Analysis of Technical Efficiencyof Coffee Production in Sidama Zone in Ethiopia

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ABSTRACT

This study analyses farmer's productivity and technical efficiency of coffee production in Sidama Zone. To this end, a stochastic Cobb-Douglass production function was estimated using cross-sectional data. The stochastic frontier analysis result showed that coffee farm size, labor, compost (organic fertilizers) and improved coffee variety were important inputs. The technical efficiency of coffee farmers varies from 10 to 97 % with the mean technical efficiency of 52%. However, coffee productivity and quality improvement package participation did not affect technical efficiency. Consistent with the hypothesis intercropping khat and coffee and age of coffee tree were found to significantly increase the technical inefficiency of farmers. The cash income of smallholder coffee farmers and the problem of low coffee production and productivity in the sector could be handled with best practices.

Key Words: Technical Efficiency, Stochastic frontier model, Cobb-Douglas Production Function, Coffee production etc.

1. Introduction

Agriculture is the driver of sustainable development for poverty reduction in most of the developing countries of the world. It shares more in gross domestic product (GDP) in most of the sub-Saharan countries in Africa. Ethiopia is the birthplace of Arabica coffee. Coffee production is Ethiopia's main industry, and it is the leading Arabica coffee producer in Africa.Ethiopian coffee is intrinsically organic and renowned for its superior quality. Coffee is produced in most parts of the Oromia and Southern Nations Nationalities Peoples (SNNP) regions and with a lesser magnitude but significant expansion potential in the Amhara region.

1.1. Problem Statement

Several earlier studies examined factors affecting agricultural output and technical efficiency of farmers. This study, focus on technical efficiency of coffee farmers and the effect of Khat production on technical efficiency of farmers' coffee production. This study contributes to the existing studies by examining the technical efficiency of smallholder coffee farmers in Sidama Zone, Southern Ethiopia. Although Ethiopia is the origin of Coffee Arabica, farmers produce organic coffee and organic coffee production accounts for the largest share of exchange earning in Ethiopia, a few studies examined technical efficiency of coffee production in Ethiopia

1.2. Significance of the Study

The study concerns tocoffee production in Sidama Zone helping the country to realize how these main challenges can be eliminated to improve the coffee sub sector in Ethiopia. This would be very important for the point view of production, financing, resources and marketing factors that contribute towards the higher production and productivity in this important sector.

In the context of literature on technical efficiency of Coffee farming in Ethiopia, the present study expected to contribute to the literature in the case of efficiency of production function in concerned region. The research would also fill the gaps in the studies previously carried out by other researchers regarding the productivity and technical efficiency of coffee production in Ethiopia and also enable other researchers to carry out the study beyond this scope.

1.3.The Objective of the Study

- To measure the mean technical efficiency of the coffee producers.
- To identify factors affecting farmers' technical inefficiency of coffee production.
- To estimate the effect of intercropping of Khat production on coffee productivity.

1.4.The Hypothesis of the Study

Main hypotheses of the study are;

H_0: Each smallholder coffee farmer in the study area is technically efficient.

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H_1: There is the existence of inefficiencies in the production of coffee in the study area.

2. Literature Review

The concept of productivity is closely related to that of efficiency. Production function concerns to technical and mathematical relationship between variables which may be direct or inverse relation. It is helpful to analyze the relationship for better understanding of variables the term production concerns to utility creation but in this study it means to absolute production of coffee in particular region of Ethiopia. Productivity is the measure of efficiency in relative term and these are used in interchangeable. Efficiency also concerns to comparison of input and output. A firm is called efficient if it gets maximum output with minimum inputs. These inputs may be optimized in better combination but maintain the quality of production also.

Alternative ways of improving the productivity of a firm, for example, are by producing goods and services with fewer inputs or producing more output for the same quantity of inputs. Thus, increasing productivity implies either more output is produced with the same amount of inputs or that fewer inputs are required to produce the same level of output (Rogers 1998). The highest productivity (efficient point) is achieved when maximum output is obtained for a particular input level.

Efficiency consists of two main components; technical efficiency and allocative efficiency. As discussed in the previous section, technical efficiency occurs if a firm obtains maximum output from a set of inputs. When a firm achieves maximum output from a particular input level, with utilization of inputs at least cost, it is considered to be an overall efficient firm.The economic efficiency is measured by the global economic performance of the firm, that is, by its ability to make its operations profitable.

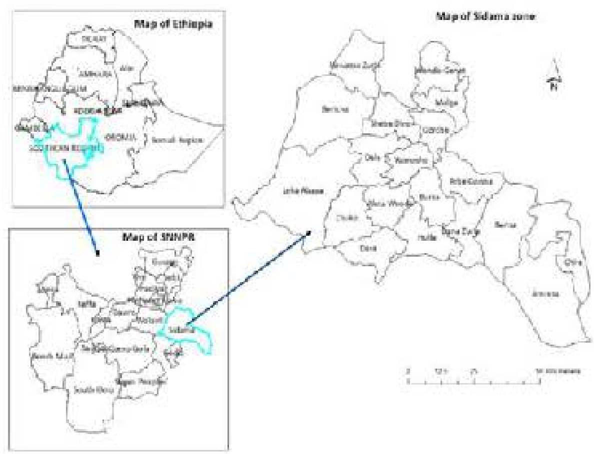
The first method consists of estimating a convex envelop while the second one permits to arrange the firms in growing order, so as to estimate a frontier in the form of stairs. The mathematical program planning helps to estimate the nonparametric approach frontiers. It is about some descriptive methods which use as support the linear program planning or the quadratic program planning.

3. Research Methodology

3.1 Description of the Study Area

This study was conducted in Sidama zone, Southern Ethiopia.Sidama is located in southern Ethiopia

Figure 1: Location of Sidama in Ethiopia



3.2 Research Design

The research employed both descriptive and explanatory (causal) research type. The reason for using a descriptive type of the research is to identify and clearly describe the factors affecting technical efficiency of coffee production, on the other hand; causal research type is used to see cause and effects of different factors on the technical efficiency of coffee growing farmers. The study also used cross-sectional studies research design which would help the researcher to collect data with a single contact with respondents due to time and resource constraints.

3.3 Data Type, Sources and Collection Method

The primary data which makes the core basis of this study were collected from 270 smallholder coffee growing farmers in Sidama Zone using a carefully structured questionnaire. The sample farmers were selected from three woredas of Sidama zone. All the data was collected for the year 2018/19harvesting year. The secondary data wascollected from scientific journal articles, books, published thesis, and reports from relevant organizations, conference proceedings, and related documents to supplement primary data.

3.4 Study Population

The study population of this research is the total number of smallholder coffee producers in Sidama zone. The sample frame (coffee producers list) from which sample size was drawn would betotal number of three kebele coffee producers from Dale, Aleta wendo and shebedinowhich is about 1445 coffee producers (Sidama Zone Agriculture Office,2010).

3.5 Sample Size and Sampling Techniques

3.5.1 Sampling Techniques

Both random and non-random sampling techniques were used. The study useda multi stage sampling technique. In the first stage, three woredas were selected using purposive sampling technique since these woredas are the known coffee producing areas in Sidama zone and their diverse agro ecological condition. In the second stage, one kebele will be selected in each sample woreda using Cluster sampling technique that also considers stratification by the prevalence of Khat intercropping status; the wider prevalence of Khat intercropping practice and none of Khat intercropping practice. Kebeles, as the smallest administrative unit in Ethiopia, were considered cluster in this study. Finally, sample coffee producers were selected randomly using a simple random sampling technique in each cluster.

3.5.2 Determining Sample Size

In stage three, the determined sample size was identified using (Yamane, 1967) fomula:

$$n = \frac{N}{1+N(e)2} \quad \text{(Yamane, 1967)}$$

Where: n = the sample size, N = the population size, and e = is the level of precision.

$$n = \frac{1445}{(1+1445\,(0.055\,)} \; 2$$

n 270

$n_i = nN_i/N$

$n_1 = n.N_1/N = 126$

$n_2 = n.N_2/N = 70$

$n_3 = n.N_3/N = 74$

Where, n = determined sample size

N = Target population

ni = number of sample in each kebele

Ni= population in each kebele

3.6. Method of Data Analysis

Data would be analyzed in descriptive statistical form as well as hypotheses have been tested to know the significant impact.STATA Software was used for estimating the farm-specific technical efficiency scores of coffee producers in the study area. The relation between hypothesized variables and farm level efficiencies was obtained by using the one stage stochastic frontier model. This is done by simultaneously estimating a stochastic frontier model.

3.7 Model Specification

3.7.1 Cobb-Douglas Stochastic Frontier Production Function Model

The study applied Cobb-Douglass functional specifications. The Cobb-Douglas functional form is specified as follows:

Y= ß0X1ß1X2ß2X3ß3......XnßneRi................ (1)

Here Yi = output of the ith farm, Xi = K × 1 vector of coffee farm inputs, β i= vector of unknown parameter and Ri= error term

The error term Ri is decomposed in two components i.e.

$R_i = v_i - u_i$.................................(2)

Here V_i is a random error that captures the random effect of measurement error in the output, observation, statistical noise, external shocks and effect of stochastic outside farmer control e.g. Natural disaster, luck, weather, etc.Ui ≥0 isa non-negative random variable and assume to account for technical inefficiency in production that captures the technical efficiency of the ith farmer. Both Vi

Table 1. Sample Size Distribution Per Three Kebeles

No.	Name of Kebeles	No. of coffee producers	A sample size of farmers producing coffee only	Sample farmers producing coffee and Khat
1.	Dela khange kebele (inshebedino woreda)	675	63	63
2	Awada kebele (in Dale woreda)	375	35	35
3	Mangudo kebele (in Aleta wondo woreda)	395	37	37
	Total	1445	135	135

and Ui cause actual production to deviate from the frontier.

Hence, $\ln Yi=\beta_0+\beta_1 \ln CFSi+\beta_2 \ln labori+\beta_3 \ln Fer_i+\beta_4 \ln Composti+\beta_5 CVi+Vi-Ui$....... (3)

Where i=1, 2, 3..., n. Ln is a natural log. β is an unknown parameter to be estimated. Yi or "Output" is the dependent variable and shows the total output of coffee (in kg) per hectare of the ith farm. "CFS" is the coffee farm size or area measured in a hectare. "Labor" is the sum of household members and waged labor hours per days worked in coffee production."Fer" is the quantity of fertilizers used such as urea and Di-Ammonium Phosphate (DAP) measured in a kilogram. "Compost" is a quantity of decomposed organic matter applied (organic fertilizer) in coffee production measured in a kilogram. "CV" is a dummy variable taking value 1 for certified hybrid seed (improved seed) which could resist bad environmental conditions and 0 for other.

And the estimation was undertaken by maximum likelihood (ML) estimation method.

3.8. Variables in the Technical Inefficiency Model

Description of the variables in Technical Inefficiency Model is presented in Table 2.

4. Results and Discussion

4.1 Descriptive Statistics

This sub-chapter incorporated descriptive statistics to figure out the study area regarding input use and coffee production.

Table 2.Description of Variables in the Technical Inefficiency Model:

Variables	Description of variables	Unit of measurement	Hypothesized sign
Household Head	household head sex	Male=1, Female=0	_
Education level	The formal education level of the household head	the highest grade completed	_
Experience	the number of years of a farmer in coffee production	Years	_
Land ownership status	the land ownership status of coffee producers	1 if Own land, 0 rented land 2 both rented and own land	_
Cooperative Membership	A membership of farmers (coffee producers) to cooperatives	1 if a farmer is a member of Sidama Coffee farmers' 0 cooperative and otherwise	-
Access to Credit	Farmers access to credit	1 if farmer has the access, 0 otherwise	_
Age of Coffee tree	the age of the coffee tree	(Years)	+
The practice of Khat intercropping.	Represents the dummy for farmer's practice of intercropping khat with coffee	1 if farmer has the practice, 0 otherwise	+
Coffee productivity and quality improvement package	farmer's participation in coffee productivity and quality improvement package	1 if farmer participated in the package and, 0 otherwise	_
Extension Service	The frequency of contact of a farmer with the extension workers in the production year.	Number of contact per season	_

Table 3: Summary Statistics of Variables Used in the Production Function

Variable	Mean	Std.Dev.	Frequency	Percent	Shebedino Woreda	Dale Woreda	A/Wondo Woreda
Coffee output	578.548	485.413	-	-	466.865	941.106	897.725
Coffee farm size	0.621	0.331	-	-	0.494	0.724	0.723
Labor	0.200	0.079	-	-	0.177	0.214	0.225
Fer A.	5.431	20.903	18	6.7	6.481	5.057	3.997
Compost A.	765.260	536.590	264	97.8	662.386	886.563	825.676
Coffee variety	Local	34	12.59	33	0	1	
	Improved	236	87.41	93	70	73	

Source: Survey Data (2019).

The dependent variable in the estimation of the stochastic production function is output, measured in Kilograms, for coffee produced by smallholder coffee producers in Sidama Zone. According to the table (4.1), the average production of coffee from the sample of major coffee producing woredas in Sidama zone was 578.548 Kgs for the year with the minimum output at 32.5 Kgs and 3,055 Kgs for the maximum. The average output in each sampled woredas for coffee producers was also 466.865, 941.106 and 897.725 Kgs in Shebedino, Dale and Aleta WondoWoreda respectively. According to the Ministry of Agriculture (2016), at the national level, the productivity of coffee is currently at 700kgs/hectare which is very low compared to the potential production capacity and other major coffee producing countries. For instance, Brazil coffee productivity is 1200kgs/hectare, Honduras coffee productivity is 1000kgs/hectare. In Ethiopia, on model farmers plot average coffee productivity of up to 12000kgs/hectare has been attained. Based on the potential capacity, Ethiopia plans to reach 1100kgs/hectare coffee productivity from the current 700kgs/hectare at the end of the GTP II period. Even if the current productivity level observed in Sidama Zone (881.331kgs/hectare) is more than the national average, overall the results show that the achieved levels of output were below the recommended levels.

83.70% of the household produce coffee on their own coffee farm while 16.30% produce on a rented farm in addition to their own coffee farm. The other input used in the estimation of the production functions is Labor measured in hours spent in the production process per day in the season. The average time spent by both family and hired labors was highest in Aleta Wondo (0.225hr) followed by Dale (0.214hr) and Shebedino (0.177hr). Generally, on average farmers spending of labor (time) in a day during the production season for coffee production was calculated to be nearly 0.2hrs. For coffee plant requires much care by its nature, farmers work culture and allocation of labor needs improvement to increase productivity from the current status. On the other, even though, it is not extensively utilized in the production of coffee, farmers also use fertilizer in the production of coffee. The average use of fertilizer per plot was the highest (6.481Kg) in Shebedino Woreda. In addition, to keeping coffee output organic for accessibility and affordability, farmers mostly applied Compost (organic fertilizer). Hence, the average application of compost per hectare was 765.260 kg.

Table 4: Summary of Continuous Variables Used in the Inefficiency Models

Variables	Mean	Std. Dev	Min	Max
Education	6.971	4.797	0	16
Experience	12.125	3.321	7	24
Age of coffee tree	7.059	1.567	3	10
Extension contact	2.192	1.366	0	7

Source: Survey Data (2019).

This table prevailed that on average the highest level of grade completed (education level attained) of sample coffee producers was found to be nearly 7 grade. The survey results further showed that 50.1% of the household attended primary school, 6.66% secondary and 21.11% attained tertiary education. This result may indicate farmers have a good experience in coffee production. The average age of the coffee tree, measured in years, among the sample, was found to be 7 years. This is also an indication that most of the coffee producers in the study area are replacingthe old local coffee tree with improved coffee variety which is relatively more productive and gives a yield over a short period of time.

Table 5: Summary of Dummy Variables Used in the Inefficiency Model

Variables	Frequency	Percentages
Household Head (1=male; 0=female)	230 40	85.19 14.81
Land ownership status (1=own land ;0 rented; 2 both own and rented land)	209 - 61	77.41 - 22.59
Membership in farmers cooperatives (1=member of farmers' cooperative; 0, otherwise)	223 47	82.59 17.41
Access to finance (1=farmer has access; 0 if the farmer do not have access to finance)	180 90	66.67 33.33
Khat intercropping practice (1= farmers have the practice of intercropping khat with coffee; 0 otherwise)	135 135	50 50
Coffee productivity and improvement package participation (1=farmers participated in the package, 0 otherwise)	264 6	97.78 2.22

Source: Survey Data (2019).

It reveals that 85.19% of total sample are household headed by male farmers in Sidama zone. The participants, on average, in land ownership status 77.41% of them farm on their own land and 22.59% uses both own and rented land for the production of coffee for both genders. The other dummy variable tries to assess farmers` membership in farmers' cooperatives. Accordingly, only 17.41 percent of respondents were not a member of coffee producing farmers' cooperatives in their community. Among the sample coffee producers, on average, 66.67 percent of them have access to finance and 33.33 percent have no access to finance. Due to purposive segmentation of farmers who produce coffee only and those who practice intercropping Khat with coffee for the purpose of achieving the objective of the study, an equal number of farmers in both are observed. Last but not list, coffee productivity, and improvement package were adopted in more than 97% of sample coffee producers in Sidama Zone.

4.2 Econometric Results

Before the preceding presentation of econometric result and interpretation of models, the multi-collinearity test was conducted to reduce wrong signs and smaller t-ratios of regression coefficients that might lead to incorrect conclusions of the research.

4.2.1 Test of Hypothesis

The first null hypothesis also can be stated as smallholder coffee farmers in the study area are technically efficient (H0: λ = 0). The computed test statistic (λ = 3.494) in Table 4.4 is greater than the critical value χ20.05=2.705 from the χ2Table. Hence the null hypothesis is rejected and the conclusion is made that smallholder coffee farmers are technically inefficient due to reasons suggested in the study.

Table 6: Summary of hypothesis test results

Hypothesis test						
Test statistic	**No technical inefficiency**	**No technical efficiency effects**	**Translog model versus the CD model**	**Constant returns to scale**	**Khat no efficiency effects**	**Household head has no efficiency effect**
		δij=0	βij=0	βij =1	δ7=0	δ1=0
Λ	3.494	198.53	29.46	0.013	8.90	47.59
Df	1	1	10	1	1	1
P-value	0.000	0.000	0.000	0.026	0.0028	0.000
Decision	Rejected	Rejected	Rejected	Accept	Reject	Reject

5. Condusion

The overall objective of this study is to analyze farmer's productivity and technical efficiency of coffee production in Sidama Zone, South Ethiopia. Moreover, the study identifies factors affecting farmers' technical inefficiency of coffee production. According to the findings of the production function coffee production and productivity was positively and statistically significantly influenced by coffee farm size, labor, organic fertilizer (compost) and coffee variety. whereas, inorganic fertilizer exhibits a positive relationship to the production and productivity of coffee but statistically insignificant (P-value= 0.102). This unexpected result shows the rare application of inorganic fertilizer in the study area due to the promotion and preference for organic coffee output.

The analysis also reveals that estimated coefficients of household head, education, experience, land ownership status, membership in farmers' cooperatives, access to finance, the practice of khat intercropping, age of coffee tree and extension service were all significantly negative. These imply that male farmers/farm owners were more efficient; coffee farmers who have formal education and completed higher grade/education level were more technically efficient than those who had none or achieved a lower level of formal education; farmers who produce on rented land in addition to own land were more efficient; members of farmers cooperatives were moreefficient; farmers who have access to financing were more efficient ; coffee farmers who have the practice of khat intercropping were less efficient which indicate a negative impact on the productivity of coffee outweigh positive effect of shedding effect; age of coffee tree had significantly direct(positive) relationship to inefficiency; and extension service were found to have significantly negative relationship to inefficiency. Coffee is the most significant agricultural commodity to the Ethiopian economy, which heavily relies on agriculture for its foreign exchange earnings.From the ambition of the government to improve the performance of the sector from the current low level of productivity and technical efficiency results in the study area, there are some strategic actions to be improved and implemented to the attainment of the sector objective and improvement of the productivity and technical efficiency of smallholder coffee producers.

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