DETERMINANTS OF EFFICIENCY AMONG ADOPTERS AND NON-ADOPTERS OF IMPROVED CASSAVA VARIETIES IN OGUN STATE, NIGERIA.

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ABSTRACT

Cassava forms an important component of Nigerian communities. Its cultivation however is still done using crude techniques and simple tools such as cutlasses and hoes. This paper investigated the determinants of efficiency among adopters (172 households) and non-adopters (44 households) of improved cassava varieties in Ogun State Nigeria. Primary data were collected through the use of structured questionnaires from 216 cassava farm households obtained in a multi-stage sampling procedure from four Local Government Areas. Stochastic frontier production function using maximum likelihood estimation (MLE) was used to analyse the technical efficiency. The results revealed that 57.40 percent of the farmers were within the age range of 31-50 years, 58.30% had farm size ranging from 1-2.49 hectares while 79.62 % were adopters of improved cassava varieties. Farm size, fertiliser, and herbicides were the major inputs that were associated with the variation in cassava output for both adopters and non-adopters. The significant socio economic variables that accounted for the observed variations in technical efficiency among farm households were age, education, farming experience, extension contact, genders and marital status. Similar results were obtained for high and low adopters of improved cassava varieties. An assessment of the technical efficiency showed that a differential of 19 % (89-70) existed between adopters and non-adopters and a differential of 12 % (82 -70) existed between high and low adopters of improved cassava varieties while the elasticity was less than one signifying that the farm households were operating at a point of decreasing return to scale which is the rational stage at which production should normally take place. However, both adopters and non-adopters operated below the economic optimum point indicating that there is some inefficiency in the allocation of inputs. It was therefore recommended that government should strengthen the adult education programme and improve the extension services delivery system while farm input such as herbicides and fertilisers should be made available at subsidised rate in the area.

Key words: Technical efficiency, Farm households, Stochastic function, Ogun State

INTRODUCTION

Cassava is an important staple food in Nigeria. Its consumption cuts across culture, age and regions. It is an important part of the diet of an average Nigerian judging from the high proportion consumed. It is widely planted by farmers across all the geo-political zones in the country. The world cassava production in 2003 stood at 189.10 million metric tonnes and Nigeria produced 17.65 % of that, i.e 33.37 million tonnes of this global production. Table I shows cassava production in tonnes by zone for the period of 2000-2002. By zone, the North-Central zone produced over 7 million tonnes of cassava a year. The South-South produced over 6 million tonnes a year while the South-West and South-East produced just less than 6 million tonnes a year. The North-West and North-East are small by comparison at 2 and 0.14 million tonnes respectively.

Table 1: Cassava production by zone 2000-2002 (tonnes).

Region	2000	2001	2002
South-West	4,993,380	5,663,614	5,883,805
South-South	6,268,114	6,533,944	6,321,674
South-East	5,384,130	5,542,412	5,846,310
North- West	2,435,211	2,395,543	2,340,000
North -Central	7,116,920	7,243,970	7,450,640
North- East	165,344	141,533	140,620
Total	**26,363,099**	**27,521,016**	**27,938,049**

Source: PCU, 2003 (Project Coordinating Unit)

Unfortunately, cassava farming method is still crude in nature involving the use of cutlass and hoes especially with the peasant farmers who form the major source of food producers in Nigeria.

Falusi (1995), observed that the main issue in the Nigerian agriculture was that of low productivity. Some of the reasons identified included the absence of consistency in the policy formulation for the agricultural sector, inadequacy or absence of supportive infrastructural facilities like storage, communication and absence of an efficient and effective extension system that will aid in transmitting appropriate research finding to famers for adoption. This ultimately resulted in lower yield for the famers. The current yield of cassava as observed by IFAD (2004) had stagnated at just over 10 tonnes per hectare since the early 1990s. This was as a result of the use of traditional planting materials which are characterised by low productivity. Increasing yields to 15 tonnes per hectare as obtained in some other countries is a significant challenge for the subsector. One of the push factors as suggested in the study carried out by IFAD (2004) was the introduction of improved varieties as a means to increasing cassava yield. However, the problem was that these improved varieties were not yet widely adopted.

The problem of adoption as identified by Rahji (2005) centred on understanding the adoption behaviour of farmers and the improved production technology available and attainable. It also borders on examining how the improved practices will lead to a structural shift in the production parameters and efficiency of the farmers. Abebaw and Belay (2010), further pointed out that the efficacy of technology dissemination programme depended mostly on the factors that influence adoption by the farmers. Extension educators need to understand the factors affecting technology adoption in order to deliver effective programme. In view of this, the study was designed to examine and compare the technical efficiency among adopters and non-adopters as well as high and low adopters of improved cassava varieties.

METHODOLOGY

Study area

The study focused on analysis of adoption of improved varieties among cassava farming households in Ogun state, in the South Western zone of Nigeria.

Sampling technique

This study was conducted on cassava farming households in Ogun State with the aid of interviews and questionnaires. A multi stage sampling procedure was used to select the respondents for the study. In the first stage, two Agricultural Development Programme (ADP) zones i.e Abeokuta and Ilaro were randomly selected. In the second stage four local governments were purposively selected from the Agricultural Development Programme (ADP) Zones in the state based on the prominence of cassava cultivation in the area. The Local Government Areas (LGAs) were Odeda and Ifo in Abeokuta zone while Yewa South and Imeko-Afon was chosen from Ilaro zone. In the third stage, five farming communities were randomly selected in each of the LGAs using the list obtained from Ogun State Agricultural Development Programme (OGADEP) thus giving a total of 20 communities. In the last stage, between 10 and 15 households were purposively selected in each community on the basis of having sole cassava plot thus giving a total of 225 cassava farming households. However, only 216 cassava farming households were used for the study. The remaining households were excluded because the data supplied were incomplete for purposes of analysis.

Analytical techniques

A number of frontier models to measure efficiency have been developed based on Farrell's work (Coelli *et al.,* 1998; Thiam, 2001). These are classified into two types: parametric and non-parametric. Parametric frontier which relies on specific functional form can be separated into deterministic and stochastic. An example of the former is the data envelopment analysis (DEA) which involves mathematical programming methods while the example for the latter is the stochastic frontier which involves econometric methods. According to Bekele *et al.* (2002), the stochastic frontier model used for this study was first proposed by Aiginer *et al.* (1977) and Mueesen and van de Broeck (1977). Various other models have also been suggested and applied in the analysis of cross-sectional and panel data on producers. The stochastic frontier method is however chosen over the DEA method because the latter has a number of limitations that were noted by Coelli *et al.* (1998) as follows: measurement error and other noise may influence the shape and the position of the frontier; outliers may influence the results; the exclusion of an important input or output can result in biased results; the efficiency scores obtained are only relative to the best firms in the sample; the addition of an extra firm in DEA analysis cannot result in an increase in the TE scores of the existing firms; the addition of an extra input or output in a DEA model cannot result in a reduction in the TE scores; treating inputs and/or outputs as homogenous commodities when they are heterogenous may bias results.

On the other hand, Coelli *et al.* (1998) argued that stochastic frontier has the following advantages relative to DEA. These are: DEA assumes all deviations from the frontier are due to inefficiency while the stochastic approach allows for statistical noise; tests of hypotheses regarding the existence of inefficiency and also regarding the structure of the production technology can be performed in a stochastic frontier analysis. In addition, Stochastic frontiers are more appropriate than the DEA in agricultural applications especially in developing countries where data are heavily influenced by measurement error and the effects of weather, disease, etc (Coelli *et al.*, 1998). Nigeria is a developing country, so a stochastic frontier production function model was selected as technique to analyse the collected data. Both descriptive and quantitative method was used in the analysis of the study data. A widely used method in many empirical studies for assessing technical efficiency differences among production units is the stochastic production frontier (Fulginiti *et al.,* 2004). The stochastic frontier production function model is specified as:

$$Yi = f\left(X_{,}\beta\right) + \varepsilon i ----------------- (1)$$

Where, Y_i is the logarithm of output, X is a vector of the logarithm of explanatory variables, β is a vector of unknown parameters. Ɛ is a stochastic disturbance term consisting of two independent elements u_i and v_i. The symmetric component, v_i accounts for random variation in output due to factors outside the farmer's control such as weather and diseases. It is assumed to be normally, independently and identically distributed as $N^{\sim}$ (o, δ_v^2). A one sided component u ≤ o reflects technical inefficiency relative to the stochastic frontier, f (x_a, β). Therefore, (i) u = 0 for a farm output which lies on the frontier. (ii) u < 0 for a farm which is below the frontier as $|N^{\sim}$ (o, $\delta_u^2|$; hence the distribution of u is half-normal. The model can be used to analyse cross-sectional data and it is given as:

$$Yi = f\left(X_{,}\beta\right) + V_i + U_i \text{---}(2)$$

$$u = f(z_b, \delta) \text{ -- } (3)$$

$Z_{b\,=}$ is vector of farmer specific factors and δ = is a vector of parameter.

The β and δ coefficients are unknown parameters to be simultaneously estimated together with the variance parameters which are expressed in terms of $\delta^2 = \delta^2_u + \delta^2_v$ and $\gamma = \delta^2_u / \delta^2_v$ where γ -parameter has a value between 0 and 1. Once the estimate of the technical inefficiency term, u_i have been obtained, Battese and Coeili (1995) suggest the level of technical efficiency of the production unit can be estimated as:

$$TE = \exp(-u_i) \text{ - - - - --}(4)$$

This measure of technical efficiency takes on value of between 0 and 1 with a value of 1 indicating full technical efficiency. Any farm operating on the frontier is said to be technically efficient while those that lie below the production frontier are said to be technically inefficient. The extent to which they lie below the frontier measures the level of their inefficiency.

Despite its well-known limitations, the Cobb-Douglas function is chosen because the methodology employed requires that the function be self-dual (Bravo-Ureta and Evenson, 1994). Xu and Jeffrey (1997) also noted that although there are other more flexible forms, the functional form has a limited effect on empirical efficiency measurement. The other reason why the specified Cobb-Douglas production function was used was because of its ease of interpretation of returns to scale. The function is homogeneous of degree a+b. If a+b exceeds unity, there are increasing returns to scale; when a+b=1 there is constant returns to scale and a+b<1 indicates diminishing returns to scale. This study also adopted the Cobb- Douglas specification due to its theoretical fitness, and wide acceptability (Ajibefun and Daramola, 2002; Aihonsu, 1999). The estimation of equation was accomplished by Maximum Likelihood Estimation (MLE). The general form of a Cobb-Douglas production function in logarithm form is given as:

$$\ln Y_1 = \beta o + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 \ln X_{6i} + \beta_7 \ln X_{7i} + v_i - u_i \text{ ----------(5)}$$

where: Y_i = Output of Cassava (kg), X_1 = Farm size (ha), X_2 = Family labour (in man-days)
X_3= Hired labour (in man-days), X_4= Value of planting materials (measure in Naira i.e ₦ which is the local currency), X_5= Quantity of fertilisers (kg), X_6 = Quantity of herbicides (litres), X_7= Tractor cost used in farming operation (₦),βo = Represent the constant
The estimated technical inefficiency model is presented as thus:

$$\mu_{i=} \delta_o + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 \text{--(6)}$$

where:μ_i= Technical inefficiency, δ_o= Constant, δ_i= Coefficient to be estimated, Z_1= Age of household heads (years), Z_2 = Level of education (years), Z_3= Household size (no), Z_4= Farming experience (years), Z_5 = Extension contact (1 if there is contact, 0 otherwise), Z_6 =Access to credit (1 if farmers have access to credit, 0 otherwise),
Z_7 = Sex (1 if male,0 otherwise),
Z_8 = Marital status (1 if married, 0 otherwise)

RESULTS AND DISCUSSIONS

Socio-Economy characteristic of cassava farming households.

The study as shown in Table 2 found that majority of the households heads (80.6%) are male having their age in the bracket of 41-50. Over 87% of the household heads are married while 35.2% are having secondary education. Furthermore, over half of the cassava farming households maintained a household size that is above four with farm size ranging between 1-1.49ha. In addition, 33.6% of them have had between 11-20 years of farming experience. While 58.3% had no access to credit, 60.2% were observed to be members of farming association.

Table 2: Socio-economic characteristics of respondents

Variables	Frequency	Percentage
Age (years)		
< 30	4	1.9
31-40	50	23.1
41-50	74	34.3
51-60	38	17.6
> 60	50	23.1
Total	216	100
Level of education		
None	60	27.8
Primary education	64	29.6
Secondary education	74	35.2
Diploma	16	7.4
Total	216	100
Household size		
Below 4	92	42.6
Above 4	124	57.4
Total	216	100
Farm size		
< 0.49	16	7.4
0.50-0.99	52	24.1
1.00-1.49	72	33.3
1.50-1.99	46	21.3
2.00-2.49	8	3.7
> 2.50	22	10.2
Total	216	100
Farming experience		
1-10	38	17.6
11-20	72	33.6
21-30	36	16.7
31-40	34	15.7
41-50	22	10.2
> 50	14	6.5
Total	216	100

Farmers status		
Adopters	172	79.62
Non-Adopters	44	20.37
Total	216	100
Reasons for planting		
Early maturity	10	4.6
Good for environment	36	16.7
Quality tuber	8	3.7
Resistance to diseases	14	6.5
Yield increase	144	66.6
Variety available	4	1.9
Total	216	100
Sources of varieties		
ADP	28	13.0
Farmers Group	13	6.0
Last Season	139	64.4
RTEP	36	16.7
Total	216	100

Source: Field survey data, 2010

Maximum livelihood estimates of parameters for adopters and non adopters of improved cassava varieties

Table 3 presents the estimated parameter results obtained from MLE for both adopters and non-adopters of improved cassava varieties. All the coefficients of the model have the expected signs except for fertiliser which has negative sign. For adopters, farm size (x_1), family labour (x_2), hired labour (x_3) and herbicides (x_6) have positive significant influence on the farm output. While farm size and herbicides were significant at 1 percent, family and hired labour were significant at 5 %. Other variables such as planting material cost and tractor cost although they have the expected sign, they do not exert any significant influence on the output. On the other hand, in the case of non-adopters, farm size and family labour have positive influence on farm output at 1 and 10 percent respectively. Although fertiliser usage has significant influence, the effect is negative. This indicates that further usage will add less to cassava output. This may be due to over utilisation of fertiliser. For all the variables that have positive coefficient for both adopters and non-adopter, it implies that as each of them is increased, cassava output increased. The magnitude of the coefficient of the significant variables indicates that farm output is inelastic to change in any of the variables used. Thus, a 1% increase in farm size, family labour, hired labour and herbicides would induce an increase of 0.838, 0.015, 0.013 and 0.021 percents respectively in cassava output of the farm households. The sigma squared (δ^2)

estimate for both adopters and non-adopters of improved cassava varieties are significantly different from zero at 1 percent attesting to the good fit of the model. The gamma (γ) is estimated as 0.862 for adopter and 0.717 for non-adopters. This suggests that about 86 percent and 72 % of the variation in output of adopters and non-adopters is due to differences in technical efficiency.

Inefficiency model

The signs of the coefficients of the variables in the model have important policy implication. A positive sign implies that the associated variable has a negative effect on efficiency and a negative sign indicates a positive effect on efficiency. Therefore, from Table 3, age, farming experience, credit access and marital status negatively affect technical efficiency while education household size, extension contact and sex affect technical efficiency positively. This implies that as the level of education, household size and extension contact increases, inefficiency in resources use decreases and technical efficiency increases and their output will be more close to the frontier. In the case of non-adopters, only extension contact and household head gender have positive effect on technical efficiency and hence less inefficient than adopters.

Table 3: Stochastic frontier production function results among cassava farming households in Ogun state

Variable	Adopters parameters	t-Values	Non-adopters parameters	t-values
Constant	9.251***	65.829	8.982***	60.055
Farm size(x_1)	0.838***	19.945	0.794***	17.838
Family labour (x_2)	0.015*	1.879	0.011*	1.629
Hired labour (x_3)	0.013*	1.612	0.012	1.305
Planting cost (x_4)	0.005	0.133	0.156	0.351
Fertiliser (x_5)	-0.005	-0.526	-0.017**	-1.667
Herbicides (x_6)	0.021***	4.256	0.015	1.223
Tractor cost (x_7)	0.016	1.289	0.006	1.010
Sigma squared (δ^2)	0.349***	3.245	0.251***	3.045
Gamma (γ)	0.862***	17.747	0.717***	16.828
Inefficiency model				
Constant	-6.096**	-2.320	-1.056*	-1.886
Age (z_1)	0.0816**	3.052	0.0521**	2.446
Education (z_2)	-1.703**	-2.768	0.667	1.124
Household size (z_3)	-0.499	-1.264	0.057	0.892
Farming Exp (z_4)	0.481**	2.113	0.025*	1.760
Extension contact (z_5)	-0.055**	-2.922	-0.012*	1.865
Credit access (z_6)	0.154**	2.525	0.022	1.452
Sex (z_7)	-1.153**	-2.558	-1.002**	-2.110
Marital status (z_8)	1.140**	2.037	0.126	1.221

Source: Computed from field survey data, 2010

*** = significant at 1 percent, ** = significant at 5 percent, * = significant at 10 percent.

Maximum likelihood of the parameters for high and low adopters of improved cassava varieties

Having estimated the frontier production function among cassava farming households categorised into adopters and non-adopters of improved varieties, it becomes important as well to estimate same function for adopters of improved varieties categorised into high and low adopters. High adopters of improved cassava varieties are those who have allocated over 45% of farm land under cultivation for cassava production for improved varieties while low adopters are those who have allocated less than 45percent. Out of the total number of 172 households who are adopters of improved varieties, 66.28% constituting 114 households are high adopters, while 33.72% representing 58 households are low adopters. Table 4 presents the estimated parameters results obtained from MLE for high and low adopter of improved cassava varieties. All the variables in the model have the expected sign except fertiliser under high adopters and hired labour and planting material cost under low adopters. For high adopters of improved cassava varieties in Ogun State, farm size (P<0.01), family labour (P<0.10), hired labour (P<0.05) and herbicides (P<0.01) was positive and statistically significant. while only farm size (P<0.010 and herbicides (P<0.05) was positive and significant for low adopters. This implies that as the variables with positive coefficient are increased, the farm output increase and vice-versa for negative signs. The sigma-squared (δ^2) is statistically significant at 1% for high adopters and 10 percent for low adopters, thus indicating a good fit of the model. The gamma (γ) is estimated as 0.809 for high adopters and 0.960 for low adopters thus suggesting that about 81% and 96% of the variation in output of high and low adopter respectively is due to difference in technical efficiency.

Inefficiency model

All the variables in the model under high adopters were significant except household size while under low adopters, only age, education and extension contacts were significant at different levels as shown on Table 3. The negatively signed parameters for both adopters and non-adopters are education level, extension contact, sex, household size and marital status. The negative sign affect efficiency positively, thus decreasing inefficiency in resources use and increase technical efficiency. On the other hand, age, farming experience and credit access have positive sign, thus associated variables affect efficiency negatively i.e. increase inefficiency in resources use and decrease technical efficiency.

Table 4. Stochastic production function of high and low adopters of improved cassava varieties in ogun state.

Variable	High Adopters Parameters	t-Values	Low-adopters Parameters	t-values
Constant	9.159***	56.768	9.396***	26.244
Farm size(x_1)	0.801***	14.870	0.772***	9.218
Family labour (x_2)	0.018*	1.699	0.020	0.106
Hired labour (x_3)	0.025**	2.217	-0.0063	-0.418
Planting cost (x_4)	0.021	0.385	-0.0058	-0.095
Fertilizer (x_5)	-0.071	-1.203	0.0039	0.206
Herbicides (x_6)	0.022***	3.147	0.022**	2.518
Tractor cost (x_7)	0.021	1.355	0.020	0.896
Sigma squared (δ^2)	0.241***	3.740	0052*	1.757
Gamma (γ)	0.809***	12.219	0.960*	1.881
Inefficiency model				
Constant	-3.768**	-2.321	-0.708	-1.324
Age (z_1)	0.042**	2.560	0.026*	1.924
Education (z_2)	-1.663**	-2.789	-0.366*	-1.811
Household size (z_3)	-0.036	0.119	-0.052	-0.164
Farming Exp (z_4)	0.292*	2.003	0.076	0.956
Extension contact (z_5)	-0.026*	-1.754	-0.022**	-2.215
Credit access (z_6)	0.137**	2.520	0.018	1.039
Sex (z_7)	-1.129**	-2.500	-0.199	-1.190
Marital status (z_8)	1.374**	2.016	-0.211	-1.494

Source: Computed from field survey data, 2010;
*** = significant at 1 percent, ** = significant at 5 percent, * = significant at 10 percent.

Efficiency estimate

Table 5 reveals that majority (83.1%) of adopters of improved varieties in Ogun state had their technical efficiency greater than 0.81, followed by 9.3% (0.71 –0. 80) and 3.5% (≤ 0.50); while for non-adopter, majority of the households had their efficiency in the bracket of 0.71 -0.80 (43.2%). In the case of high and low adopters, majority had their technical efficiency greater than 0.81 for high adopters and 0.71 -0.80 for low adopters of improved cassava varieties. An assessment of the technical efficiency shows that a differential of 19% (89-70) existed between adopters and non-adopters and a differential of 12% (82 -70) between high and low adopters of improved cassava varieties. This means that both the adopters and high adopters are 19% and 10% technically efficient than the non-adopters and low adopters respectively.

Elasticity of production and return to scale

The parameter estimate in a Cobb-Douglas production function is the elasticities and the sum gives the return to scale. If the sum of all the elasticities is more than one, it is increasing return to scale; if less than one, it is decreasing return to scale and constant return to scale if it is equal to one. A look at the Tables 5 and 6 shows that the sum of the elasticities for all variables is less than one i.e. the farm households are operating at a point of decreasing return to scale. This is the rational stage at which production should normally take place because addition to output is positive with an increase in input utilisation.

Table 5: Frequency distribution of T.E estimated for adopters and non-adopters of improved cassava varieties

Frequency	**Adopters**		**Non-adopters**	
	Frequency	**Percentage**	**Frequency**	**Percentage**
≤ 0.05	6	3.5	--	--
0.51 – 0.60	2	1.2	12	27.3
0.61 - 0.70	5	2.9	10	22.7
0.71 – 0.80	16	9.3	19	43.2
>0.81	143	83.1	3	6.8
Total	172	100	44	100

Source: Computed from field survey data, 2010

Table 6: Frequency distribution of T.E estimates for high and low adopters of improved cassava varieties

Frequency	**High adopters**		**Low adopters**	
	Frequency	**Percentage**	**Frequency**	**Percentage**
≤ 0.50	2	1.8	--	--
0.51 -0.60	8	7.0	105	8.6
0.61 -0.70	22	19.3	18	31.0
0.71 -0.80	31	27.2	28	48.3
>0.81	51	44.7	7	12.1
Total	114	100	58	100

Source: Computed from field survey data, 2010

Table 7: Elasticities of production and return to scale

Variables	**Elasticity of adopters**	**Elasticity of non-adopters**
Farm Size	0.838	0.794
Family labour	0.015	0.011
Hired labour	0.013	0.012
Planting cost	0.005	0.156
Fertilizer	-0.005	-0.017
Herbicides	0.021	0.015
Tractor	0.016	0.006
Return to Scale	0.903	0.977

Source: computed from field survey data, 2010

Table 8: Elasticities of production and return to scale

Variables	Elasticity of high adopters	Elasticity of low adopters
Farm Size	0.801	0.772
Family labour	0.018	0.002
Hired labour	0.025	-0.0063
Planting cost	0.021	-0.0058
Fertilizer	-0.071	0.039
Herbicides	0.022	0.022
Tractor	0.021	0.020
Return to scale	**0.837**	**0.808**

Source: computed from field survey data, 2010

CONCLUSION AND RECOMMENDATIONS

The production frontier analysis revealed that inefficiency exists among cassava farming households in Ogun state for both adopters and non-adopters. Therefore, it is recommended that government should strengthen the adult education programme and improved extension services delivery system while farm input such as herbicides should be made available at low prices. This may tend to bring about increase in output.

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