FARM SIZE AND PRODUCTIVE EFFICIENCY: LESSONS FROM MBINGA COFFEE FARMERS

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Abstract

Productive efficiency measurement is very important both in developed and developing agriculture and its roles are widely recognized by farmers, researchers and policy markers. This study attempted not only to investigate on the farm size and productivity relationship debate which has not gone through a complete circle in Tanzania but also find out whether inefficiency resource use by farmers is a problem or not. The study revealed that, mean level of profit efficiency was 52.4% which implied that an estimated 47.6% of the profit was lost due to a combination of both technical and allocative inefficiency in coffee production. The efficiency difference were explained largely by household size, farmer's experience, age of coffee trees, education level, extension services, capital amounts, and time used by a farmer to move from one coffee farm to another. It was concluded that very small and small size farms were associated with more profit-loss compared to medium size farms. It is recommended that farmers should increase their farm size at least to medium farms of more than 1 262 coffee trees in order to increase coffee farm efficiency hence profit.

Key Words: Production, coffee, profitability, poverty reduction, profit-loss, Tanzania.

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1.0 Introduction

Agriculture is again a major item on the economic development agenda for Sub-Saharan Africa (SSA), although there remains considerable doubt in the international development community as to whether it can successfully generate sufficient growth in Africa (Maxwell and Slater, 2003). The lack of absolute evidence regarding the existence of economies of scale and required productive efficiency in agriculture in developing countries has made decisions on where to focus agriculture development difficult (Maxwell, 2004). The debate on the relationship between farm size and productivity in Tanzania has not gone through a complete circle. According to Shenggen and Connie (2005), literature has failed to provide consensus on whether there exists an inverse relationship between farm size and productivity. This study was an attempt to contribute on this debate and find out whether inefficient resource use was a problem, also, relationship between farm size and productive efficiency among Mbinga coffee farmers was assessed.

2.0 Literature Summary

The popular approach to measure efficiency, the technical efficiency component, is the use of frontier production function (e.g., Battesse, 1992). However, Yotopolous and others argue that a production function approach to measure efficiency may not be appropriate when farmers face different prices and have different factor endowments (Ali and Flinn, 1989). This led to the application of stochastic profit function models to estimate farm specific efficiency directly (e.g., Rahman, 2003). In contrast with the widespread use of frontier production functions to estimate efficiency, use of profit frontier approach is highly limited hence adopted by this study. Profit efficiency, therefore, is defined as the ability of a farm to achieve highest possible profit given the prices and levels of fixed factors of that farm and profit inefficiency in this context is defined as loss of profit from not operating on the frontier (Ali and Flinn, 1989).

3.0 Methodology

This study was carried out in Mbinga District in Ruvuma region of Tanzania. Mbinga coffee farmers were the target respondents for this study. Both small and medium coffee farmers were considered in obtaining the sample for this study. Smallholder coffee farmers who are majority in Tanzania constituted a large part of the study sample. A total of 116 farmers were selected randomly from particular villages, where by a total of 102 and 14 farmers represented small and medium size farms respectively on the basis of number of coffee trees available.

Both questionnaire and interview schedules were used in this study to collect required data from the coffee farmers. The questionnaire consisted of a set of structured questions which reflected the study objectives. The data obtained from the field were subjected to analysis using descriptive and inferential statistics in which the later involved for testing hypotheses.

Regarding this study, Coelli (1996) model was used to specify the stochastic frontier function with behaviour inefficiency components and to estimate all parameters together in one step Maximum Likelihood Estimation (MLE). The production/profit efficiency of coffee farm *i* in the context of the stochastic frontier profit function was defined as:

$$\ln \pi' = \beta_o + \sum_{j=1}^{6} \beta_j \ln P'_j + \frac{1}{2}\sum_{j=1}^{6}\sum_{k=1}^{6} \beta_{jk} \ln P'_j \ln P'_k + \sum_{j=1}^{6}\sum_{l=1}^{1} \beta_{jl} \ln P'_j \ln Z_l + V - U$$

Where:

π' = restricted profit (computed as total revenue less variable cost) normalized by price of specific average coffee output (P_y)

P' = price of the *j*th input (P_j) normalized by the average coffee output price (P_y)

j = 1, fertilizer price; 2, insect treatment price; 3, disease treatment price; 4, herbicide price; labour wage

Z_l = quantity of fixed input, l

l = farm size (number of coffee trees)

v = two sided random error

u = one sided half-normal error

ln = natural logarithm

β_0, β_j, and β_{jk} are parameters to be estimated

3.1 Inefficiency Model (Profit Loss Sources)

Profit-loss is defined by Rahman (2003) as the amount that has been lost due to inefficiency in production given prices and fixed factor endowments and is calculated by multiplying maximum profit by (1 – PE). The maximum profit per coffee trees grown is computed by dividing the actual profit per coffee trees of individual farms by its efficiency score.

To identify factors associated with profit-loss, a multiple regression model was estimated as follows:

The inefficiency model (Ui) is defined by:

$$U_i = \delta_0 + \sum \delta_i L_{ni}$$

$$U_i = \delta_0 + \delta_1 L_{1i} + \delta_2 L_{2i} + \delta_3 L_{3i} + \delta_4 L_{4i} + \delta_5 L_{5i} + \delta_6 L_{6i} + \delta_7 L_{7i} + \delta_8 L_{8i} + \delta_9 L_{9i}$$

Where: δ_0 is a constant, δ_i are model coefficient and L_1, L_2, L_3, L_4, L_5, L_6, L_7, L_8 and L_9 represent household size (number), farming experience (years), age of coffee trees (years), level of education (years), extension contact (number) (dummy variable to measure the influence of agricultural extension on efficiency. Value 1 is if the farmer has had contact with an Agricultural Extension Officer in the past year, and 0 meant otherwise). Moreover, the capital amount was given in TAS, estimated time movements from one farm to another was in minutes, estimated slope was in percentages and estimated shade given was also in percentages as well. These socio-economic variables were included in the model to indicate their possible influence on the profit efficiencies of the coffee farmers (determinants of profit efficiency).

The estimate for all parameters of the stochastic frontier profit function and the inefficiency model were simultaneously obtained using the program FRONTIER VERSION 4.1c (Coelli, 1996).

4.0 Results and Discussions

4.1 Summary Statistics

The summary statistics of the variables used have been presented in Table 1. A number of points can be noted from the Table. First, it was revealed that the farms were small, with average sizes of 1 489 coffee trees which is equivalent to more than one hectare. The average level of education of the farmers was less than 8 years of schooling. On the other hand, the average age of coffee trees was more than 27 years and the average estimated slope for coffee farms was 25%. It was also found out that farmers spend an average time of more than 12 minutes to move from one farm (coffee) to another (other crops).

Table 1: Summary Statistics

Variables	Mean	Standard Deviation
Output, Profit and Prices		
Coffee Output (Kg)-Home Process	307.76	351.26
Coffee Output (Kg)- Cherry	897.69	1 195.78
Profit (TAS)	867 128	1 090 408
Coffee Price-Home Process (TAS/Kg)	1 537	353
Coffee Price-Cherry (TAS/Kg)	292	118
Fertilizer Price (TAS)	104 962	64 716
Insect-Treatment Price (TAS/Unit)	30 996	13 987
Disease-Treatment Price (TAS/Unit)	17 600	1 350
Herbicide Price (TAS)	15 309	2 065
Hired Labour Pay (TAS)	27 393	39 253
Farm Size (# of Trees)	1 489	852
Farm-Specific Variables		
Number of Household	3.78	2.38
Experience (Years)	24.7	16.14
Coffee Trees Age (Years)	27.3	12.37
Education Level (Years)	7.55	2.54
Extension Contact Number	2.3	1.51
Capital Amount	76 075	70 964
Time Movement (Minutes)	12.6	11.86
Estimated Slope Grade (%)	25.29	9.54
Estimated Shade Given (%)	19.56	11.03
Total Observation	116	

Note: Exchange rate: 1 USD = 1 512.46 TAS (BoT, 2012) and 1 ha = 1 262 coffee trees (TACRI, 2008)

4.2 The Structure of Coffee Production

The Maximum-Likelihood Estimates (MLE) of the parameters of translog stochastic frontier profit function defined by equation (12) and homogeneity were automatically imposed because normalized specification was used. Moreover, the specifications for the inefficiency effects defined by equation (14) were obtained using FRONTIER 4.1 (Coelli, 1996). The results of the profit frontier function are presented in Table 2.

Furthermore, Table 2 indicates results for testing hypothesis that the efficiency effects jointly estimated with profit frontier function are not simply random errors. The key parameter is $\gamma = \sigma_u^2/\sigma_u^2+\sigma_v^2$, which is the ratio of the errors in equation (6) and is bounded between zero and one, where if $\gamma = 0$, inefficiency is not present, and if $\gamma = 1$, there is no random noise. The estimated value of γ is close to 1 and is significantly different from zero, thereby, establishing the fact that a high level of inefficiencies seemed to exist in Mbinga coffee farming.

Table 2: Maximum Likelihood Estimates (MLE) of Translog Stochastic Frontier Profit Function and Inefficiency Model for Mbinga Coffee Farmers

Variable	Parameter	Coefficient	Std Error	T-ratio
Profit Function				
Constant	β_0	6.947***	0.629	11.043
LnFsize	β_1	0.603***	0.251	2.404
LnFert	β_2	0.246	0.223	1.097
LnInse	β_3	-0.271	0.212	-1.278
LnDis	β_4	-0.973	1.046	-0.930
LnHerb	β_5	-0.318	0.263	-1.207
LnLab	β_6	-0.357**	0.183	-1.951
1/2lnFsizeXlnFsize	β_7	0.038	0.083	0.463
1/2lnFertXlnFert	β_8	-0.037	0.031	-1.192
1/2lnInseXlnInse	β_9	0.071**	0.035	2.008
1/2lnDisXlnDis	β_{10}	0.108	0.828	0.130
1/2lnHerbXlnHerb	β_{11}	0.067	0.065	1.029
1/2lnLabXlnLab	β_{12}	0.100***	0.030	3.338
lnFsizeXlnFert	β_{13}	-0.004	0.069	0.061
lnFsizeXlnInse	β_{14}	0.025	0.088	0.288
lnFsizeXlnDis	β_{15}	-0.170	0.148	1.147
lnFsizeXlnHerb	β_{16}	-0.161**	0.077	2.087
LnFsizeXlnLab	β_{17}	-0.044	0.049	-0.891

Inefficient Effects				
Constant	δ_0	2.040***	0.876	2.330
Household Size	δ_1	-0.086	0.110	-0.786
Farmer's Experience	δ_2	0.012	0.014	0.865
Age of Coffee Trees	δ_3	0.005	0.012	0.420
Education Level	δ_4	0.000088	0.060	0.001
Extension Contacts	δ_5	-0.152*	0.102	-1.493
Capital Amount	δ_6	-0.000024***	0.0000033	-7.274
Time Movements	δ_7	-0.016	0.015	-1.119
Variance Parameters				
$\sigma^2=\sigma_u^2+\sigma_v^2$	σ^2	0.718***	0.195	3.678
$\gamma=\sigma_u^2/\sigma_u^2+\sigma_v^2$	Γ	0.771***	0.073	10.516
Log Likelihood	LLF	104.880		
Number of Observations		116		
Mean Technical Efficiency		52.4%		

Note: *** Significant at 1 percent level (P<0.01)

** Significant at 5 percent level (P<0.05)

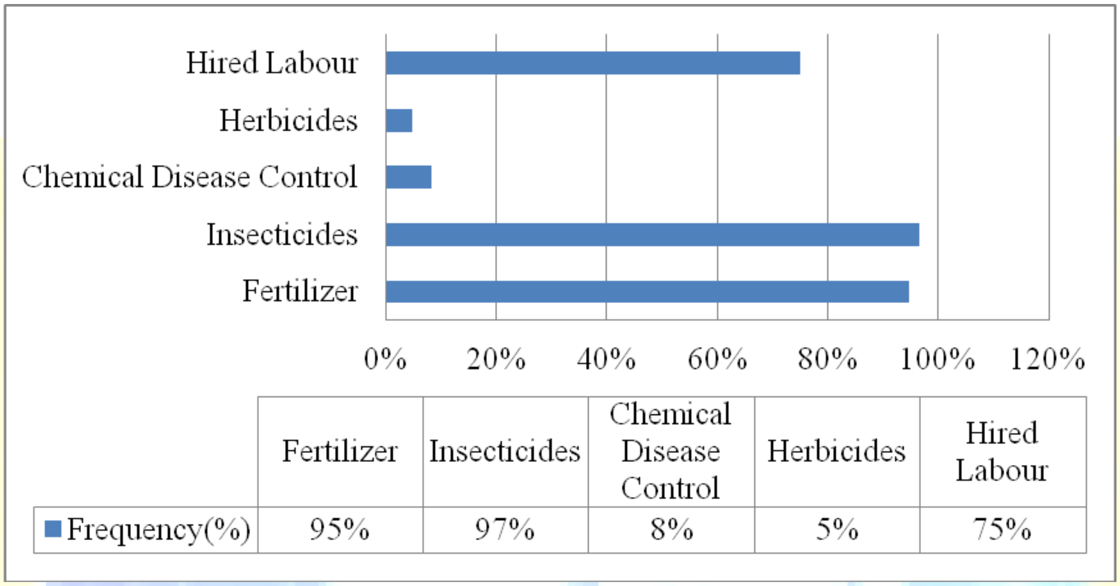
* Significant at 10 percent level (P<0.10)

Also, Fsize = farm size, Fert = fertilizer, Inse = insect control units, Dis = disease control units, Herb = herbicide, Lab = labour

4.2.1 Input use and their frequency

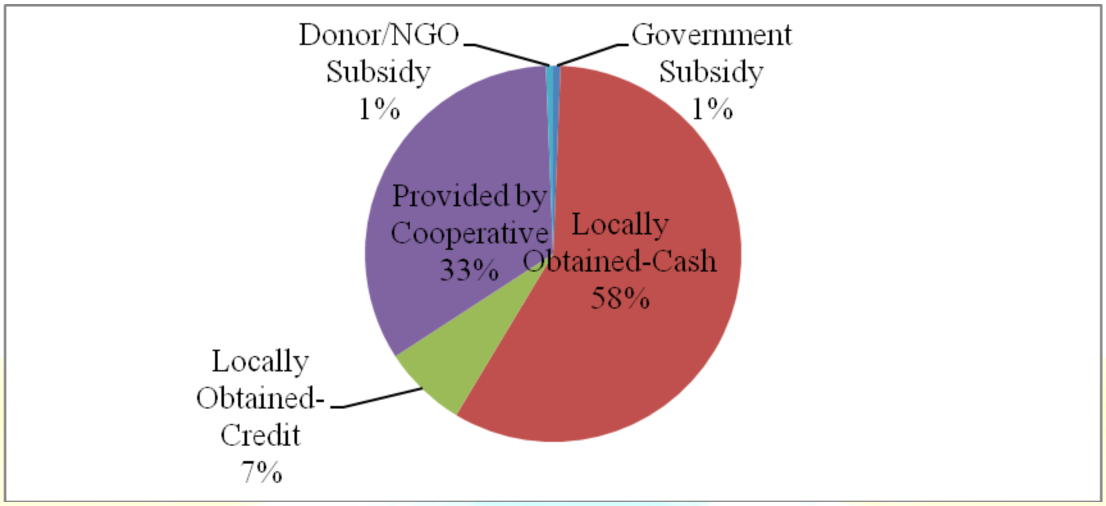
On the basis of basic features of production structure, namely, the input and output shares and profit with respect to changes in variable input prices and fixed factors, shown in Table 2. Figure 1 presents frequencies of which major inputs had been used by coffee farmers in the production. It was revealed that, the frequency of using fertilizer and insecticides were high as they were presented by 94.8% and 96.6% respectively. Furthermore, out of 75% of the rate that was spent on hired labour, 73.3% of the same was used to pay for harvesting costs while the rest was used to pay for planting, mulching, weeding, pruning, and spraying activities. This phenomenon could be attributed to the use of family labour in most of the activities and significant importance of harvesting rather than other activities in coffee production.

Figure 1: Farmer's Inputs Use Frequency



Generally, coffee farmers seemed to apply inputs below the recommended rate. As noted by Mwakalobo (2000), Mbinga farmers were found to use insecticides and herbicides for insects and weed control below the recommended rate. Additionally, the study revealed that, the average rate of 29.9 and 32.9 instead of 40 milliliter/knapsack were used by farmers for controlling insects and weeds respectively. Credits support could be significantly important in increasing their purchasing power during the production season. Moreover, improvement of inputs services provided by the cooperative societies would be important as well (Figure 2).

Figure 2: Coffee Farm's Inputs Sources



4.2.2 Sources of farms inputs

Figure 2 shows different sources of inputs to coffee farmers. Most of the surveyed farmers (58%) obtained their inputs by buying locally. Through farmer's cooperatives and inputs services provision systems, only 33% of respondents obtained their inputs from these sources. However, this call upon further improvements of the related services to farmers since it is easy to get inputs through already established systems to cooperatives members and pay in credit through post-harvest sales deductions. It was also revealed that the frequency of farmers to use inputs from NGO/donor and government in form of subsidy was very poor. Furthermore, the locally obtained inputs provided in the form of credit accounted for only 7% of use. In order to improve both production and productivity, government subsidies provision to coffee farmers should be improved and the system to ensure the same should be sustainable.

4.3 Production/Profit Efficiency and Distribution

The distribution of profit efficiency of coffee farmers is presented in Table 3. The average profit efficiency score was 52.4% implying that the average farm producing coffee could increase profits by 47.6% by improving their technical and allocative efficiency. This average TE or PE does not differ significantly with that of 49.2% of Rungwe coffee farmers as presented by Mwakalobo (2000). Farmers exhibited a wide range of profit inefficiency in the production season, ranging from 97.7% less than the maximum profit to 6% less than the same. Observation of wide variation on profit is not surprising and similar results were found in Bangladesh, Pakistan and China. For example, Rahman (2003) and Ali and Flinn (1989) reported the mean profit efficiency level of 0.77 (with a range from 16.8 to 94.1%) and 0.69 (with a range from 13 to 95%) for rice producers in Bangladesh and Pakistan respectively. Wang *et al*. (1996) reported the mean profit efficiency level of 0.62 (with a range from 6 to 93%) for rural farm households in China. Despite the wide variation in efficiency, more than 32% of farmers had less than 40.1% efficiency level. In this regard, most of the farmers seemed to be skewed towards profit efficiency of less than 60%. Nevertheless, the results imply that a considerable amount of profit can be obtained by improving technical an allocative efficiency in Mbinga coffee production.

Table 3: Frequency Distribution of Frontier 4.1c Technical Efficiency Scores

Efficiency Score (%)	Number of Farmers	Percentage
2.0-21.0	15	12.93
21.1-40.1	23	19.83
40.2-59.2	29	25.00
59.3-78.3	21	18.10
78.4-97.4	28	24.14
Total	**116**	**100**
Average Score (TE or PE)= 52.4%		

Moreover, it was not a surprise for 12.9% of farmers being below 21% of efficiency score in developing country's agriculture (Table 3). Related findings from elsewhere have revealed that maize smallholder farmers were reported to have the highest frequency for efficiency score below 20% while 79% of farmer's plots had efficiency score below 70% (Chirwa, 2007).

4.4 Profit-Loss Estimation and Factors Explaining Inefficiency (Socio-economic Variables)

An estimation of profit-loss given prices and fixed factor endowments revealed that coffee farmers were losing to the tune of TAS 787 696 per mean index of coffee trees equivalent to more than one hectare which could be recovered by eliminating technical and allocative efficiency (Table 4).

Table 4: Profit Loss in Coffee Farming and Key Constraints

Farm-Specific Characteristic	N	Average Profit	Estimated Profit Loss[a]	Farm Size (# Trees)	Average PE (%)
Profit loss by household size					
More than 3 household	53	1 127 297	748 405	1 580	60.1
Up to 3 household	63	648 257	745 844	1 428	46.5
Profit loss by farmer's experience					
More than 24 years of experience	47	972 873	733 921	1 581	57.0
Up to 24 years of experience	69	795 099	807 923	1 442	49.6
Profit loss by age of coffee trees					
More than 40 years		812 965	863 252	1 381	48.5
Up to 39 years	97	877 737	762 280	1 521	53.52
Profit loss by level of education					
Some education	114	1 227 050	520 884	1,725	70.2
Zero education	2	860 813	788 254	1 494	52.2

Farm-Specific Characteristic	N	Average Profit	Estimated Profit Loss[a]	Farm Size (# Trees)	Average PE (%)
Profit loss by extension contacts					
Farmers having extension contacts	116	867 128	787 696	1 498	52.4
Farmers not having extension contacts	0	-	-	-	-
Profit loss by capital amounts					
More than 76 000 TAS	48	1 529 660	512 609	1 760	74.9
Up to 76 000 TAS	68	399 458	680 158	1 313	37.0
Profit loss by time movements					
More than 12 minutes	39	865 899	653 222	1 330	57.0
Up to 12 minutes	77	867 750	850 567	1 583	50.5

Profit loss by farm's slope					
More than 25%	51	931 424	816 088	1 485	53.3
Up to 25%	65	816 680	747 841	1 507	52.2
Profit loss by shade given					
More than 20%	39	770 328	776 515	1 720	49.8
Up to 20%	77	916 156	777 293	1 385	54.1
All farms	116	867 128	787 696	1 498	52.4

Note: # represents number of, and N represents number of respondents, while categories of household size, farmer's experience, capital amounts, time movements and slope are based on the mean index score while the rest are based on TACRI (2008) recommended rates.

[a] Estimated loss from maximum profit obtained given prices and fixed factor endowments; maximum profit is computed by dividing the actual profit of individual farms by its efficiency score.

The impact of socio-economic factors accounting for this inefficiency in coffee production is presented in the lower panel of Table 2. On the basis of the presented statistics, it is important to point out prior assumptions which guided investigation of the stated variables.

It was expected that household size, experience of growing coffee, education level, extension services, capital, and shade would be positively related to efficiency, while age of coffee trees, time movements, and slope would be associated with lower efficiency levels. Results of this study revealed that coefficients of six (out of nine variables) were significantly weak.

For instance, the poor effect of education on coffee production was not surprising. Similar results had been reported in the past analyses of technical efficiency in Bangladesh agriculture (see Rahman, 2003). The average education levels of less than eight years (Table 1) seemed to clearly explain the role of education. It was further noted that farmers with no education seemed to incur higher profit loss and performed at significantly lower levels of profit efficiency, hence their effect was not captured in the regression analysis.

It was also revealed that household size performed better than it was expected. This was largely due to availability of family labour for coffee production. Table 4 shows that, farms with household size of more than 3 persons performed well with higher levels of profit efficiency.

On the other hand, farmer's experience in growing coffee seemed to perform well as expected in the study. It was found that farmers with more than twenty four years of experience in growing coffee earned higher profits. They also seemed to operate at higher level of profit efficiency compared to those who had up to twenty four years of experience (Table 4).

The age of coffee trees was included to reflect the relative importance of younger trees in terms of increasing farm profit. The positive sign on the estimated coefficient implied that the more aged trees had reduced farm profit. Table 4 clearly shows that coffee farms with trees older than 40 years, operated at lower levels of efficiency. Hence farmers incur high profit-loss.

The capital amounts used by farmers seemed to play the expected roles in increasing efficiency in coffee production. Regarding this, it was revealed that farmers whose capital amounts were more than TAS 76 000, performed significantly better in terms of earning actual profit. This is because they incurred more profit and operated at higher levels of efficiency.

Time spend by farmers to move from one farm to another was expected to have a significant management impact on coffee farms hence affecting yields. The weak significance of the coefficient was not expected for this variable. It was revealed that, farmers who spent less than 12 minutes to move from coffee farm to other farms obtained higher actual profits. Conversely, these farmers were found to have less efficiency with more profit-loss as shown in Table 5.

Similarly, farmers located at relative higher slopes performed better than their counterparts in areas with gentle slopes. Furthermore, farmers with more shade in their farms (more than 20%) operated at lower levels of efficiency and earned less actual profit and incurred high profit-loss. These results do not differ from those of TACRI (2008) in which open grown coffee was found to yield more than the shaded coffee.

4.5 Coffee Farm Sizes and their Distribution

Coffee farm sizes and their distribution among Mbinga farmers are presented in Table 5. It was revealed that, more than 75% of farmers owned farms that had less than 2 000 coffee trees which is equivalent to 1.58 hectares. However, the average farm size among respondents was 1 498 trees. This concurs with the national averages since agriculture in Tanzania is dominated by smallholder farmers (peasants) cultivating farms of an average sizes of between 0.9 and 3.0 hectares (URT, 2008; TACRI and TCB, 2010). Despite the wide variation of farm sizes (Table

5), coffee farmers seemed to be skewed towards lower farm sizes of below 1 500 trees which were not economically profitable (Figure 3).

Table 5: Coffee Farms and Farm Size Distribution

Farm Size (# Trees)	Number of Farms	Percentage
<= 500	12	10.3
501-1 000	24	20.7
1 001-1 500	33	28.4
1 501-2 000	24	20.7
2 001-2 500	9	7.8
>= 2 500	14	12.1
Total	**116**	**100**
Average Farm Size = 1 498 Trees		

Note: # represents number of.

4.6 Profit Efficiency and Farm Size Relationship

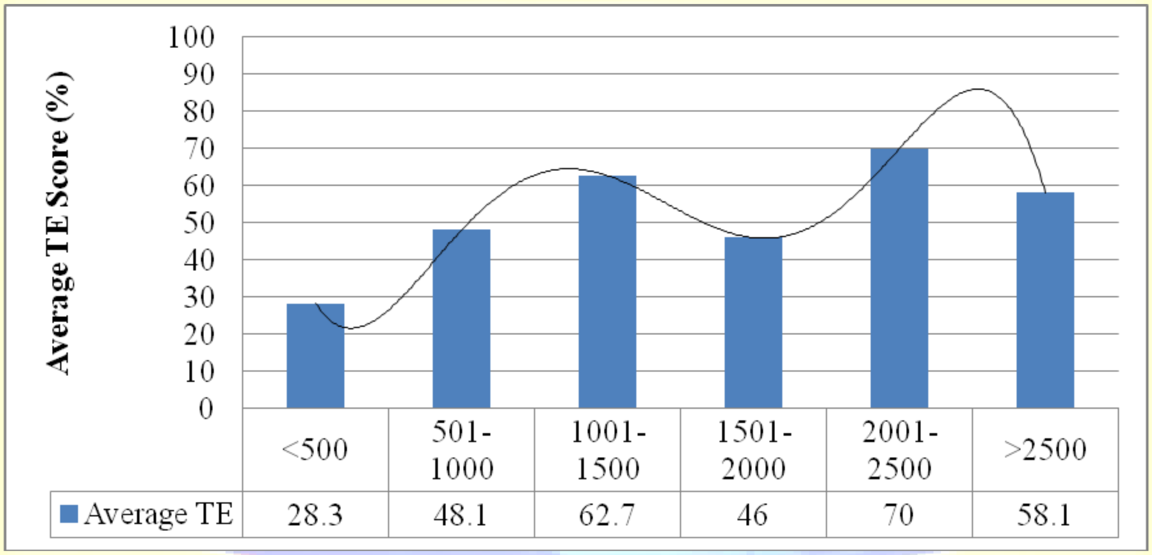
As presented in Figure 3, the relationship between profit (technical) efficiency and farm size show some fluctuations. It can be noted clearly from the findings that, the average TE/PE score for small farms (less than 2 hectares or less than 2 524 coffee trees) was relatively less efficient than farms measuring above 2 hectares (medium farms). It was noted that, small farms and medium farms revealed the average TE/PE score of 51.96% and 58.08% respectively.

The observed tendency of increasing farm efficiency when moving from very small or small farms to relatively medium farms could be also attributed to factors as shown in Table 4.

4.7 Profit Trend and Farm Size Relationship

Figure 3 presents relationship between average profit trend and farm size among coffee farmers. It indicates that the average profit per coffee trees increase steadily after sharp increase from less than 501 to less than 1 500 trees. The increase of average farm profit which is associated with increase in farm size when there is an increase from more than 1 500 coffee trees could be attributed to factors such as household size, suitable age of trees, education level, access to capital and time management (Table 4). Conversely, it was also found that 0.198 kg/tree and 1.66 kg/tree were obtained for home processed coffee and coffee cherry respectively. The ratio of one to eight was revealed, which is slightly less than the recommended rate. This was probably due to inefficiency of individual farms.

Figure 3: Average Profit Efficiency Scores and Farm Size



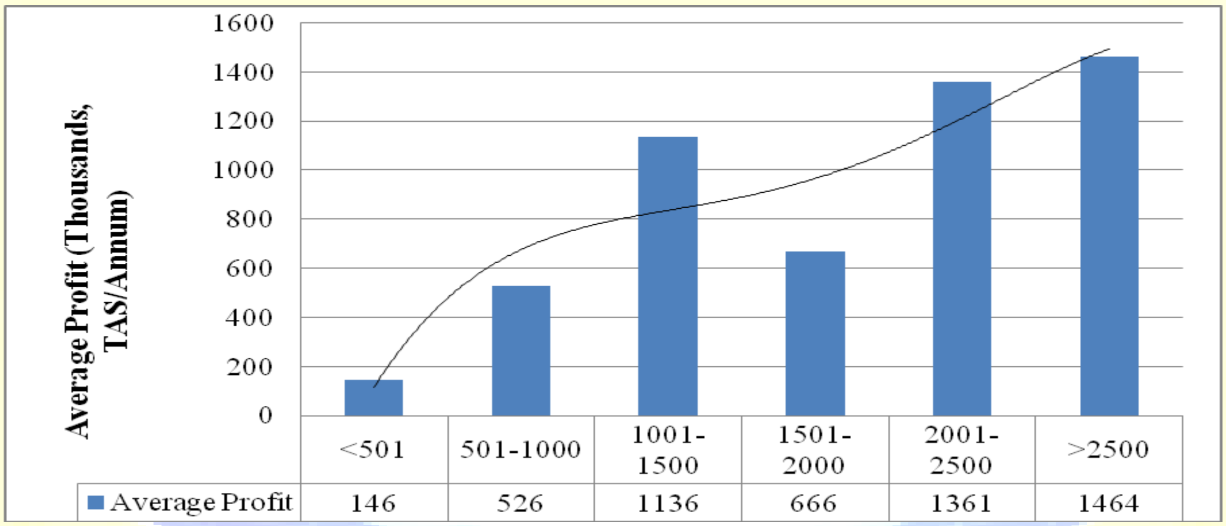
Note: Values in x-axis indicate the number of coffee trees (farm size)

It was also noted with concern that, there was an increase of average profit per unity area among coffee farmers due to farm size increase (Figure 4). The findings indicated clearly that medium farms (more than 2 524 trees) had significant higher profit ratios than small farms. Small size farms and medium farms seemed to have an average profit ratios of 35% and 65% respectively. On the basis of this evidence, it can be confidently stated that the increase in profitability was associated with increasing farm size. In other words, it means that small size farms are associated with more profit-loss compared to medium size farms.

4.8 Contribution of Coffee Production to the Livelihood of Farmers and Poverty Reduction

According to Tanzania's Poverty and Human Development Report (2009), Poverty levels in Tanzania are still high in rural areas where 37.6% of rural households live below poverty line compared with 24.1% of urban households. In this study, coffee farming revealed to have the ability to increase farmer's income hence reduces poverty significantly. Philip (2009), in his study on productivity, used a similar approach to examine if the size of sugarcane was an important variable in determining productivity. The variations of coffee farmer's income per capita are well shown in Figure 4.

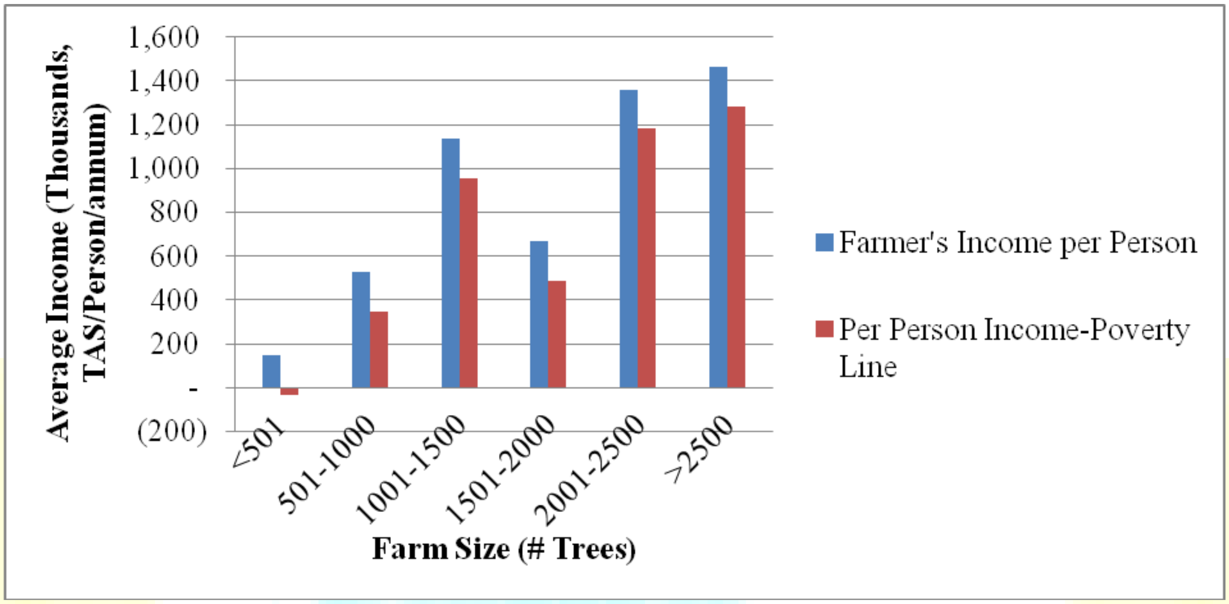
Figure 4: Average Profit Trend with Farm Size



Note: Values in x-axis indicate the number of coffee trees (farm size)

As presented in Figure 5, farmers with more than 500 coffee trees had income per person higher than the international poverty line. For the farmers to experience more than 13 998 TAS per 28 days which is the 2007 poverty line level as stipulated by Policy Forum (2011), they should be encouraged and supported to increase their farm sizes to at least 0.39 hectares. Based on farmers' responses on new plantings, only 19.8% and 54.3% were realized by those who wanted to expand and replant respectively. In this regard, a support should be provided to them especially new seedlings of new varieties.

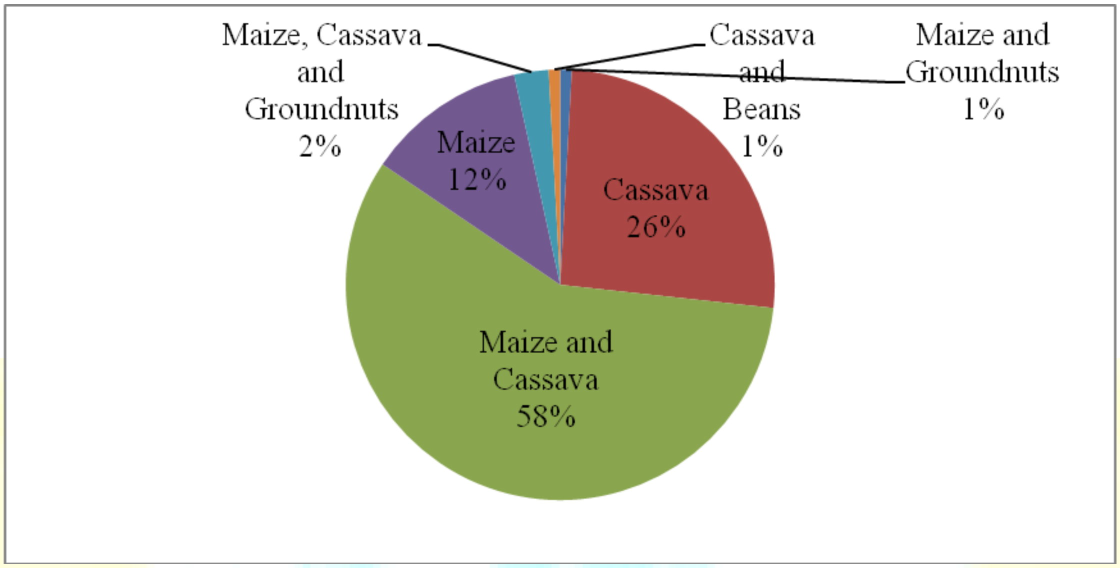
Figure 5: Discrepancy of Coffee Farmer's Income per Person



4.9 Alternative Crops Grown

In an attempt to spread risk, coffee farmers were found to grow other crops as well. Figure 6 presents other crops grown by coffee farmers and it was revealed that, more than 60% of farmers grew other crops. Maize and Cassava seemed to be grown by most farmers, 58% of respondents grew both maize and cassava, and 12% and 26% grew maize and cassava respectively. This is not surprising because maize was reported to be a major food crop in a district (Table 6). Cassava which is a drought resistant crop has started gaining importance in recent years because of climate changes.

Figure 6: Alternative Crops Grown by Coffee Farmers



According to Amani (2004) and DALDO (2011), both maize and cassava are used as staple crops and cash crops in areas which produce in surplus. Apart from maize and cassava, other crops cultivated by farmers though in small percent include beans, and groundnuts. The big challenge was however on how to support processing and other value addition activities to these major alternative crops such as maize and cassava.

Table 6: Actual Food Crop Production for 2009/10 Season and Projection for 2010/11

Crop	Average Households in Production	Actual Production 2009/10 (tons)	Estimated Area 2010/11 (ha)	Production Estimates 2010/11 (tons)	Actual Area 2010/11 (ha)	Actual Production 2010/11 (tons)
Maize	49 283	144 635	59 082	165 430	60 321	166 669
Beans	34 540	17 724	19 844	20 382	19 850	20 388
Paddy	7 256	24 100	14 200	39 050	11 425	31 418.7
Cassava	47 098	96 348	48 773	110 800	47 414	107 712
Sweet Potatoes	28 581	52 416	14 344	60 280	12 067	50 711
Wheat	5 872	2 207	3 012	2 538	3 018	2 543
Banana		2 653	80	3 216	72	2 894.4

Total	**340 083**	**159 335**	**401 696**	**154 167**	**382 336.1**

Source: DALDO Mbinga (2011)

Moreover, coffee farmers grow maize and cassava not only because they are major food crops in their area but also due to cheap production costs. For instance, costs of producing one kilogram of each produce is very cheap compared to other crops such as beans (Table 7). Since most of the farmers have small plots of these food crops, it is easy for them to manage at relatively low costs. It was also found out that, farmers used an average time of 12.6 minutes to move from one plot to another. Thus, it seemed that it was profitable for them to be engaged in both cash (coffee) and food crop production, especially maize and cassava.

Table 7: Summary and Estimates of Maize, Beans and Cassava Costs of Production

Cost Items	Maize	Beans	Cassava
Labour Costs (TAS/ha)	130 000	45 000	101 000
Material/Intermediate Inputs (TAS/ha)	220 200	88 600	258 000
Total Variable Costs			
TAS per ha	350 200	133 600	359 200
TAS per kg	80	120	75
Fixed Costs			
TAS per ha	25 800	24 400	24 500
Total Costs			
TAS per ha	326 000	158 000	383 500
TAS per kg	80	120	75

Note: Exchange rate: 1 USD = 1 512.46 TAS (BoT, 2012) and 1 hectare = 1 262 coffee trees (TACRI, 2008)

5.0 Conclusion and Recommendations

5.1 Conclusion

The study used stochastic profit frontier functions to analyse farm size and productive efficiency of Mbinga coffee farmers. Using detailed survey data from 116 coffee farms in 2010, measures of profit inefficiency were computed, indicating a wide variation among farmers. The mean level of efficiency for coffee farming was 0.524 indicating that there are potential opportunities for increasing profits by improving technical and allocative efficiency.

The farm-specific variables which were used to explain inefficiencies indicated that farmers who had some education, more household size, more experience in growing coffee, younger coffee trees, better capital, and less shade provided to farms seemed to be more efficient. Due to the gap of 47.6% inefficiency level, generally, farmers are losing to the tune of TAS 787 696 per mean index of coffee trees which is 1.18 hectares.

On the basis of findings of this study, it can be concluded that inefficiency in coffee farming can be reduced significantly by increasing farm size: that is increasing number of trees. Increasing size of farms could not only increase farm's efficiency but also contribute in alleviating poverty among the farmers. In addition, capital amounts and extension services need to be improved in order to increase efficiency. It was also found that, cooperative services and government subsidy programs should be strengthened so as to bring more positive impact on farm's productivity.

As an attempt to overcome risks, farmers were found to grow alternative crops such as maize and cassava. The crops were preferred for two major reasons: first their production costs were relatively low and apart from using them as food crops, the surplus could be sold as well. Increased productivity and efficiency, in conjunction with rational government policies, would dramatically alter positively the economic contribution of coffee sub sector to trade, food security and livelihoods of important stakeholders along the chain.

5.2 Recommendations

Results of this study have clearly revealed that farmers were general responsive to changes in farm size which are also coupled with changes in output and inputs prices. In addition, it seemed that profitability increased substantially with increase in farm size under cultivation in terms of number of coffee trees. In this regard, it is recommended that coffee farmers should increase their farm size at least to medium farms of more than 1 262 coffee trees.

Since most of the farmers had small farms, cooperatives societies, private sector, and government should put in place initiatives which will create conducive environment for improving efficiency and profitability in coffee production business.

Since, most of agricultural inputs are often imported and are expensive (particularly fertilizers, herbicides and insecticides). The government should continue to provide input subsidies to farmers. The already established mechanism for provision of subsidy should be reviewed in a bid to improve coffee productivity. It is also recommended that, private sector should join hands with government efforts to ensure timely availability of farm inputs at affordable prices.

Lastly, a special attention should be directed on alternative crops which do not only spread risks of farmers but also play a significant role in improving farmers' income, hence stabilizing their economic positions. In this regard, the production of various crops should be emphasized since they have positive impact on the efficiency of coffee farms.

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