

Resource - Use Efficiency: An Application of Stochastic Frontier Production Function to Plantain Farmers in Ogun State, Nigeria

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Abstract
This study assessed the resource-use efficiency of plantain farmers in Ogun State, Nigeria using the stochastic frontier production function analysis. Primary data were collected from 160 plantain farmers in Abeokuta zone of Ogun State Agricultural Development Programme (OGADEP). The mean efficiencies values for plantain production were 0.835, 0.675 and 0.721 for technical, allocative and economic efficiencies respectively. The return to scale value showed that plantain production was at stage of decreasing positive return to scale. The study also revealed the presence of inefficiency in the resource-use among plantain farmers in the study area ($p < 0.05$). The distribution of results also showed that the plantain farmers were more efficient in the use of some inputs. Changing the input combinations was observed to increase farm level efficiency. The farmers in the study area therefore need to use available input intensively so as to reduce current inefficiencies significantly.
Keywords: Food security, Plantain farmer, Allocative efficiency, Stochastic frontier, Technical efficiency
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1.0 Introduction

The major challenge facing Nigeria today is that of feeding her teeming population. The challenge remains that of self-sufficiency in food production (Dare, 2008; CBN, 2005). According to Balogun (2001), food insecurity problem is a serious issue in Nigeria and other African countries. The problem of food insecurity in Nigeria arises from the fact that food production is still being carried out largely on subsistence level, with the use of primitive farm implements, increasing population, poor post harvesting technology, lack of proper storage and processing facilities/industries in the country (Dare, 2008). Food insecurity when combined with poverty status has been shown to have a negative and significant effect on Technical Efficiency (TE) in resource utilisation. Poor nutrition, as a result of food insecurity could dampen labour productivity within a household and by extension; low-income status can weaken access to and the efficient use of household resources (Chavas *et al.*, 2005). World Bank survey in 2004 revealed that about 37 percent Nigerians are food insecure.

Studies (Akinseinde, 2006; Ogundari, 2006; Ojo, 2007) attributed the gap between food production and population growth in Nigeria to low productivity of resources being used and technology, arising from shortfall in the essential farm inputs, which necessitates the use of primitive tools. The resultant effect of low-level technology is low yield which is not enough to feed the teeming population; hence the increase in prices of food crops. Other factors accountable for low productivity of resources are poor implementation of government policies; high level of illiteracy among the rural dwellers, especially the farming population; poor quality of planting material and breeding animal stock; and poor pricing policy. Low productivity is also attributed to high poverty rate among food crop farmers. According to Akinyosoye (2005), farming is seen in Nigeria as a harbinger of poverty for most of the participants, particularly the subsistence farmers who barely make enough income to cater for their daily needs. The low productivity has continued to widen the gap between food production and population growth. To bridge this gap, World Bank report (1989), estimated that, agricultural production in Nigeria must grow by at least 4 percent a year. However, Federal Department of Agriculture (1993) proposed an estimated annual average food crops growth rate of 5.9 percent, as being necessary to meet domestic food demand and reduce importation significantly.

Moreover, Amaza and Olayemi (2002) identified low crop yield and productivity of resources utilized as the main constraints to rapid growth in food production in Nigeria. If resources are properly harnessed and efficiently allocated, increase in farmers output from the existing hectares of land being cultivated is achievable. Idiong (2007) noted that productivity of farmers in Nigeria could be raised either by adopting improved production technologies or through improved efficiency in resource utilization or both. He submitted that the low rate of adoption of improved technologies by farmers makes improved efficiency in resource utilization the best option for increased farmers' productivity in the short-run.

Increase in the prices food crops may not only be attributed low productivity which is positively related to inefficiency in resource utilization, but to high cost of production (increase in cost of agricultural inputs and labour wage due to rural-urban migration) and removal of subsidies on most agricultural inputs. Uduma (2007) revealed that cost of labour account for as much as 60-75 percents of total cost of production. The way forward is to undertake studies on resource use efficiency on food crop production by focusing on food crops that could help mitigate food insecurity and poverty problem in Nigeria. Plantain, according to Schinzl (2003) and Tijani

(1993), is one of such food crops that could fulfill these requirements. This explains the choice of plantain for this study. Resource use efficiency study is in line with ongoing government Agricultural Transformation Agenda (ATA) that is centered on treating agriculture as business rather than development project as it was the case in the past (FMA&RD, 2012). This is in a way to bring about efficient utilization of resources in agriculture; thus moving away from subsistence to commercial farming that will bring about increased productivity and improved farmers' wellbeing.

Plantain is a food crop believed to have the potential of mitigating the twin problems of food security and poverty. It is regarded as the second cheapest sources of energy after cassava, and having the least cost of production among food crops in terms of per hectare/kilogramme/1000 calories (per caput) (du-Montcel, 1987; Johnston, 1958). Plantain is important in the diet of many Nigeria families. In the urban areas, it is normally eaten in convenient forms like "Dodo" (fried ripe pulp), chip (fried unripe pulp) and as plantain flour (Akinwunmi, 1999). Plantain flour has an advantage over other starchy foods, because it contains protein, mineral and vitamins. Medicinally, it can be used to cure certain ailments like sore throats, tonsillitis, diarrhea and vomiting. Other important plantain products documented includes: Soymusa, "Sekete" local beer and "Boli" roasted plantain, as well as local processed form known as "Dodo Ikire", a local plantain chips processed from over ripped plantain spiced with hot pepper (Idachaba, 1995; Adetunji and Adesiyan, 2008). In addition, plantain is being used in compounding livestock feeds as an alternative source of energy in some West Africa countries as Cameroon and Ghana (Fomunyam, 1992).

The two-third of the total estimated 12 million metric tons annual production of plantain in Africa comes from West Africa (INIBAP, 2003). Nigeria is regarded as the largest producer of plantain in West Africa, having an annual production of about 2.4 million metric tons. It is also noted that about 49% of farming households in Nigeria produce plantain as main crop (Nweke, 1996). The current level of plantain production in Nigeria has been inconsistent and low, thus allowing for home consumption and local trade but no export (Swennen, 1990; FOS, 1999). According to Echibiri (1996), plantain yield in Nigeria is as low as 15ton/ha as against 26t/ha production in Cameroon.

Despite the export potential and its capability of addressing problems of food insecurity and poverty, there is little literature (s)/studies on resource use efficiency in plantain production except the few ones on technical efficiency and management factors in Oyo state (Awotide and Adejobi, 2006; Awotide *et al.,* 2005); hence, the need for this study. The choice of Ogun state is because of its climatic suitability for plantain production. From the foregoing, the research intends to fill the lacuna in literature on resource use efficiency in plantain production. The need for this research becomes imperative bearing in mind the need to address the problem of food insecurity and poverty. It is expected that the findings of this research will be useful not only to the farmers that are already into plantain production but also those that are planning to go into plantain production by ensuring efficient allocation of resources. The study is also expected to enhance the value chain of plantain production so that employment opportunities will be created in the areas of processing plantain into chips, flour among others as well as supply to eateries in urban centers.

2.0 Theoretical and analytical framework

2.1 Theoretical framework

The modeling, estimation and application of stochastic frontier (SF) production functions to economic analysis has assumed prominence in econometrics and applied economic analysis in the last two decades. Early application of SF to economic analysis include the pioneer seminal work of Farrell (1957), Aigner *et al* (1977), Meeusen and van de Broeck (1977), Battese *et al.* (1996), Battese and Corra (1977), Battese and Coelli (1995), Ajibefun and Abdulkadri (1999), Amaza and Olayemi (2002), Helfand (2003), Amos *et al*. (2004) among others. Much of the earlier empirical measure of production efficiency focused on imperfect, partial measure of productivity, such as yield per hectare or output per unit of labour (Coelli and Battese, 1996). The inherent shortcoming of this method earlier alluded to under theoretical framework provided Farrell (1957) with the impetus for developing a better method of measuring production efficiency, which was mathematical programming method.

Stochastic Frontier (SF) build hypothesized efficiency determinants into the inefficiency error components (Coelli and Battese, 1996), thus, it can simultaneously estimate all the parameters involved in the production function model. This means that SF accounts for random errors and has the advantage of making inference possible (Coelli *et al*, 2002). However, SF is sensitive to the choice of functional form and that when analyzing the technical and allocative parts of economic efficiency, a dual functional form (that is, Cobb-Douglas) has to be chosen (Johansson, 2005). This explains why Cobb-Douglas functional form is chosen for this study.

2.2 Analytical framework

Generalized log likelihood ratio test is used to evaluate the suitability or otherwise and significance of the adopted functional form, and model employed. It is equally used to affirm or otherwise the null hypothesis that socio-demographic characteristics and improved management practices have no effect on plantain producers' (in) efficiency (that is, for the confirmation of the presence of inefficiency).

The functional form proposed and used by Ogundele and Okoruwa (2004), and Kareem *et al* (2008), following Aigner *et al.* (1977), is specified as:

$$\ln X = \sum i \ln Li = \sum i\left\{-\ln\partial - \tfrac{1}{2}\ln\left(\tfrac{2}{\pi}\right) - \left(\tfrac{\varepsilon_i}{\partial}\right) + \ln\left(-\tfrac{\varepsilon\lambda}{\partial}\right)\right\} \text{..........}(1)$$

or

$$\lambda = -2\left\{LLF(Ho) - LLF(Ha)\right\} \text{ (Rezitis, et al., 2003)}$$

or

$$\chi^2 = -2\ln\left\{\frac{L(Ho)}{L(Ha)}\right\} \text{ (Battese, et al., 1993)}$$

Simply expressed as:

$$LR = -2\ln\left\{\frac{L(Ho)}{L(Ha)}\right\} = -2\left\{\ln\left[L(Ho) - (Ha)\right]\right\} \text{ (Ogundari et al, 2006)}$$

Log-likelihood LLF (Ho) and LLF (Ha) are the values of the log-likelihood function under the null and alternative hypotheses respectively. λ has asymptotic chi-square distribution or mixed chi-square distribution when the null hypothesis involves $\lambda = 0$ (Coelli, 1995), or $\gamma = 0$ (Ojo, 2007; Selim, 2007). This implies that there is no inefficiency effect in the production process; a situation that is ably described by Ordinary Least Squares (OLS) model in which there were restrictions.

LLF (Ha) represents the value of the likelihood function for Maximum Likelihood Estimation, in which there are no restrictions, that is, $\gamma \neq 0$, or $\lambda \neq 0$, indicating there was technical inefficiency in the production operations.

The implication of the above exposition is that, any variation in output, according to the OLS model, is due only to stochastic error, whereas, for the Maximum MLE model, variations in output are due to both technical inefficiency effects and random error, thus explaining the sophistication and preference of MLE to OLS in stochastic frontier analysis.

3.0 Methodology

The study was conducted in Ogun State which is located within the rainforest belt of the tropical region in Nigeria. The study covered Abeokuta zone of Ogun State Agricultural Development Programme (OGADEP), which is made up of five local government areas, namely: Abeokuta North, Abeokuta South, Ewekoro, Ifo and Odeda. Abeokuta North, Ewekoro, Ifo and Odeda Local Government Areas were actually considered for this study because of the suitability of their agroclimatic conditions for the cultivation of plantain. Primary data were collected from the population of plantain farmers in the study area. A three-stage sampling technique was used in selecting the respondents. In the first stage, purposive sampling was used to select only local government areas known for farming. Abeokuta south local government area was excluded because of its metropolitan nature. In the second stage, a purposive sampling was used to select seventeen villages that are known for the cultivation of plantain. In the third stage, twelve plantain farmers were randomly selected per village. A total of 204 questionnaires were administered and 160 were returned to time.

Descriptive and stochastic production frontier analyses were employed in this study. The descriptive technique involved the use of simple percentage and proportion/frequency table, mean, standard error and or deviation, among others to profile the characteristics of individual plantain farmers. The study employed a stochastic frontier production function of the type proposed by Battese and Coelli (1995). In this model, a production frontier defines output as a function of a given set of inputs, together with technical inefficiency effects, which define the degree to which plantain farmers fail to reach the frontier because of technical inefficiencies of production. The model and its estimating form used in determining the effects of inputs on plantain output, as used by Ogundari and Ojo (2007); Umoh (2006); Alene and Hassan (2005) was specified in a linearized form as:

$$\ln Y_i = \ln \beta_0 + \beta_j \sum \ln X_{ij} + V_i - U_i \ldots\ldots\ldots\ldots\ldots\ldots.(2)$$

Where:

Y_i is plantain output from farm ith (Kg),
β_0 & β_j are the vectors of parameters to be estimated,
X_i are the inputs used in plantain production,
V_i and U_i represent error term,
X_1 represents farm size (Ha),
X_2 represents total labour (Man-day),
X_3 represents quantity of planting material used (Kg),
X_4 represents quantity of fertilizer used (Kg) and
X_5 is the volumes of agro-chemical used (Litres).

Total labour concept was used in this study because it was found out that aged farmers are in majority in the study area. The implication is that this group of farmers could not do much of farm work other than supervision and minor farm operation, hence, often time labour are hired. Moreover, in order not to get wrong TE estimate, farm tools expressed in monetary term were omitted as variable. It is important to know that Technical efficiency function (a production model, dealing with physical inputs and output) does not reckon with variable expressed in monetary term. Some of the studies by Nigerians (Amaza and Maurice, 2005; Ogundari and Ojo, 2007; Idiong, 2006; Udoh and Etim, 2007; Ajewole and Folayan, 2008) reviewed in the course of this study, used wrong variable specification in regards to production function by mixing physical value with monetary value of some variables. Also, the number of plantain suckers bought and planted is used as proxy for quantity of planting materials.

Technical Efficiency (TE) of individual farmer, as specified by Ogundari and Ojo (2007); Umoh (2006); Alene and Hassan (2005) is expressed as:

$$TE_i = \frac{Y_i}{Y_i^*} = \frac{f(X_i,\beta)\exp V_i - U_i}{f(X_i,\beta)\exp V_i} = \exp(-U_i) = e^{-U_i} \ldots\ldots\ldots\ldots(3)$$

The Allocative Efficiency (AE) of individual farmer as specified by Ogundari and Ojo (2007) is expressed as:

$$AE = \frac{Ci}{C_i^*} = \exp(U_i) \ldots\ldots\ldots\ldots\ldots(4)$$

Economic efficiency (EE) estimated from the Farell (1957) formula specified as:

$$EE = TE \text{ x } AE \ldots\ldots\ldots\ldots(5)$$

To identify the sources of these efficiencies/inefficiencies, which according to Bravo-Ureta and Pinheiro (1997), can be done by investigating the relationship between farm/farmer (socio-demographic) characteristics and the computed TE, AE and EE indices separately. This is aimed at identifying socio-demographic factors affecting production efficiency or possible sources of production inefficiency (ies) in plantain production in the study areas. The inefficiency model that was used is specified thus:

$$U_i = \delta_0 + \delta_i \sum Z_{ij} + e_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

Where:

U_i represents the efficiency effect of the ith farm,
δ_o & δ_j represent the parameters to be estimated,
Z_{ij} represents the vector of socio-economic factors,
e_i represents the disturbance term,
Z_1 represents the age (years);
Z_2 represents the gender (1 = Male; 0 = Female);
Z_3 represents the household size;
Z_4 represents the educational level (Yrs);

Z_5 represents the experience in plantain production (Yrs);
Z_6 represents the off-farm/non-farm activities (1 = If engaged in either or both; 0 = Otherwise);
Z_7 represents the extension Contact (1 = respondent had extension contact; 0 = Otherwise);
Z_8 represents the access to credit facility (1 = Access to credit; 0 = Otherwise);
Z_9 represents the improved management practice (1 = Use of fertilizer and or pesticide; 0 = Otherwise) and Z_2, Z_6… Z_9 represent the dummy variables.

The error terms in equation (7) are V_i and U_i. The first component of error term, V_i, is a two-sided conventional random error term that is independent of U_i and assumed to be normally distributed with constant variance and mean of zero (i.e. N ~ $(0,\sigma^2_v)$). This component is supposed to capture statistical noise (i.e., measurement error) and random exogenous shocks such as bad weather and diseases that disrupt production. The second component, $U_{i,}$ is also a random variable but, unlike V_i, it is only a one-sided variable taking non-negative values. This term captures technical inefficiency of an urban crop farm in producing output (Osawe *et al.*, 2008).

The following research hypotheses were tested in order to realize the objective of the study.

(i) Ho: $\gamma = 0$ (Plantain farmers are not resource use inefficient)
H1: $\gamma \neq 0$ (Plantain farmers are resource use inefficient)

(ii) Ho: The functional form (production) used for the analysis is not appropriate.
H1: The functional form (production) used for the analysis is appropriate.

Results and discussion

4.1 **Descriptive statistics**

Table 1 shows the socio-demographic characteristics of plantain farmers in the study area. The table reveals that majority (49.4%) of the plantain farmers' falls within the age bracket of 46 – 60years. Also, majority of the respondents are married (87.50%), while male dominates plantain production in the study area (70%). This implies that women in the study area probably considered plantain production too strenuous, hence they engaged in other activities such as processing and marketing along its value chain. The table also shows that most of the respondents (42.5%) had primary school education while 23.8% had no formal education. This indicates low level of education among the plantain farmers in the study area. This might have affected the productivity of the farmers in the study area bearing in mind positive relationship between farmers' education and productivity as revealed by studies (Reimers and Klasen, 2011; Das and Sahoo, 2012; Awolola, 1991). According to Tijani (2008), low literacy level will not only discourage farmers from adopting new technology but also make it difficult for such farmer to understand and evaluate information on new techniques of farming. However, the negative effect of low level of education may be attributed to few plantain farmers (11.3%) embracing improved management practices. The study reveals that 40% of respondents in the study area had between 11 and 20 years' experience in plantain production with an average of 16.4years. According to Rougoor *et al.* (1998) and Tijani (1993), farming experience serves as an indication of the practical knowledge a farmer acquired through trial and error, which will enhance his production efficiency.

More than half of the respondents (53.8%) engaged off/non-farm activities to complement poor returns from their plantain farming. This may not be unconnected with low productivity as a result of inefficiency in resources allocation among other problems of agricultural production in the study area.

Table 1: Socio-demographic characteristics of plantain farmers in Ogun state

Variables	Frequency	Percentage (%)
Age (Years):		
16-30	8	5.0
31-45	51	31.9
46-60	79	49.4
>60	22	13.8
Average age: 48.8yyears		
Sex:	112	70.0
Male	48	30.0
Female		
Marital Status:	140	87.5
Married	16	10.0
Widow/Widower	4	2.5
Divorced		
Household size:	65	40.6
1-5	91	56.9
6-10	4	2.5
>10		
	38	23.8
Educational Status (Years):	68	42.5
Informal	26	16.3
Primary	22	13.8
JSS/Modern	6	3.8
SSS		
Tertiary	50	31.3
Experience (Years):	64	40.0
1-10	27	16.9
11-20	19	11.9
21-30		
>30	48	30.0
Land Acquisition Methods:	66	41.3
Inheritance	46	28.8
Rent/Lease		
Purchase	96	60.0
Variety of Plantain:	28	17.5
Local	36	22.5
Hybrid		
Both		

4.2 Summary statistics of estimated models variables

Summary statistics of the variables used for the stochastic function analysis is presented in table 2. The average output of plantain per farmer per year is 919.91kg/ha (1.08ton/ha) with an average of 55.2man-day of labour. This output is below 5-7ton/ha recommended by FAO (2006) for Nigeria. The average farm size of 0.85 ha is above 0.69ha recorded by Amujoyegbe (2012) in forest agroecological zone.

Table 2: **Summary statistics of variables of the estimated stochastic production model**

Output/Input Variables	Minimum	Maximum	Mean	Standard Deviation
Average Revenue (₦)	71,500	656,134	385,008.62	238895.7
Average Output per Farmer (kg) (Q)	130	4205	919.91	767.78
Average Farm Size (Ha) (X1)	0	5	0.85	1.09
Total labour (Man-day)(X2)	15.00	123.00	55.16	24.37
Quantity of planting material (Kg) (X3)	0.00	180.00	23672.50	20599.38
Quantity of fertilizers used (Kg) (X4	0.00	650.00	113.22	107.72
Volumes of agro-chemical used (Litres). (X5)	0.00	4.50	0.65	0.81

4.3 Determinants of plantain output

Table 4 shows the estimated coefficients of the production function and their corresponding levels of statistical significance. Four (farm size, quantity of fertilizer, and agrochemical used and quantity of planting material) out of the five variables used in the model are significant. Specifically, farm size, quantity of fertilizer and agrochemicals used showed a positive causal relationship with plantain output. Contrary to *a priori* expectation, the coefficient of planting material showed a negative relationship with plantain output.

The maximum likelihood estimation (MLE) of the frontier function revealed that σ^2 and γ are significant at 1 percent level. The significance of σ^2 shows the presence of inefficiency effects and random error in plantain production in the study area. The gamma value shows that 72% of the variability in the output of plantain farmers that are unexplained by the function used. This may be attributed to technical inefficiency and random error. The significance of gamma estimate indicates that it is different from one, meaning that the frontier is stochastic (Ajewole and Folayan, 2008).

Table 3 presents the results of null hypotheses, the first being on the appropriateness of the functional form for the estimation of the parameters, while the second hypothesis address the presence of (technical and cost) inefficiency.

Table 3: Generalized likelihood ratio-tests

Null Hypotheses	L (H_0)	L (H_a)	LR	$\chi2$ (7, 5%)	Decision
$\beta_i = 0$	-948.84	-927.49	-0.046	12.59	Accept H_o
$\gamma = 0$		0.72	42.69	12.59	Reject H_o

The result affirmed that the functional form (production) used is appropriate for the analysis ($p > 0.05$). The second hypothesis tested indicates the presence of inefficiency in the use of resources among plantain farmers in the study area ($p < 0.05$). This calls for concerted effort to see that the problem of inefficiency in the resource – use in plantain production is addressed through policy intervention based on identified problems.

Table 4: Maximum likelihood estimate of the stochastic production function for plantain production in Ogun state, Nigeria

Variables	Parameters	MLE Coeff.	t-value
Production Function:			
Constant	β_0	0.215	0.840
Farm Size (Ha)	β_1	0.718***	7.417
Total Labour (Man-day)	β_2	-0.398	-0. 832
Plant Mat. (Kg)	β_3	-0.113**	-2.193
Fertilizer (Kg)	β_4	0.133*	1.726
Agro-xcals (L)	β_5	0.314*	1.662
Variance Parameters:			
	σ^2	0.152***	52.317
	γ	0.724***	7.090
	log-likelihood		-927.492
	L/R-test	42.689	

Note: ***Significant at 1 percent, **Significant at 5 percent and *Significant at 10 percent.

4.4 Production elasticities and return to scale

Production elasticities indicate the percentage change in output relative to a percentage change in inputs, if other things are held constant. From the nature of the Cobb-Douglas production function fitted, the regression coefficients which is also known to be the estimated parameters of each variable in table 4 is the elasticity of production of the variables.

The estimated elasticities of the explanatory variables show (see table 4) that the farm size, quantity of fertilizer, and agrochemical used and quantity of planting material are positive decreasing functions to the factors, indicating that the variable allocation are in the stage of economic relevance of the production function. The elasticity of planting material used is -0.113. This means that the output of plantain will decrease by 113 percent for every percent increase in planting material. This result, though not expected but an increase in planting material by farmer that is not backed by improved managerial ability may lead to reduction in plantain production. Also the elasticity of quantity of fertilizer and volume of agrochemicals used are 0.133 and 0.314 respectively. All things being equal, this means that one percent increase in quantities of fertilizer and agrochemicals used is expected to raise plantain production by 133percent and 314percent respectively.

Returns to scale (RTS), which is the sum of the coefficients of independent variables (elasticity of production), is shown in table 5. The table reveals RTS of 0.654. This value implies that plantain production in the study area is in stage II of production where production increases at decreasing rate.

Table 5: **Elasticity of Production and Returns to Scale**

Variables	Elasticity
Farm Size (Ha)	0.718
Total Labour (Man-day)	-0.398
Planting Material (Kg)	-0.113
Quantity of Fertilizer used (Kg)	0.133
Vol. of Agro-chemical used (Ml)	0.314
RTS	**0.654**

Hence, it is advisable, according to Ogundari and Ojo (2007) that production units should maintain current levels of input utilisation, as this will bring about maximum output from a given level of output, *ceteris paribus*.

4.5 Determinants of resource-use efficiency in plantain production

Measure of resource use involves the estimation of technical, allocative and economic efficiency. This was done and the results generated showing the determinants of technical, allocative and economic (in) efficiency are presented in table 6. For technical inefficiency, the coefficients of age ($p<0.10$), household size ($p<0.10$), education ($p<0.05$) and extension contacts ($p<0.10$) are significant, while only with household has positive coefficient. For the allocative inefficiency model, age, gender, education, experience, extension and improved management are the significant ($p<0.01$) factors at 1% levels; education and experience positively related to allocative inefficiency. For economic inefficiency, coefficients of education, experience, off/non-farm, credit and improved management are negatively significant ($p<0.05$). It is only the coefficient of household size that is positively related to economic inefficiency ($p<0.05$).

Furthermore, the coefficient of age (year) is negatively related to technical ($p<0.10$) and allocative ($p<0.01$) inefficiencies. While the negative relationship between age and allocative inefficiency is in agreement with Okoye *et al.* (2006) findings, the negative relationship between age and technical inefficiency conforms to Dimelu, *et al,* (2009) findings. The means that both technical and allocative inefficiencies would reduce as farmers' age increases. That is, as plantain farmers' advance in age, inefficiency in resource use decreases and technical efficiency increases, there output is expected to be closer to production frontier. This is contrary to previous findings that as farmers advance in age they tend to be averse to adoption of improved technology, as they would be less energetic to work and would tend to misallocate resources (Ogundari and Ojo, 2007; Idiong, 2005; Ajibefun and Aderinola, 2004). Ike and Inoni (2006) also affirmed that labour productivity decreases with age because of the arduous nature of farm operations, hence aged farmers do not often show willingness to adopt new practices which could raise their overall level of efficiency. Moreover, the positive coefficients (significant) of household size for both technical and economic inefficiencies imply that the inefficiencies increase as household size increases. However, according to Dimelu *et al,* (2009), large household size serves a ready source of labour for most farm operations. However, this may not be the case where a large proportion of household member are children.

The coefficient of education was found to be negatively related ($p<0.01$) to technical and allocative inefficiencies. This means, that increase in year of schooling reduces technical inefficiency or it is a factor for increased technical efficiency (Dimelu *et al,* 2009), whereas it could lead to increase in allocative inefficiency of the farmers. The import of this finding is that plantain farmers with more years of schooling tend to be more technically efficient, presumably due to their ability to acquire technical knowledge or respond promptly to the use of improved technology, such as fertilizer application, use of pesticides and so on, thus making them move close to the frontier output (Amaza and Maurice, 2005). Simply put, education enhances the acquisition and utilisation of information on improved technology by the farmers, as well as their innovativeness (Idiong, 2007).

Increased farming experience, according to Khai *et al.* (2008), may lead to better assessment of importance and complexities of good farming decision, including efficient use of inputs. Table 6 shows that there is a positive relationship between farming experience (year) and allocative ($p<0.01$) and economic ($p<0.05$) inefficiencies. These results are in agreement with Khai *et al.* (2008) findings, meaning that allocative and economic inefficiencies increased with increased years of farming experience. This suggests that older plantain farmers are less efficient, and that being an experienced farmer is not enough to significantly make a farmer to attain higher level of efficiency (Idiong, 2007).

Table 6: Determinants of technical, allocative and economic inefficiencies

Inefficiency model	Parameter	Technical inefficiency		Allocative inefficiency		Economic inefficiency	
		coefficient	t-value	coefficient	t-value	coefficient	t-value
constant	α_0	0.13	0.64	1.05	14.70***	-0.03	-0.03
age (year)	α_1	-0.66*	-1.87	-0.11	-7.22***	0.22	0.32
gender	α_2	0.11	0.31	-0.22	-7.23***	0.64	0.619
household size	α_3	0.30*	1.81	-0.61	-0.99	0.36	2.36**
education (year)	α_4	-0.27**	-2.66	0.36	11.34***	-0.12	-2.29**
experience in farming (year)	α_5	0.21	0.41	0.24	14.64***	0.34	2.31**
off/non farming activities	α_6	-0.11	-0.34	-0.12	-0.72	-0.65	-2.14**
contact with extension agent	α_7	-0.27*	-1.81	-0.14	-5.35**	-0.12	-1.00
access to credit facilities	α_8	0.92	1.35	-0.72	-0.30	-0.34	-1.89*
disposition to improved technology	α_9	0.43	1.00	-0.12	-4.49***	-0.73	-2.22**

Note: ***significant at 1 percent, **significant at 5 percent and *significant at 10 percent

The negative sign of off/non-farm income coefficient ($p<0.05$) indicates that any increase in off/non-farm income will result in decrease in economic inefficiency. This may be due to the opportunity such activities afford the farmers to get fund for use on their plantain farms since it is generally difficult for farmers to source for credit. Coefficient of extension contact is negatively correlated with technical ($p<10$) and allocative ($p<0.01$) inefficiencies. This result conforms to earlier findings by Ajewole and Folayan (2008) and Obwona (2006). It implies that, farmers that had more extension contact through visitation tend to be less inefficient. Extension contact is known to enhance efficiency through better management and provision of up-to-date information for farmers. This fact is attested to by the negative relationship between coefficient of improved management practices and allocative ($p<0.01$) inefficiency on one hand and economic ($p<0.05$) inefficiency on the other hand. The importance of this result is that, as plantain farmers embrace improved technologies it is expected that allocative and economic inefficiencies reduce.

Also, the coefficient of credit accessibility is negatively related to economic inefficiency ($p<0.10$). The result indicates that as farmers get access to more credit coupled with extension contact, the better efficient they will be. This is because such credit accessibility will enable farmers to make timely purchase of necessary inputs to enhance their production.

4.6 Frequency distribution of farm-specific efficiency levels

The frequency distribution of technical, allocative and economic efficiency, as shown in table 7, revealed that the predicted farm specific efficiency range between 0.52 and 0.98 with a mean of 0.84 for technical efficiency (TE); 0.57 and 0.89 with a mean of 0.68 for the allocative efficiency (AE). The predicted farm specific economic efficiency (EE) ranged between 0.63 and 0.93 with a mean of 0.72.

Table 7: Frequency distribution of farm-specific efficiency levels

Efficiency level	Technical Efficiency		Allocative Efficiency		Economic Efficiency	
	Frequency	%	Frequency	%	Frequency	%
0.50-0.55	5	3.125	10	6.25	-	-
0.56-0.60	4	2.50	19	11.87	-	-
0.61-0.65	6	3.75	80	50.00	20	12.50
0.66-0.70	8	5.00	14	8.75	30	18.75
0.71-0.75	12	7.50	16	10.00	90	56.25
0.76-0.80	80	50.00	10	6.25	7	4.37
0.81-0.85	30	18.75	8	5.00	6	3.75
0.86-0.90	7	4.37	3	1.88	5	3.13
0.91-0.95	6	3.75	-	-	2	1.25
0.96-1.00	2	1.25	-	-	-	-
Minimum	0.523		0.572		0.631	
Maximum	0.975		0.894		0.928	
Mean	0.835		0.675		0.721	

The allocative inefficiency contributed more to the short fall in plantain production between maximum possible (frontier) level of production and recorded output. Specifically, the result above indicates that 16.5%, 32.5% and 27.9% reduction in plantain production from maximum possible (frontier) output is attributed to technical, allocative and economic inefficiencies respectively.

Moreover, 68.8% of the farmers' attained technical efficiency that ranges between 0.76 and 0.85, 61.9% attained allocative efficiency of between 0.56 and 0.65, while 87.5% of the farmers recorded an economic efficiency of between 0.61 and 0.75. The implication of this result is that most of the farmers fairly utilized and allocate existing resources in their area for good production.

5.0 Conclusion

The maximum likelihood estimates of the frontier production showed clearly that farm size, planting materials, farm tools, fertilizer and agro-chemicals are the most important inputs in plantain production. The stochastic frontier function estimated for the 160 respondents showed that the mean technical, allocative and economic efficiencies values are 0.835, 0.675 and 0.721. The return to scale value obtained from the study (0.754) showed that plantain production was at stage of decreasing positive return to scale (stage II), which is considered as the stage where resources allocation and production are believed to be efficient.

The study revealed that technical inefficiency is not so much a serious problem to the plantain production compared to allocative and economic inefficiencies. Specifically, allocative inefficiency was found to be negatively related to coefficients of age, gender and improved management practice. On the other hand the coefficients of educational level, off/on-farm, availability of credit and improved management practice were found to be negatively related to economic inefficiency. This indicated that these factors led to decrease in allocative/economic inefficiency or increase in allocative/economic efficiency. The farm specific resource use efficiency distribution revealed that none of the farms reached the frontier threshold, implying that production could still be increased by 16%.

The elasticities of production for the inputs used are 0.718, -0.398, -0.113, 0.133 and 0.314 for farm size, total labour, quantity of planting material, quantity of fertilizer used and volume of agrochemical used respectively. These low values of below 1, point to relative inelastic response. The farmers could intensify more on the use of fertilizer/agrochemical for more output in plantain.

Stakeholders in plantain production such as the research institution, extension agents, and food processing industries that are making use of plantain should intensify effort in the area of sensitizing farmer with respect to the right level of input combinations that can improve efficiency level of plantain production in Nigeria. This is in order to benefit optimally from the suitability of agroclimatic condition for its production. In addition, the study has shown that extension service, availability of credit, age of farmer and educational level are important determinants of efficiencies in plantain production. The aging of plantain farmers call for serious attention from government by discouraging rural-urban migration through provision of basic infrastructural facilities in the rural area. Plantain farmers' education should be taken with all seriousness in order to be able to derive maximum benefits from improved technologies. This is because, the appreciation and use of improved technologies of production and marketing increases with the level of education and awareness.

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