantity of compost used in Kg)

$\mathbf{X_3}$=Human labor used in total hours of work

$\mathbf{X_4}$=Amountofdepreciationagriculturalequipmentorcapital β = is a (Kx1) vector of unknown parameter to be estimated.

The stochastic frontier model also estimates the variance parameters for certain errors, such as the total variance of the model"s errors (σ2), which is represented in this way:

$$\sigma^2 = \sigma_u^2 + \sigma_v^2 \quad \ldots \quad (3)$$

Whichσ2u isthevarianceofui andσ2vis thevarianceof vi

The statistical significance of σ2 is an indicator of the quality of the fit and a test of the applied specification assumption for the distribution of those errors that are related to the technical inefficiency (ui). Second, the ratio between the standard deviation of the errors of the technical inefficiency(u) and the standard deviation of the model specification errors (v) is represented by (λ); this ratio is formally expressed as:

$$\lambda = \frac{\sigma_u}{\sigma_v} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

If λ zero, then either σv is very large or σu is close to zero. Similarly, when σv is close to zero, λ becomes large and the one-sided error becomes the dominant source of random variation in the model. In addition, the parameter of the ratio of variances (γ), which relates the variability of ui to the total variability of the model"s errors, is defined as follows:

$$\gamma = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_v^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

Thisexpressionisameasureofthelevelofinefficiencyofthestochasticfrontierproduction model and its outcome ranges between 0 and 1

Accordingly, the trans-log specifications function is the appropriate functional form that fits the data set adequately after comparing the Cobb-Douglas production function. For this study, the likelihood ratio test was used to select the best specification, among the two, that describes the datawell. This value was compared with tabulated chi-square which is given by Kodde and Palm (1986: 1246).

TheLRteststatistic(ʎ) is calculated as follows:

$$ʎ = -2\ln[L_0 - L_1] \quad \text{-----------------------------------} \quad (6)$$

where Lo-indicate values of the logarithm likelihood function of cob-Douglas production function and L1-logarithm likelihood translog production function

3.6. Sources of Technical Inefficiency

With the help of a step approach the value of the technical inefficiency component would be derived either via E(u/e) or m(u/e) given the assumptions zero mean, unknown variance$\delta$and non-negative random term, u. The technical inefficiency component is assumed to be independently and identically distributed between observations and is obtained by truncation at point zero of the normal distribution with mean u. (under truncated normal distribution) and varianceδ. The technical efficiency estimates obtained are regressed on some socioeconomic factors using the Tobit model.=δzi+wi

Where the mean of $technical\ efficiency$ Zi-the socio economic factor hypothesized as determinants of TE, and WI=unobserved random error term can be stated as:-

Where;is them ean of mean of technical efficiency of each specific farmer, Z"srepresents socioeconomic factors supposed to be the determinants of technical inefficiency component.

Determinants of Inefficiency: socioeconomic and biological variables, chosen relative to former studies and logical reasoning, are used in identifying the determinants of inefficiency. Most literature is used to analyze determinants of efficiency rather than inefficiency. However, the only difference between them is only on the interpretation.

Z_1=Age(AGE): This refers to the age of the household head measured in years.

Z_2=Education(EDUCATION): This is the educational level of the household head measured in years of schooling, giving zero value to the illiterate.

Z_3=Experience (EXPERIENCE):This refers to years of household head active farming of coffee

Z_4=Extension contact(EXTFREQ): This variable is measured as the frequency of contact of a farmer with the extension workers in the 2015/2016 production year.

Z_5=Gender of household head (GENDER): dummy variable having a value of 1 for female and 0 otherwise

Z_6=Distance (DISFHOM): The distance of coffee plot from home in km

Z_7=Proximity tomarket(PROXMARK): the distance of plot from the nearest market in kilo meter (km)

Z_8=Variety of coffee planted (VARIETY): A dummy variable having the value of 1 if the farmer has used improved coffee trees (Java) and 0 otherwise

Z_9=Family pressure(FAMPRES): Expressed as family size per total land owned by the household head

Z_{10}=Membership in the local organization; a dummy variable having the value of 1 if the household head is a member of the local organization and 0 otherwise

Z_{11}= Livestock ownership; the number of livestock owned in(TLU)

Z_{12} = Off-farm income (OFFINCOM): This is also a dummy variable which is measured as 1 if one of the household members participates in off-farm activity in the last four months (which is production season counting back starting from the survey period) or 0 otherwise.

.δ=isa(Mx1) vector of unknown parameter to be estimated

3.7.Variabledescriptionand hypothesis

Output(dependent variable): The total output of a farmer was measured as the total quantity of coffee produced in a crop year and measured in kilograms.

Land (independent variable 1): is the total area of land used for coffee farms in hectares (ha). Land is the most important input for smallholder farmers. In this study, land refers to the total area of farm land used for coffee farming. It doesn't include marginal, set aside lands, and grazing lands.

Labor (Independent variable2)*:* is the total number of family and hired laborers used in different stages of production such as general cultivation and harvesting.

Manure (compost) (independent variable 3): is a dummy variable assuming 1 if the household uses manure and 0 otherwise. Then compost is measured by kg. Studies indicate that those households using manure (compost) are more efficient in Production than those who are not using manure. Hence, it is hypothesized that farmers using manure are more efficient than others

Capital (independent variable 4): Indicates the amount of depreciation agricultural equipment in birr last coffee production year.

In general, several studies have shown a positive association between inputs and output in production. This implies that households who use appropriate inputs are expected to produce more output. Therefore, a positive association between the dependent variable (value of output) and all explanatory variables (inputs) is expected.

3.7. Socioeconomic VARIABLES

Age: is an indication of experience of the household in agricultural operations. Empirical studies for example Tan *et al.* (2010) and Etim and Okon (2013) argue that older households are more experienced than younger ones. Therefore, experience is expected to have a positive impact on farm output and the level of technical efficiency of the farmer.

Education*:* indicates the years of schooling of the household head. Education is usually an indication of the quality of labor. It is argued that educated (skilled) farmers have better skills in managing farm operations and understand new technologies that increase their production. Hence, education is expected to be positively associated with farm output and the level of technical inefficiency of the farmer. Coelli and Battese (1996) have confirmed the positive influence of education on farmers‟ production efficiency

Farming experience: A farmer's coffee farming experience is measured in years of coffee farming. Literature reviews on farming experience on efficiency have given mixed results. Farming experience could have negative or positive effects on the efficiency of the farmer. Parikh et al. (1995) reported a positive relationship between the age of the farmers (which is positively correlated with farming experience) and the efficiency of farmers in Pakistan and Ethiopia. These findings stem from the fact that farmers with more experience and who are older are likely to be more conservative and therefore less willing to adopt new practices, thus leading to low efficiencies in production. Coelli and Battese (1996) reported negative production elasticity with respect to farming experience for farmers in two villages in India, thus suggesting that older farmers are relatively more efficient and vice versa

Household Size: represents the number of household members. In smallholder production, the size of the household is a means to have more supply of labor. Weir &Knight, 2000 the larger the household size the higher the level of production they produce and the higher technical efficiency they will be. Hence, the size of the household is expected to have a positive association between production and the technical efficiency of the farmer.

Extension contact**:** is a dummy variable taking values of 1 if an extension expert visits the farmer and 0 otherwise. Those households who are visited by extension experts are expected to have more information which enables them to produce efficiently. Hence, the impact of extension services on the level of efficiency is expected to be positive

Sex of HH Head*:* is a dummy variable representing the sex of household head taking a value of 1 for male-headed households and 0 for female-headed households.

Distance: is indicates the distance between the farm plot and to home of the farmer, and it is expected that when the distance near to farm plot is expected farmers are more efficient

Proximity of market: it is distance between farm plots to nearest market.

Variety of coffee planted: it indicates type of coffee that bearing product .it is dummy variable that 1 for modern 0 for local type. It is expected that a farmer who use modern type are more efficient.

Variety of coffee planted (VARIETY): A dummy variable having the value of 1 if the farmer has used improved coffee trees (Java) and 0 otherwise. It is expected that a farmer has modern type of coffee is more efficient.

Membership of local organization: it is dummy variable that household head is member of local organization or not. It is expected that those who are member of local organization are more efficient than non-member farmer.

Livestock owned*:* agricultural productivity can also be affected by the number of livestock owned by the farmer.

Off-farm Income*:* It represents total income generated from any type off-farm activities including remittances.

IV. Results and Discussion

4.1. Descriptive statistics results

Among many descriptive summaries that can be incorporated in this study, the researcher considered, frequency and percentage to summarize categorical factors affecting coffee yield of the farmers. Additionally, other descriptive measures like average, standard deviation, variance, minimum, and maximum were considered to get general information about the response and covariate or continuous predictors as it was discussed below.

Table 2: DemographicandsocioeconomicVariables

Characteristics	Category	Count	Table N%
Sex of the respondents	Female	15	10.00%
	Male	135	90.00%
Education status	Illiterate	14	9.30%
	Elementary	92	61.30%
	High School	37	24.70%
	Certificate and above	7	4.70%
Marital Status	Single	0	0.00%
	Married	146	97.30%
	Divorced	4	2.70%
	Widowed	0	0.00%

Source: survey result

As the above result, Table 2 indicates that out of 150 respondents 135 are male and the remaining 15 are female. This indicates that 90% of sample kebele's coffee farmers are male and the remaining 10% are female which indicates that the majority of farmers producing different agricultural products in general and coffee in particular are males. This indirectly shows that the agricultural sector of our country is mainly owned by males. However, to have stable growth of certain products, they should be produced by both males and females simultaneously. But, this does not mean that males are the only participants in the production of coffee in the selected woreda. From their, educational status 14(9.3%) don't get a formal education, 92(63.3%) of respondents attend primary school, 37(24.7%) are attending secondary school and the remaining 7(4.7%) of smallholder coffee farmers are join certificate above which indicates that most of sample kebele coffee farmers are primary level education. This shows that the majority of farmers producing coffee in Dale woreda do not have enough education background, since most household heads have only attended primary education and some does not have any education. We know that education is primary tool any economic activities and without education, someone can face many problem during production even if education is not only solution for the problem. For those who have basic educational background, they can easily manage and solve the problem of cost and balance of expenses and gain at the end of each year. From them 146(97.3%) are married and left 4 (2.7%) are divorced. This shows that in study area about 98% of household head are married and leading their life in participating agricultural sector. These help coffee farmers to lead their life stable way.

Table 3: ContinuousDemographicMeasures

	Mean	Maximum	Minimum	SD	Total N
Age of the Household head	46	71	28	10	150
Farming Experience	25	55	6	11	150
Family Size(numbers)	6	12	2	2	150

Source: **survey result**

From total of age house head respondents minimum age is 28 year and maximum is 71 years this indicate that the range of this very high means that most of small holder coffee farmer in study area is adult thus they are capable to run their farming system more and manage their farm properly than those young farmers in average 46-year-old. The farmers in sample kebeles are participate in coffee farming more than 6 years and to the maximum 55 year in coffee farming experience whose mean year farming is 25 in average. Those farmers having long time experiences in coffee production can manage collect necessary information relating to how tackle factors those affect coffee yield and lead their farm more profitable way as compare with farmers having less experiences. In addition, sample kebele family size in average6 families per household whose dependent ratio is above dependency ratio which is 6 people per household to the minimum dependency ratio about 2 families per household and to the maximum 12 family per household. In study area population density too high which helps to get cheap labor coffee yield by using available man power effective way (Table 3).

Table 4.Continuesvariablesdeterminingtechnicalefficiencyoffarmers

Variables	Mean	Std. Deviation	Min	Max	TotalN
Land Size	1.37	0.66	0.30	3.00	150
Land Covered by Matured Coffee in ha	0.60	0.29	0.10	1.35	150
Age of the Coffee Tree in years	18	9	5	42	150
Number of labor hours Participant	164.5	49.24	78	249	150
Amount of composited used in kg	788.6	781.97	0	4000	150
Capital for agricultural equipment in birr	128	44	30	270	150
Amount of Annual Coffee produced in kg	994.3	541.79	100	2800	150
Distance from home to coffee plot in km	0.085	0.157	0.010	1.120	150
Livestock holding TLU	2.987	1.4409	0.68	8.98	150

Source: survey result

In sample kebele land owned by coffee farmers are minimum area is 0.3 hectare and to the maximum 3.0 hectare in average 1.37-hectare land have owned by sample kebele out of from total land owned by smallholder farmer matured coffee is covered 0.1 to 1.35 hectare in average 0.60 hectare of land is covered by matured coffee. Land is an essential input for farmer to produce agricultural products in general and coffee in specifically without land producing agricultural product is impossible and it a scarce resource that cannot extended. Due to this it need proper management and keeping its fertility a serious issue to sustain life with agriculture. Average year of coffee trees in study area is about 18 years old whose minimum age of tree is 5 years and its maximum is year is about 42 years old from this researcher found that coffee tree ageisinaverageabout 18meanthatinstudykebele"salmostallfarmerhavematuredcoffeethat can bring coffee.

The labor participated by smallholder coffee farmers in sample kebeles is on average 78 an hour in all directions for coffee collection, harvesting, weeding, and pruning activities. Many people in Dale woreda participate in coffee farms because more than 80% of Dale Woreda participate in agricultural activities. in sample kebele out of 150 coffee farmer 131 use compost in their coffee which improves coffee product by increasing soil fertility of the land covered by matured coffee. It very important input in coffee production because in our country's context, it is forbidden to use chemical fertilizers for these reasons in Ethiopia coffee farmers use natural fertilizers like compost, manure, and dung which maximizes coffee yield.

In the study area production season on average 788.66 kg of compost is used by smallholder coffee farmers to a minimum of 0 kg to a maximum of 4000 kg of compost is used in sample kebele's farmer which improves coffee yield. In coffee production, compost has a large effect on its yield because it improves the fertility of the soil and helps coffee to bring yield continually. The value of agricultural equipment that lost its value in the last coffee season is calculated by the straight-line method result is an average of 128/birr which in a minimum of 30 Ethiopian Birr depreciates in the last coffee production season and to the maximum of about 270 Ethiopian Birr of agricultural equipment loses its value by giving service for farmer to produce last season coffee yield. In the study, area coffee production ranged from 100kg to 2800 kg and its mean is about 994.28kg of coffee production in 2008/2009productionyear. The distance between the coffee plot and the home of the household heads coffee in sample kebele is in mean 0.085km (85m) far away from the farmers' home means that the farm plot to the farmer's residence is not far which is at minimum 0.001km(10m) far and which is too far is 1.12km(1120m) far away from farmer residence.

Household livestock holding in the study area ranges from 0.68 to 8.98 TLU and the mean TLU is about 2.98. The livestock holding has positively affected the production level in the study area by making compost from livestock manure, dung, etc, in addition, farmers who have livestock can sell them can buy agricultural input and get more yield due to these reasons being livestock ownership has the advantage to increase coffee yield in the study area.

Table 5. Determinants of technical efficiency of farmers in Dale woreda

Variables		Count	Percent
Composite Usage Status	No	19	12.70%
	Yes	131	87.30%
Availability of Extension service	No	47	31.30%
	Yes	103	68.70%
Service obtained from the extension service	PruningSystem	0	0.00%
	Weeding	0	0.00%
	Harvesting	6	4.00%
	CompositeUse	30	20.00%
	All of the above	114	76.00%
	Others	0	0.00%
A variety of coffees used	Local	31	20.70%
	project/modifiedtype	54	36.00%
	Both/mixed method/	65	43.30%
Market access for agriculture imputes	No	44	29.30%
	Yes	106	70.70%
Are you a member of Cooperative Ass	No	39	26.00%
	Yes	111	74.00%
Do you have any off-farm income	No	67	44.70%
	Yes	83	55.30%
If yes for Q31, for what purpose do you use it?	Consumption	27	32.50%
	Buyinginputs	4	4.80%
	Both	52	62.70%
	Others	0	0.00%

Source: survey result

From the sample kebele out of 150 respondents 12.7 %(19) do not use compost and the remaining 131(87.3%) of respondents use compost fertilizer for their coffee farm. Those farmers who use compost for their farms are more efficient than those who do not use compost use for farm compost important input for coffee production in the study area and 103(68.7%)of farmers have access to extension advice for farming systems and 47(31.3%) of respondents do not have access to get extension access .from 103(68.7%)of farmers those have access to the extension they have got information and advice how to pruning; how to weeding; how to harvest; how to use prepare and use compost fertilizer for their coffee farm. Of the advice that farmers get from an extension agent 114 (76%) are general about how they can properly manage their coffee, and how they can prune, harvest, weeding and compost usage, in general, the remaining 6(4%) how to harvest and the remaining 30(20%)are especially how they prepare and can apply compost in their farm.

The type of coffee planted in the study area is 31 (20.7%) of farmers use local type of coffee 54(36%) of farmers use project/modern type coffee which is recommended by extension agent and remaining 65(43.3%) of farmer use both local and project type of coffee. Coffee variety is necessary issue to get average yield in production period because farmers who use modern type of coffee variety harvest better yield than those who use local/traditional type of coffee tree. Out of 150 farmers 44(29.3%) of coffee farmers have no sufficient market access to get agricultural equipment in near them and left 106(70.70%) of coffee farmer in study area have an access to market to buy agricultural equipment near them. Agricultural equipment helps farmers to plot properly and periodically without any obstacle of their coffee farm. Farmer in Dale out of 150 respondents 111(74%) of them are member of cooperative association and remaining 39(26%) of coffee farmers are not member of cooperative association. Being member of association gives an opportunity to share different information relevant to increase coffee yield, market information and share different information that helps farmers to tackle factors that affect productivity of coffee yield .in addition to coffee farmers in study area participate in different economic activities and have get off farm income. out of 150respondents 83 (55.3%) of coffee farmers participate in different economic activities and remaining 67(44.7%) of farmers lead their life participating only on farming activity. those farmers who participate in off farm activity manage their income for consumption purpose, to buy agricultural inputs and for both purposes. From 83 respondents those have an off farm income 27(32.5%) of farmer use their off farm income for consumption purpose, 4(4.8%) of them use to buy only agriculture input and the rest 52(62.7%) farmers use their off farm income both for consumption and to buy agricultural inputs for their coffee farm.

Descriptive Statistics of Technical Efficiency of Farmers

This section highlights a key result of the study gives some general evidence on the technical efficiency of farmers and gives direction about their average technical efficiency as well as their variability with others. The results on factors influencing the technical efficiency of coffee production are also presented in the next section. (Results of TE by using frontier 4.1c software).

Table 6: Summary of Technical Efficiency of Farmers in Dale Woreda

TE	Frequency	Percent	Valid Percent	Cumulative Percent
<0.5	37	24.7	24.7	24.7
0.5-0.6	25	16.7	16.7	41.4
0.6-0.7	22	14.7	14.7	56.1
0.7-0.8	19	12.7	12.7	68.8
0.81-0.90	27	18.0	18.0	86.8
0.91-1.00	20	13.3	13.3	100
Total	150	100	100	

Source: survey result

A study revealed that technical efficiency ranges between 2.9 and 99.04%. The lowest level of efficiency is 2.9%, which is far below the efficient frontier by 96.14%. Such production units are technically inefficient. The majority around (24.7%) of smallholder coffee producers achievedtechnicalefficiencybelow50%, followed by between (0.81-0.90)18%, (0.51-0.60) 16.7%, (0.61-0.70) 14.7%, (0.0.91-1.0) 13.3%, and (0.71-0.80) 12.7%. This result shows that most respondents' technical efficiency is above 50% and still there are a significant number of farmers whose technical efficiency is below 50%.

Table 7: Descriptive Statistics on Responses

	N	Min	Max	Mean	SD
AmountofAnnualCoffee produced	150	100	2800	994.3	541.79
TechnicalEfficiency	150	.02	.99	.6543	.2256
Technical inefficiency	150	.01	.98	.3457	.2256

Source: survey result

The mean technical efficiency score (65.43%) of the sample production units implies that on average, 34.57%% more coffee output would have been produced with the same level of inputs if the producer had been in their most efficient frontier following best practices. From this, it can be concluded that on an average farmer in the sampled area could save an average of 33.91 % [i.e.1- (0.6543/0.99) x100] of cost saving if a farmer was to achieve the technical. efficiency level of his most efficient counterparts.A similar calculation for the most technical inefficient farmer reveals cost saving of 79.798 percent [i.e. 1-(0.2/0.99) x100].

Results on factors affecting production of CoffeeYield andits Interaction Effects

Selection of functional form and Hypothesis testing

If we are using maximum likelihood estimation and wish to test whether certain parameter restrictions are supported by the data, one useful and very convenient test is likelihood ratio test. In a large sample we know that Λ follows the chi-square distribution. First hypothesis is concerned about the selection of appropriate functional form that adequately fit the data. In order to select frontier model that fits the data well, Trans log specifications are considered.

Accordingly,Translog specifications function is the appropriate functional form that fits the data set adequately after comparing it with Cobb Douglas production function. For this study, likelihood ratio test was used to select the best specification, among the two, that describes the data well. The likelihood ratio test here is

calculated based on the formula stated in part three. This value was compared with tabulated chi-square which is given by Kodde and Palm (1986: 1246).
TheLR test statistic(ƛ) is calculated as follows:
ƛ=−2ln[L_0-L_1] , the values of logarithm, likelihood function for Cobb-Douglas and trans log model for coffee production were -67.556385 and -12.326363 respectively. Therefore, generalized likelihood ratio test result would be:-
ƛ=−ƛ=−2ln[L_0-L_1]=-2lnL0=LnL1=-2[-67.556385-(-12.326362)]=-2[67.556385+12.326362]=110.46

The value of likelihood ratio statistics was found to be 110.46 which was greater than the critical chi distribution value of 16.75 with 10 degrees of freedom (the number of restrictions for the interaction terms in the model) at a 5% level of significance. The null hypothesis which says the Cobb-Douglas production function is the appropriate functional form that fits the dataset (H0:βik = 0) adequately is rejected. Hence, the trans-log production function is used for the analytical purpose in this study since it was more precise and consistent compared to the cob-Douglas (restricted) model.

Having selected the trans log production function specification for explaining in efficiency term (ui), the second null hypothesis for this study state that farmers are technically efficient and no inefficiency is attached to production level and that is to mean farmers are operating on the technically efficient frontier. Putting this in simple terms, Dale woreda coffee producers were technically efficient(H0: μ=0). This test was computed automatically when the frontier model was estimated using STATA version 13 (Table 7).

As indicated in table 4.3.1, the inefficiency component of the disturbance term (u) is significantly different from zero. Therefore, the null hypothesis of technical inefficiency (H0: Sigmau=0) is rejected. This indicates that there is statistically significant inefficiency in the data. The lambda (λ) value is also greater than one in all the cases. This is a further indicator of the significance of inefficiency. Similarly, the value of gamma tells us the percentage of total variation caused by the technical inefficiency of farmers concerned under the study. In the model, 97.4% of the total variation of output is caused by technical inefficiency. This means that technical inefficiency is likely to have an important effect in explaining output among farmers in the sample.

The third null hypothesis for this study states that variables included under the inefficiency effect model do not significantly explain the inefficiency of the farmers in Dale woreda (that is to say algebraically (H0:ƛ= δ0=δ1=…δ12=0). The null hypothesis which states that age, educational level of the farmer, sex, experience in coffee farming, off-farm income, cooperative credit, livestock ownership, variety of coffee planted, distance to plot, proximity to market, and extension visit do not significantly influence farmers technical efficiency level is also rejected. In fact, this last result indicates that the joint effects of all the explanatory variables on the productive inefficiencies are important even if some of them are not statistically different from zero.

Parameter estimates

Most of the variables determining technical inefficiency are also statistically significant. It is evident from Table 4.3.1 that the estimate of Lamda ƛ is 6.702 (the variance parameter showing the ratio between the normal error term and half normal positive error term), which indicates that the one side error term u dominates the symmetric error v, so the variation of actual output of coffee production mainly comes from differences in farmers practice (mismanagement of farm) rather than random variability.

Moreover, this verifies the fact that there are measurable inefficiencies in coffee production probably caused by differences in the socioeconomic characteristics of the households and their management practices. Here, the results of the production function of coffee yield using regression after transformation were considered and factors responsible for the change in coffee yield by each household were obtained at 5% and 5% confidence levels and the results are described below.

Table 8: Coefficients of coffee production by farmers using Maximum Likelihood Estimation

Stoc.Frontiernormal/truncated-normal model	Numberofobs	=	150
	Replications	=	131
	F(1, 130)	=	90.07
Loglikelihood=-12.326362, Prob >F	= 0.0000		

Lncoffeeyield	Coef.	Jknife*Std.Err.	t	P>|t|
Lnland cover	.8327486	.8827905	1.94	0.046
LLaborhour	1.195931	1.117679	1.07	0.041
Lncompost	2.168333	.6518139	3.33	0.001
Lncapital	1.99959	1.295398	1.54	0.123

$Lnland^2$	1.3264871	.0952414	3.43	0.001
Llabor2	1.3549672	.1677797	2.12	0.034
Lnconp2	.2144416	.0237023	9.05	0.000
Lncapital2	.0106212	.0966259	0.11	0.912
LnLandXLnlabor	-.0400403	.076948	-0.52	0.603
LnLandXLncompst	-.0976181	.1108996	-0.88	0.379
LnLandXLncapital	-.0897992	.2560566	-0.35	0.726
LnLaborXLcomst|	.3851998	.1913751	2.01	0.044
LnLaborXLncapital	-.3080956	.0920582	-3.35	0.001
LncompostXLcapital	-.369755	.0970861	-3.81	0.000
_cons|	.327761	4.166846	0.08	0.937

Varianceparameters

Lamda [] 6.702

sigma2|	.4217228	.639533	
gamma|	.9740476	.0443574	
sigma_u2(σ^2_u)|	.4107781	.63194	
sigma_v2(σ^2_v)	.0609447	.0182667	
	z =-3.179	Prob<=z= 0.001	

From the output of the frontier model, factors like the land cover, the labor force in hours, and the amount of composite used which are considered individual are significant since their p-vale is less than 5% at a %5 significance level. Also, the square of the above significant factors i.e. the square of (land covers, labor in hours, and compost used) is significant at a 5% level of significance. When we come to the interaction effect, the interaction effect of factors like labor hours vs compost, labor hours vs capital, and the interaction of compost vs capital are significant at 5% level of significance.

The maximum likelihood estimates of the parameters of the stochastic production frontier were obtained by using the program Stata13 and presented in the Table above. The result from MLE is presented above after the necessary transformations were made. Estimated MLE results obtained from the study revealed that out of four individual predictors their squares and the corresponding interaction effect, three variables, their squares, and the four interaction effects are significant at a 5% level. The signs of the coefficient in both estimate cases are the same and have expected signs.

The parameter gamma lies between 0 and 1; with a value equal to 0 means that technical inefficiency is not present and ordinary least square estimation would be an adequate representation of a value close or equal to one implying that the frontier model is appropriate the estimate of gamma is significant.

The maximum likelihood estimates for the parameter gamma (γ), furthermore, explain that around 97.4% of the variation in the model is caused by technical inefficiency. This indicates that from total variation of output in coffee production, 97.4% of the variation is due to the inefficiency effects of farmers' specific attributes and the rest 3.6% is due to random error. This means that the major problem for the deviation of output from the potential level is due to the inefficiency error, ui and not due to the random error, vi beyond the control of farmers. Similarly variance (σ)is also 0.41 which are significantly different from zero, indicating a good fit and correctness of the specified distribution.

Furthermore, lambda (λ) which is around 6.7 indicates that variations in coffee yield by farmers in Dale woreda of Sidama Region are mainly due to differences in the production practices or technical efficiency of farmers and not by random variations. Similarly, gamma (γ) measures the share of changes in the technical inefficiency with respect to the total variability of the model errors. Thus, the estimator of gamma (γ) indicates that around 97% of the total variation in the coffee yield by farmers is due to technical inefficiencies in the study area rather than other factors. Also from the results of the analysis, variables like: Lin Land cover, Lin composite used andtheir squares and four interaction effects presented in the is significant at 5% level ofsignificance.

This indicating that, as one increases his plowing land size his or her coffee yield also increases since the coefficient is positive indicating the existence of positive relationship between land cover and coffee yield by farmers (β=.8327486,t=1.94andp-value=0.046<5%) which means that as one improves his land size for coffee production may be from one hectare to above, his yield also increases. This is clear that rather than producing coffee in small Pluto of land, it is better to consider the larger land size even if it is difficult to get some extra land which issuitable for coffee production. But, this does not mean that, byincreasing land size only, one can increase his/her yield because to get better yield someone has to consider other important inputs in addition to land size in order to get better coffee yield in the study area.

When we come to significant predictor labor used in hours, it is significant at a 5% level and the coefficient is positive indicating the positive increasing relationship between labor used and with amount of coffee yield by farmers (B=1.195931, t= 1.07and p-value=0.041). This means that, as one increases the use of labor to produce better output, the amount of coffee yielded by farmers also increases. As we know, as one improves the proper land management as well as plowing, he/she can get better yield and this can be done by increasing the number of laborers which is very important to get better yield as well as take care of original coffee which has a better market value. Even if it is not the only solution to get better yield, it is the best option in relation to accessibility, value, cost, and future betterment of land usage by farmers in the area.

When we come to significant predictor compost usage, it is significant at the 5% level and the coefficient is positive indicating a positive increasing relationship between the amount of compost used with coffee yield by farmers (β=2.168333t=3.33,p-value=0.001<5%). This means that, as one increases the use of different natural compost, the amount of coffee yielded by farmers also increases. As we know, as one improves the nitrogen content of the soil, he can get a better yield and this can be done by using compost which is very important to get a better yield as well as original coffee which has better market value. Even if using compost is not the only solution to get better yield, it is the best option relative to accessibility, value, cost, and future betterment of land usage by farmers in the area.

The square of the above three inputs land, labor, and compost are significant since their p-value respective is (0.001, 0.034, and 0.00) which is less than 5% at a 5% level of significance. This indicates that their square is also significant in addition to individual effect significance, i.e. by working on those, factors, one can get better coffee yield. Their coefficients respectively are (1.3264871, 1.3549672, and 0.2144416) which is positive indicating the positive relationship between coffee yield and the square land, labor, and compost effects.

The cross product of exponential variables like; (labor and compost), (labor and capital) and (compost and capital) are significant at a 5% significance level. This indicates that using high compost with sufficient capital has a significant contribution to high coffee yield because one has to use each input proportionally. This is an indication that using a wider manpower size is not the only solution to get better yield, rather, using it with sufficient manpower brings an effective working environment for the industry, the coefficients are negative (β=-0.369, t= -3.81 and p- value=0.000) indicating that, one has to use capital, appropriately, since expanding high amount with sufficient adjustment can negatively affect coffee yield.

Also when considering the interaction effect of labor in hours and amount of compost used, its coefficient is positive and significant indicating that, as one increases his man power on the agricultural land of coffee with proportional amount of compost for the land, he/she would get better yield since p=value is less than 5% at 5% significance level (β=0.3851, t=2.01with p- value=0.044<5%). This is due to the fact that, as one increases his land cover with sufficient amount of compost, he/she has better chance to get better coffee yield for which hecan get better income by selling those coffee even if this is not only final solution to get better. Because, to get better yield someone to consider other factors like labor, technology, fertilizer and the like to get better yield in addition to the land cover and compost use.

When discussing about the interaction effect of labor hours and capital, it is statistically significant at 10% significance level (β= -.3080956, t= -3.35 with p-value=0.001<5%) which shows that as labor and capital for an equipment increase, then it has significant negative effective for coffee yield by farmers. this may be due to, as capital for different agricultural equipment increases, then it significantly affects their yield because when price as well as labor increase, they have expend high amount money for buying agricultural equipment and wage for labor which indirectly affects their net income. It has a negative effect; since capital and labor they have the expected sign and it needs further study to decide on those factors.

Results of Technical efficiency by Farmers and Associate Factors

In this portion, the results of technical efficiencies of the 150 respondents of the Dale woreda are presented. To incorporate the technical efficiencies and the associated factors, among many methodologies, Stochastic Frontier Analysis (SFA) was used. It is a parametric technique that uses standard production function methodology with some assumption on the distribution of error terms. The approach explicitly recognizes that the production function represents technically the maximum feasible output level for a given level of input. The Stochastic Frontier Analysis (SFA) technique was used to model functional relationships between farmers' technical efficiency on coffee yield and corresponding various factors affecting the coffee yield of farmers in the study area with some theoretical bounds:

Factors Determining Technical In/Efficiency of Coffee Production Using SFM

The determinants of efficiency were modeled using socio-economic factors, that affect farm operations and technical efficiency of coffee production to have policy implications. For this purpose, the parameter's technical efficiency (TE) indices were estimated by using a two-limit censored Tobit procedure, and the results are presented in Table below. Based on the results of the analysis, factors like the educational status of the respondents, age of the coffee tree, household livestock holdings, membership of a local Cooperative association, service obtained from the extension service, and presence of some additional income are significant predictors of technical efficiency of farmers in Dale Woreda since the p-value of those factors is less than 5% or 10% at the respective level of significance.

The education level of the farmers had a positive coefficient for technical efficiency (δ= 0.691, t= 0.215, p-value=0.002 and β=0.933, t= 0.076, p-value=0.001) respectively for two dummies. The positive coefficients obtained for the level of education implied that education contributes to an increase in the efficiency of coffee production since its coefficient is positive. Educated farmers were more sensitive to technical change, and they had a higher adoption rate than those educated less. From this, it can be concluded that more educated farmers achieved a higher level of technical efficiency than farmers with less education. The result from this study is consistent with evidence from Battesse and Coelli, (1996), Kibaara(2005), Wakil(2012), Nchare(2007), Elibarik and Shuji(2008), Kariuki et al. (2008), and Njeru (2010) indicated that education enhances the ability to utilize available technology and increase's efficiency of farmers thereby.

The estimate for farming experience is positive and significant (δ = 0.500, t= 4.167 and p-value=0.003<5%); this suggests that the more experienced a farmer is the higher the chances of that farmer being more efficient. This can be explained by the fact that farming is done under risky environmental conditions such as erratic rainfall, therefore, farmers who have cultivated the same crop over a long period can make accurate predictions on when to sow, the inputs to use, the quantity to use as well as the timing of the use of these inputs and are therefore more efficient in the use of these inputs as compared to inexperienced farmers. This finding is similar to the findings of Wakil (2012) and Elibarik and Shuji(2008), who also found that experience positively affects the level of technical efficiency.

Concerning the age of the coffee tree, it is significant and positive (δ = -0.400, t=-3.333 and p-value=0.001), which indicates that the age of the coffee tree has a negative significant effect on the level of technical efficiency of farmers. This means that if the age of coffee trees increases the productivity of coffee/coffee production decreases due to the biological life expectance of year coffee tree. It is mostly assumed by researchers that, coffee trees have some age limit for which the tree minimizes productivity similar to any other product. After its marginal age of productivity, its yield will decrease and finally, the tree is going to die out. Thus, after its marginal productivity age, an increase in the age of the coffee tree will increase the inefficiency of farmers because even if they fulfill all necessary inputs for production, the yield will decrease due to the age limit of the tree.

When we come to Household Livestock Holdings, it is significant in determining the technical efficiency of farmers since its (δ= 0.287, t= 2.208, and p-value= 0.003) are significant at a 5% level of significance. The coefficient is significant and positive indicating the positive relationship between technical efficiency and household livestock holds, which means as the number of livestock holdings increases, coffee production, speed of plowing, income, and the like increases leading to improving efficiency of farmers in different aspects.

Membership of local cooperative association was represented as a dummy variable in the model; i.e., 1 having had a member of the cooperative association and 0 otherwise. Its coefficient was positive and it affected efficiency significantly, since (δ = 0.978, t= 3.155, and p-value=0.002<5%). The positive coefficient of membership of a cooperative association means that membership of an association results in increases in technical efficiency. This suggests that households that belonged to farmer cooperative associations or clubs were more likely to benefit from better access to inputs such as modern coffee variety and information on improved farming practices. Being a member of the coffee cooperative association provides an avenue for information and technology transfer by extension agents and often leads to the sharing of information even among members themselves. This enables the household heads to make appropriate decisions, which in the long run enhance productivity and efficiency.

The estimated coefficient associated with contact with extension service agents is positive and statistically significant since (δ = 0.219, t= 1.810 and p-value=0.080 < 10%) at a 10% level of significance, implying that contact with extension service by farmers for advice helps to reduce technical inefficiency. Al-Hassan (2008) reported similar findings that confirm that contact with extension service by farmers reduces inefficiency. The result therefore seems to emphasize the role of extension service in coffee production. Agricultural extension serves as a bridge between researchers and farmers and thus represents a mechanism by which information on new technologies; better farming practices and better management are transmitted to farmers. An increase in the number of extension contacts with coffee-specific messages is expected to improve farmers" productivity and technical efficiency. The results show that farmers who have increased frequency of extension visits produced less inefficiency compared to farmers who had few contacts with extension agents. This result is consistent with the study carried out by Wakil (2012). This implies that effective extension visits and supervision will go a long way to improve farmers‟ production efficiency

Distance is also another variable affecting the technical inefficiency of farmers. In many empirical studies, it is hypothesized that the distance between the plot and home increases the level of inefficiency of farmers. In line with this hypothesis, the coefficient of the variable is found to be positive and statistically significant at a 10 percent level of significance. The more distant the farmer’s plot is from home, the more technically inefficient the farmer is. This could be because; one, the level of close supervision may not be so strong when the plots are far away from home; two, a coffee farm plot that is outlying from home could be affected by negative externalities like theft, pest and wild animals; three, disease like coffee berry could attack the coffee fruit.. Moreover, a higher distance to the market leads to higher transaction cost that reduces the benefits that accrue to the farmer. More importantly, a longer distance from the market discourages farmers from participating in market-oriented production. A similar result was found in the work of Alemu *et al.(*2008).

The estimated coefficient associated with off-farm income is negative and statistically significant(δ = -0.182, t= -2.220 and p-value=0.091 < 10)at a 10% level of significance with technical inefficiency, implying that farmers in the study area have off-farm income are less give less attention on coffee production and use theirs out of farming activity. The researcher expected that off-farm income would increase the technical efficiency of coffee production but the final finding shows that off-farm income does not have a positive effect on the technical efficiency of coffee production in the study area. This result is consistent with the findings of Abdulai & Huffman (2000) who argued that non-farm labor supply curtails farming efficiency.

Other remaining factors are not significant in determining the technical efficiency of farmers in the chosen areas but have the same expected sign also the researcher rejected the null hypothesis of no difference and concluded that at least one of the explanatory variables considered under the study has significant contribution in determining technical efficiency of farmers in dale woreda.

Table 9. Results of Estimated Coefficients of Technical Efficiency of farmers using the Tobit model

		Coefficients		t	Sig.
		δ	Std. Error		
(Constant)		0.632	0.211	2.995	0.003
Age of the Household head		0.1003	0.12	0.836	0.706
Educational Status of the Respondents	D1	0.821	0.721	1.139	0.348
	D2	0.691	0.215	3.231	0.002*
	D3	0.933	0.076	12.276	0.001*
Farming Experience		0.5	0.12	4.167	0.003*
Family Size(numbers)		-0.18	0.35	-0.514	0.621
Proximity to market		0.423	0.304	1.39	0.538
Age of the Coffee Tree		-0.4	0.12	3.333	0.001**
A variety of coffees used		0.029	0.08	0.363	0.723
Distance from Home to Coffee plot in Km		0. 610	0.313	1.949	0.062**
Household Livestock Holdings		0.287	0.13	2.208	0.030**
Membership of the Cooperative Association		0.978	0.31	3.155	0.002**
Extension service		0.219	0.121	1.810	0.080*
Access to off-farm income		-0.182	0.082	-2.220	0.091*

Source; study result (*-significantat10%and**- significant at5%significancelevel)

Checking the Validity of the Model

When fitting the linear model after, we have to check the validity of the assumptions like normality, heteroscedasticity, autocorrelation, and multicollinearity. The result presented in the appendix B (1 to 6) indicates that:

1. A histogram with a normal curve and p-p-plot shows that the data is normally distributed since the residuals are randomly distributed around the normal curve with the mean at the center of the distribution.
2. When considering the autocorrelation: the value of the D-W test in Appendix A is equal to 1.98 which is closer to 2. But, when the D-W test is closer to 2, then the population correlation coefficient is closer to zero

indicating no autocorrelation between the neighboring residuals. i.e. the neighboring residuals are not correlated with each other.

3. Concerningthemulticoleanaritywhich can be mostly measured using tolerance as well as VIF and the VIF for all explanatory variables considered under this study is less than 5, as it was presented in the appendix which is sufficient to suggest that there is no multicollinearity. i. e. the explanatory variables are not correlated with each other.

V. Discussion

The primary contribution of this study is that it points out different factors affecting coffee yield in the selected woreda of Sidama Region by using the application of the stochastic frontier production function approach in order to measure and explain the technical inefficiency of farms in Sidama Region. This enables a more detailed understanding of the nature of technical efficiency in coffee production in the Sidama Region. The empirical results of technical efficiency and influencing factors are necessary for policymakers to enable them to choose the appropriate direction of policy implications to increase productivity and, thus, sustain the demand and supply chain of coffee in the Sidama Region. The second contribution of this study is the provision of information, especially in coffee farms. The third contribution of this study is that, by using empirical results, Region policymakers can better understand that the considerable variability of fertilizer types does not have different impacts on technical efficiency in coffee production in different farms.

Wilson et al., 1998 indicated that, given the difference in efficiency levels among production units, it is valuable to question why some producers can achieve relatively high efficiency while others are technically less efficient. Variations in the technical efficiency of producers may arise from farm-specific socio-economic and management factors that impact the ability of the producer to adequately use the existing technology. The parameter estimates for the inefficiency effects model shown in the table above suggest six important findings. First, the estimated coefficients of Educational status, Farming Experiences, Service obtained from the extension service, membership of cooperative associations, household livestock holdings, Age of the Coffee Tree, and presence of additional off-farm income and dummy variable proxied for a producer with categorical variables are mostly negative except Age of the Coffee Tree. This implies that producers with more experience, and used organic farm practices achieved higher levels of technical efficiency. In other words, producers with higher education and used organic production systems are likely to get higher levels of technical efficiency in their farm management. Second, the empirical results have a positive effect on technical inefficiency. This suggests that farmers who have many aged coffee trees achieved lower levels of technical efficiency.

VI. Conclusion and Recommendation

5.1. Conclusions

The results of SFA on the technical efficiency of farmers indicate that an increase in technical efficiency of farmers is due to factors like increases in education status, increase in farming experience, decrease in age of the Coffee Tree, decrease in Distance from Home to Coffee plot in Km, increase in Household Livestock Holdings, being a member of Cooperative Association, availability of extension service and presence of any off-farm income. Thus, the above factors are significant in determining the technical efficiency of the farmers in the dale woreda, and by working on those factors, farmers can improve their technical efficiency directly and improve their coffee yield indirectly.

5.2. Recommendations

The results show that this group of farmers still lacks the levels of education and experience that are sufficient to approach optimal levels of productive efficiency. Strictly speaking, only acreage, education, and experience were statistically significant. Nevertheless, variables such as family size and variety of coffee did not contribute positively to the levels of technical efficiency, but they were not statistically significant.

Therefore, these farmers can further optimize production by increasing the use of compost, proportional labor, and land cover, maximizing land cover, and using sufficient labor force with minimum capital for equipment simultaneously, they can improve technical efficiency which further leads them to have better coffee yield.

Farmer's woreda can improve their technical efficiency by replacing the old coffee trees with new ones, improving educational status through learning, improving the farming experience by maximizing good trends, and adding some Livestock Holdings that have significant contributions to plowing as well as compost formation.

According to the evidence, the policy implications are clear. Given the high and positive correlation between the years of schooling and technical efficiency, these farmers should be encouraged to improve their levels of education by becoming involved in rural extension programs such as continuing education centers for adults. Greater efforts must be made by government institutions with regard to providing technical assistance and promoting the training of farmers in new technologies that would help them boost their current levels of

efficiency. If these efforts were made, farmers would be better prepared to take advantage of increases in yield. Furthermore, access to credit is necessary to stimulate technological innovations that foster increases in coffee yield.
Another possibility would be to conduct studies of technical efficiency on this type of crop by using non-parametric methods such as the aforementioned Data Envelopment and Bayesian Analysis to compare the results that have been obtained to date.

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