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Factors Influencing Coffee Productivity in Jimma Zone, Ethiopia

Gezahagn Kudama

Wollega University, Shambu Campus,
Department of Agricultural Economics, P.O. Box: 38 Shambu, Ethiopia

Abstract: In spite of the fact that coffee is the mainstay of Ethiopian economy and several millions people in the country, as well as familiar in the study area since the time of its discovery, its full productivity capacity has not been exploited yet. Furthermore, researches conducted on the analysis of coffee productivity also scarce in the study area. Hence, this study presents factors influencing coffee productivity in Jimma zone, based on the primary data generated from 153 randomly sampled coffee farmers. The Cobb-Douglass production function model, in which coffee productivity is specified to be the function of different variables result shows that having more farm experiences, numbers of coffee tree per plot of land, membership of coffee cooperatives, literateness of farmers and applications of organic fertilizers tend to increase coffee productivity. On other hand, remoteness of coffee farm, large coffee farm size, aged coffee tends to reduce coffee productivity. Finally the finding proves that policy measures that improve: farmers' participation in cooperative, the capacity of farmers with regards to coffee farm management skill along with proper allocation of resources for coffee production and technology that simplifies coffee farm activities will lead to increase coffee productivity.

Key words: Cobb-Douglass Production Function · Coffee · Factors · Productivity

INTRODUCTION

Coffee which is originally recognized by goatherd, Khalid in 9th century in Oromia regional state, Jimma zone, Goma district, Choche or Keta Muduga locality [1], nowadays produced by more than 70 countries in the world [2].

Coffee is the topmost export for Ethiopia and represents just about one-third of overall exports worth of the country. Sharing 40% of Africa and 4% of global coffee of production, Ethiopia is the top and the sixth largest Arabica coffee producer in Africa and the world respectively. Coffee is cultivated by in excess of four million smallholder farmers and generates living revenue for estimated 15 million (about 15% of the population) different coffee value chain actors in the country [3]. On the other hand, holding around 95% of total production of the country smallholders' coffee farming dominates coffee production in Ethiopia.

Even though coffee production doubled over past two decades in Ethiopia, coffee productivity is stagnant and lower as compared to other coffee producer countries like Vietnam and Brazil [4]. Factors which hinder the coffee productivity back from achieving its full potential comprise: poor tree management practices, low productive aged coffee trees, soil degradation, rising temperatures and increasingly unpredictable weather status [5].

However, the country has still the unexploited capacity to boost coffee yield. Ethiopia has high potential and environmentally conducive for coffee production [6]. So as to keep its competitiveness in global coffee market, Ethiopia must improve coffee productivity and create advanced value added products. Although contradictory components exist between productivity improvement and value-added advancement, given the situation of coffee production in Ethiopia there exists a room for both productivity and value added improvement simultaneously [4].

According to Jzardo [7] coffee production from Jimma zone contributes 21% of national export and generates higher cash income for the livelihood of several coffee farm households in the area. Furthermore, there exist favorable environmental situations for coffee yield intensification and quality improvement.

Corresponding Author: Gezahagn Kudama (MSc in Agricultural Economics), Wollega University, Shambu Campus Department of Agricultural Economics P.O. Box: 38 Shambu, Ethiopia. Tel: +251982151857.

Despite the fact that coffee production in Jimma Zone is well known from early coffee production time and has high potential for coffee production, the coffee yield stacked back and still low. So far numerous researches have been conducted on coffee marketing and other different topics regarding coffee in Ethiopia but research conducted on coffee productivity is scarcely exists in the country in general in Jimma Zone in particular. Cognizant this fact, this research was conducted in response to high research gap observed in this particular area. Hence, this study is designed to determine factors influencing the coffee productivity in Jimma Zone.

MATERIALS AND METHODS

Description of the Study Area: The study was conducted in Jimma zone of Oromia National Regional State in Ethiopia. The Jimma zone capital, Jimma town is situated 335 km to the South west of Addis Ababa in the Ethiopia. The zone is situated between 7°13' – 8°56' latitudes and 35°49 -38°38' longitudes. It shares borders with East Wollega zone in the North, East Shoa zone and Southwest Shoa zone in North East, with south nation, nationalities and people's administration in the South East and South and with Ilu-Ababora zone in the West.The zone is characterized by a tropical highland climate with heavy rainfall, warm temperatures and a long wet period. Its annual rainfall ranges from 1, 200 mm and 2, 500 mm [8].

From a total of 1.1 million hectares of land, the area covered by coffee is estimated 0.1 million hectares in the zone. Even if coffee is produced by state and private investors in the zone, the coffee farms are largely owned by smallholder farmers [7]. Similarly, coffee is the mainstay for the large mass of the communities in the zone [8].

Among eight potential districts (Gomma, Manna, Gera, Limmu Kossa, Limmu Seka, Seka Chokorsa, Kersa and Dedo) for coffee production in Jimma zone, Gomma and Manna districts were randomly selected for this study.

Agaro, the capital town Gomma district is located 397 km away from Addis Ababa (the capital city of Ethiopia) in Southwest direction and 50 km far away from Jimma town (the capital town of Jimma zone). The annual rainfall of the district varies from 800-2000 mm. The agro climate of the district involves: highland (8%), intermediate high land (88%) and low land, 4% (Samuel et al., 2016). From [9] population census extension Gomma district has an estimated total population of 300200 of whom 153095 were males and 147105 were females.

The capital town of Manna district, Yebu is located at 368 km southwest of Addis Ababa and 20 km west of Jimma town. The district constitutes 12% highland, 65% intermediate highland and 23% lowland with altitude ranges between 1470 – 2610 meter above sea level [8]. Based on CSA [9] census extension, the district has an estimated total population of 206700 of whom 105267 were males and 101433 were females.

Data Sources, Collection Method and Sampling Procedures: The data for this study was collected both from primary and secondary sources. The secondary data source includes different reports, census data and journal documents, whereas the primary source of data was entirely from sampled respondents of coffee farmers. The primary data was obtained through structured questionnaire developed for this study by researcher. So as improve the contents of the questionnaire and increase precision of the research the questionnaire was pre-tested.

This study was followed multiple stage sampling procedures. The first stage comprised random selection of two districts (Mana and Goma) among eight potential districts in coffee production from Jimma zone. The second stage was followed by random selection of three rural *kebele* administrations from each district. Finally, based on the estimated proportion of coffee farmers of the two districts, a total sample of 153 respondents (farmers who produced coffee) were selected and data on inputs, output, yield, farm practices, socioeconomic characters and prices of 2017/ 2018 cropping season were collected from coffee farmers with the aid of six trained enumerators for the study.

Data Analysis: Descriptive statistics and econometric models results were analyzed with aid of STATA version 14.

Econometric Model: In analyzing functional relationship between coffee productivity and selected variables, this study employed Cobb Douglass production function. It is a commonly used model in similar studies [10]. Similarly [11, 12] were employed Cobb Douglass production function for Coffee and Lychee productivity analysis respectively. For this study the Cobb Douglass production is specified as follows:

$$Y = A.X_1^{\alpha_1}.X_2^{\alpha_2}.X_3^{\alpha_3}.X_4^{\alpha_4}.X_5^{\alpha_5}.e^{B_1D_1} + B_2D_2 + B_3D_3 + B_4D_4 + U_4 \quad (1)$$

where,
Y: *Coffee productivity* (quintal/Hectare);
A: Constant term;
X_1, X_2, X_3, X_4, X_5: *are continuous explanatory variables (coffee farming experience, coffee farm size, number coffee trees, remoteness of coffee farm and age of coffee tree respectively).*
$\alpha_1, \alpha_2, \ldots, \alpha_5$: are coefficients of explanatory variables,
$\beta_1, \beta 2 \ldots, \beta_4$: are coefficients of dummy variables
$D_1, D_2, \ldots, D_4$: are dummy variables (membership coffee cooperatives, literacy, level of shade tree canopy and application organic fertilizer).

U_i = Error term

The linear transformation of the above equation by taking the natural logarithm of the function can be given as:

$$\mathrm{n}Y = \ln A + \alpha_1 \ln X_1 + a_2 \ln X_2 + \ldots + \alpha_5 \ln X_5 + \beta_1 D_1 +,\ldots,+ \beta_4 D_4 + U_i \quad (2)$$

Parameters, $\alpha_1, \ldots, \alpha_5$ and $\beta_1, \ldots, \beta_4$ are estimated by OLS (Ordinary Least square) method.

Definitions and Hypothesis of the Variables

Coffee Productivity: Is a continuous dependent variable which represents quantity of dry cherry coffee or equivalents for other forms of coffee produced by farmers and measured in kilogram per hectare.

Coffee Farming Experience: Is a continuous independent variable, represents duration of participation in coffee farm activities by farmers and measured in years. Farmers with longer farming experience are expected to be more knowledgeable and skillful. Therefore, it was hypothesized to influence coffee productivity positively.

Coffee Farm Size: Is a continuous variable that refers to the size of land allocated for coffee production by farmers and measured in hectare. Excess land allocation for coffee production demands additional apportionment of resources which may disgust and discourage farmers. This in turn, decreases production efficiency of coffee. Hence, it was expected to affect coffee productivity negatively.

Coffee Trees per Hectare: Is continuous variable, which stands for the figure of coffee tree that farmer possesses per hectare of land. Productivity increase with number of coffee tree stands until some point and then tends to decline in production function. Therefore, it either positively or negatively affects coffee productivity. However, in this study it was assumed to have positive influence on coffee productivity.

Remoteness of Coffee Farm: Is a continuous variable and refers to time (minutes) farmer spends to access coffee farm. It can limit the frequency of farm visits and cares given by farmers to their coffee farms that it affects amount of coffee yield. Thus, it was expected to influence coffee productivity negatively.

Age of Coffee: Is a continuous variable and represents a number of years that coffee plant has existed. Coffee productivity continues until the age 15 to 20 years [13]. However, coffee trees in the study area have been observed while inherited from generation to generation without replacement and kept for long period of time. Hence, age of coffee assumed to have negative influence on coffee productivity.

Literacy Status: Is a dummy variable which is categorized into literate (farmers who able to write and read) and farmers who are not able write and read in this study. Literate farmers are supposed to be productive as they are close to technology adoption that enhances their yield. Accordingly literacy was hypothesized to increase coffee productivity.

Membership of Coffee Cooperatives: Is a binary variable that stands for membership and non-membership of coffee farmer cooperatives. Coffee cooperatives provide information about inputs, technology to its members that it is expected to have positive relationship with productivity.

Level of Shade Tree Canopy: Is a dummy variable which is categorized into light shade tree canopy (0 – 40% coverage) and medium shade tree canopy (40 – 70% coverage). Even if coffee is shade loving tree, more shade trees may competes for space and feed with coffee. Hence, medium level of shade tree canopy is expected to reduce coffee productivity.

Application of Organic Fertilizers: Is a binary variable that stands for farmers who applied organic fertilizers (like manure and compost) or didn't apply organic fertilizers to their coffee farms. Coffee is nutrient consuming plant that application of organic fertilizers is assumed to favor coffee productivity.

RESULTS AND DISCUSSION

Descriptive Statistics Result: The descriptive statistics results of continuous variables are given in Table 1. Coffee farming experience of the farmers ranges from 3 to 24 years with average 11.88 years. The average coffee farm size is 0.57 hectare with minimum and maximum coffee farm size of 0.031 and 2 hectare respectively. Furthermore, the average number of coffee trees per hectare was 2826.32 (Table, 1).

The remoteness of coffee farm ranges from 1 to 50 measured in minutes on foot walk. Similarly, the average of age of the coffee trees was 30.3 years old which ranges from 6 to 70 years. The mean dry cherry coffee produced by farmers was 845.605 kg per hectare (Table, 1).

Table 2 presents the descriptive statistics result of dummy variables. It shows that 59.48% of the respondents were literate (read and write). This implies that more than the average of the respondents could read and write. Similarly 25.49% of the respondents were the members coffee cooperatives. It implies that few numbers of the coffee farmers were participated in coffee cooperatives. Furthermore, 56.86% the coffee farm had light shade canopy, whereas 43.14 had medium shade canopy. The share the respondents who applied organic fertilizers to their coffee farms were 24.84% (Table, 2). This shows that the experiences of organic fertilizers application to coffee farms are less practiced by coffee farmers in the study area.

Econometrics Model Result for Coffee Productivity: The productivity function that was employed to determine the nature of inputs and output relationship per a hectare of land in coffee production is shown in Table 3. The result depicts that the estimated values of the coefficients and related statistics of Cobb-Douglas production function. The F ratio was significant at 1% probability level indicating that there is a significant linear relationship between the independent variables taken together and coffee productivity. The R- squared of 0.7019 shows that 70.19% changes of coffee yield are explained by the various independent variables used in the model and the rest 29.81% changes is due to other determinants not included in the model (Table 3).

From the total of nine variables estimated to affect coffee productivity, all except level of shade tree canopy are found to be factors which considerably affect coffee productivity of farmers. Whilst coffee farming experience, coffee farm size, number coffee trees, remoteness of coffee farm, age of coffee tree, membership coffee cooperatives and application of organic fertilizers are statistically significant at level of 1%, literacy status is significant at level of 5% (Table 3).

The coefficient of coffee farming experience, 0.159 implies that 1% increase in farm experience leads to increase coffee productivity by 0.16% ceteris paribus. This is due to the facts that having farming experiences for long duration of time helps the farmers to develop perfect practical skill of inputs output relationship through time and make good decision in choosing appropriate inputs use. Subsequently, farmers who have accumulated coffee farm experiences over long period of time have better chances to intensify their coffee yield. Similar result was obtained by Anteneh and Aman [11].

The coefficient of coffee farm size, -0.339 depicts that 1% increase in coffee farm size tends to decrease coffee yield by 0.34% keeping other variables constant (Table 3). This suggests that excess land allocation for coffee production requires additional apportionment of resources which may disgust and discourage farmers. This leads to decreases production efficiency of coffee. The sign of the coefficient is concur to the findings of Adesoji and Farinde[14] and Minai *et al.* [15].

The coefficient of number of coffee trees, 0.303 indicates that 1% increase of coffee tree per hectare of land leads to increase coffee farm productivity by 0.30% keeping other factors constant (Table 3). The estimated numbers of coffee trees per hectare on farms were relatively less densely populated. In other words, higher coffee population per hectare implies greater number of coffee tree stands per hectare and marks higher yield, except where there is over-crowding leading to competition for nutrients and results in low yields. This finding supports the result indicated by Anteneh *et al.* [16], which suggests coffee yield increase for coffee population density up to 8 thousand coffees per hectare in Gera high land. However, the average coffee density per hectare of land in the study area is 2826.32 (Table, 2). Hence, farmers in the study area still have the chances to enhance their coffee yield via increasing their coffee density.

The coefficient of remoteness of coffee farm, -0.121 shows that, as the time it takes on foot walk by the farmers from their residences to access their coffee farms (measured in minutes) get farther by 1%, coffee farm productivity decreases by 0.12% ceteris paribus (Table 3). In analysis of Technical Efficiency of Coffee Production on Small Holder Farmers in East Wollega Zone [17] found that remoteness of farmers' residence from their corresponding coffee farm plots would reduce coffee

Table 1: Descriptive statistics for continuous variables used in the study

Continuous variables	Minimum	Maximum	Mean	Std. Deviation
Coffee farming experience (year)	3	24	11.88	5.114
Coffee farm size (hectare)	0.031	2	0.5708	0.49562
Coffee trees per hectare	645.16	6451.61	2826.32	1062.19
Remoteness of coffee farm (minutes)	1	50	14.4118	13.0604
Age of coffee tree (year)	6	70	33.3007	20.8447
Coffee yield (kg/ha)	107.53	2000	845.605	467.211

Source: own survey computation, 2018

Table 2: Descriptive statistics for dummy variables used in the study

Dummy variable	Number	Percentage
Literacy status		
Literate	91	59.48%
Not able to read and write	62	40.52%
Membership of coffee farmers cooperatives		
Membership	39	25.49%
Non-membership	114	74.51%
Level of shade tree canopy		
Light	87	56.86%
Medium	66	43.14%
Application of organic fertilizers		
Applied	38	24.84%
Didn't apply	115	75.16%

Source: own survey computation, 2018

Table 3: Cobb-Douglas regression estimate for coffee productivity

Variables	Coefficient	Standard Error	t	P>t
Coffee farming experience	0.159***	0.060	2.67	0.009
Coffee farm size (ha)	-0.339***	0.083	-4.07	0.000
Coffee trees per hectare	0.303***	0.076	4.01	0.000
Remoteness of coffee farm	-0.121***	0.035	-3.5	0.001
Age of coffee	-0.392***	0.051	-7.65	0.000
Membership of coffee cooperatives	0.243***	0.070	3.45	0.001
Literacy status	0.127**	0.060	2.13	0.035
Level of shade tree canopy	-0.075	0.060	-1.25	0.212
Organic fertilizer application	0.229***	0.077	2.96	0.004
Constant	5.233	0.699	7.48	0.000
Number of observation		153		
$F(9, 143)$		37.41		
Probability > F		0.000		
R^2		0.7019		
Adjusted R^2		0.6831		

Note (**and *** for 5% and 1% Significance level respectively).

Source: Own survey computation, 2018.

production efficiency. In other words, those farmers who are living in near vicinity to their coffee farm gain higher coffee yield. This is due to the fact the opportunity cost of time and less transportation cost encourages farmers for higher production and improves their production efficiency.

The coefficient of age of coffee is - 0.392 implies that as age of coffee increases by 1% the productivity of decreases by 0.39% (Table 3). The finding supports coffee research investigation recommendation. Despite the fact that Production Guideline –Coffee [13] limits that the productive ages of Arabica coffee plants between 15 to 20 years, the average age of coffee is 33.3 years in the study area (Table 1). This implies that the habits of staying coffee plants for long period of time, beyond the scientific recommendation age limits costs the farmers via reducing their coffee yield.

The coefficient of membership of coffee cooperatives is positive and significant, indicating that farmers who are involved in coffee cooperatives gain more coffee yield.

The coffee cooperatives in the area provides information about improved seedling supply, coffee farm practices and post-harvest management, coffee demand and prices for their members that, membership of coffee cooperatives have better opportunity in gaining more coffee yield over non-members. The finding is analogous to Tru [12] who conducted research on factor affecting lychee productivity in Vietnam.

Similarly, the coefficient of literacy status also positive and significant, which displays that literacy of farmers tends to increase coffee yield. This result shows that farmers who are literate (who can read and write) tend to be more efficient in coffee production as compared to farmers who are unable to read and write. The finding supports [18] who found negative relationship between educational level of farmers and technical inefficiency of coffee production in Cameroon.

Furthermore, the coefficient of application organic fertilizers is positive and significant, which implies that farmers who apply organic fertilizers to their coffee farms get more coffee yield over those farmers who don't apply organic fertilizers to their coffee farms. This is due to the fact that coffee is a highly nutrient feeder naturally. Similar result was obtained by Anteneh and Aman [11].

CONCLUSION

The objective of this study was to determine factors influencing the coffee yield in Jimma Zone. To achieve this objective, the Cobb-Douglass production function in its linearized form was employed.

The coffee productivity was specified to be functions of coffee farming experience, coffee farm size, number of coffee trees per hectare, remoteness of coffee farm, age of coffee, membership of coffee cooperatives, literacy status, level of shade tree canopy and application of organic fertilizers.

The analysis shows that coffee farming experience, number of coffee trees per hectare, membership of coffee cooperatives, literacy status and application of organic fertilizers had positive and significant influence over coffee productivity. Whereas, coffee farm size, remoteness of coffee farm and age of coffee had negative and significant effect on coffee productivity.

Based on finding of the study, the following policy implications may be emphasized. Coffee productivity improvement linked to capacity building and proper allocation of resources in Jimma zone. Accordingly, policy measures that improve the capacity of farmers with regards to coffee farm management skill along with proper utilization of resources and technology that simplifies coffee farm activities will lead to increase coffee productivity.

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