

# TECHNICAL EFFICIENCY AND MANAGEMENT FACTORS IN PLANTAIN PRODUCTION IN HUMID FOREST ZONE OF NIGERIA: A SIMULATION ANALYSIS

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## Abstract

The paper investigated the effect of changing some management factors on technical efficiency in plantain production with a view to understanding the functional relationship between technical efficiency and agricultural productivity. Data were collected from a cross-sectional survey of two local government areas and six villages in Ibadan area of Oyo State in the humid forest zone of Nigeria. Stochastic frontier and multiple regression models were fitted and a simulation analysis was carried out on the management levels of plantain farmers. The results revealed that educational level alone did not significantly influence technical efficiency but its combination with extension assistance significantly influenced technical efficiency in the study area. Periodic extension assistance received significantly influenced technical efficiency.

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**Keywords:** plantain, stochastic frontier, technical efficiency, management factors, simulation analysis

## 1 Introduction

Plantain and banana have been an important traditional staple food for both the rural and urban populace in Nigeria. They have diverse uses to millions of Nigerians serving as a source of revenue for smallholders who produce them on mixed and sole farms (Baiyeri, 1996). However, the level of production of plantain in Nigeria has been inconsistent and low (FOS, 1999) Reported yield is as low as 15 t/ha (Echibiri, 1996) as against 26 t/ha in Cameroon (Ngalani, 1996). To produce sufficient banana and plantain fruits to meet the demand associated with rising population pressure, the current level of its production must be improved. This implies that the limited resources available to plantain farmers have to

be optimised. This becomes even more necessary in view of the prevailing traditional systems of production in Nigeria (Ogunfowora & Olayide, 1975). The production of plantain in Oyo State is generally affected not only by availability of land, labour, capital, and management but also by the efficiency of use of these resources. The efficient allocation of inputs will lead to the minimisation of cost, which invariably maximises profit, and motivate farmers to produce more. This leads to competitiveness in plantain production and enhance food security.

The crucial role of efficiency in increasing agricultural output has been widely recognised by researchers and policy makers (Bravo-Ureta & Evenson, 1994; Xu & Jeffery, 1998; Amaza & Olayemi, 1999; Adewuyi & Okunmadewa, 2001). Thus, considerable efforts have been devoted to the analysis of farm level efficiency in developing countries. An underlying factor behind many of the studies is that efforts designed to improve efficiency would be more

cost-effective if farmers are making efficient use of existing technology, rather than introducing new technologies as a means of increasing agricultural output (Shapiro, 1983).

Determining the efficiency status of farmers is very important for policy purposes. Efficiency is also a very important factor of productivity growth. In an economy where technologies are lacking, efficiency studies will be able to show that it is possible to raise productivity by improving the efficiency of use of existing resources or developing new technology. It also helps to determine the under-utilisation or over-utilisation of factor inputs. It is against this backdrop that this study aims to model the technical efficiency and some management factors of farmers in the production of plantain in Oyo State, Nigeria.

## 2 Methodology

### 2.1 Study area, data collection and sampling procedure

The study was conducted in Ibadan area of Oyo State. This area falls within the humid forest zone of Nigeria and has great potential for the cultivation of almost all types of crops. The rainy period is between April and October with an average annual rainfall of 1100 mm, spread over an average of between 90 – 100 days annually. Monthly sunshine hours fluctuate between 6.6 and 8.1 hours. Temperature ranges between 21.1 and 23.6 degrees centigrade and the maximum temperature ranges between 29.3 and 34.5 degrees centigrade. Relative humidity varies between 60 and 80 percent (IITA, 2002). This climatic condition is highly favourable to plantain production. This reflects the importance of plantain in Oyo State.

Data used for this study were collected in the 2003 plantain harvesting season through the use of well-structured questionnaires. Information on farm size, farm production, cost of inputs, prices of inputs and output, incomes and their sources, labour time allocation and utilisation and socio-economic variables such as age and education were collected. The cross-sectional survey covered two local government areas and

three villages within each area. A multistage sampling procedure was employed in selecting the sample. Purposive sampling was employed to select two local government areas (LGAs) namely Ibadan Northwest and Akinyele notable for plantain production in the state. This constituted the first stage of sampling. A list of all major plantain planting villages within these two LGAs was then obtained from the State's Agricultural Development Programme (OYSADEP). From this, three villages were chosen at random from each LGA constituting the second stage of sampling. Within the identified villages, 15 plantain farmers were randomly selected at the third stage of sampling. Ninety questionnaires were administered in total out of which 15 were rejected for inconsistency and inadequate information.

### 2.2 Model formulation

Stochastic frontier production function was used to determine the technical efficiency of plantain farmers in the study area. The predicted technical efficiencies were then used in a regression analysis to obtain their respective determinants. The modelling of the factors influencing the technical efficiency are grouped into two effects viz. environment and management effects. Although studies have been conducted on technical efficiency in recent times, the inclusion of environment as a factor influencing technical efficiency has not been considered (Tadesse & Krishnamoorthy, 1997; Wilson *et al.*, 1998; Amaza & Olayemi, 1999; Ajibefun & Abdulkari, 1999; Oredipe & Akinwunmi, 2000; Adewuyi & Okunmadewa, 2001; Amaza *et al.*, 2001; Ajibefun *et al.*, 2002). In addition to this observation, the management factors employed in the studies were considered separately with no attempt made to have a combined effect and to vary these factors with a view to understanding which combination will significantly influence technical efficiency. This study attempts to bridge this gap in knowledge in the literature. A simulation analysis of efficiency measurement in plantain production is then conducted to analyse the effect of changing management levels on the technical efficiency of plantain production.

### 2.3 Stochastic frontier production function

Following Aigner *et al.* (1977) and Meeusen and Van dan Broeck (1977) method of estimating a stochastic frontier production function in which the disturbance term ( $\varepsilon$ ) is composed of two parts, a systematic term (V) and one-sided (U) component, a Cobb-Douglas production function of the following form was specified:

$$Q = g(X_a; \beta) + \varepsilon_j \quad (1)$$

Where Q is the quantity of agricultural output,  $X_a$  is vector of input quantities, and  $\beta$  is a vector of parameters.

$\varepsilon_j$  (error term) is defined as

$$\varepsilon_j = v_j + u_j \quad j = 1, 2, \dots, n \text{ farms} \quad (2)$$

On the assumption that  $u_j$  and  $v_j$  are independent, the parameters of the production frontier (Eq. 8) were estimated using maximum likelihood estimation method by an econometric software called LIMDEP Version 7.0 (Greene, 1998). The farm-specific technical efficiency ( $TE_j$ ) of the  $j^{\text{th}}$  farmer was estimated by using the expectation of  $u_j$  conditional on the random variable  $\varepsilon_j$  as shown by Battese and Coelli (1988). That is,

$$TE_j = \exp(-u_j) \quad (3)$$

So that  $0 \leq TE_j \leq 1$

The estimating equation is

$$\ln Q = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + (v_i - u_i) \quad (4)$$

Where

Q = output of plantain (kg per harvesting season);

$X_1$  = value of materials including expenditures on suckers, and other purchased inputs used for the production of plantain (₦)<sup>1</sup>;

$X_2$  = family and hired labour used in plantain production (hours);

$X_3$  = the area devoted to plantain production (ha);

$\beta_i$  = parameters to be estimated ( $i = 0, 1, 2, 3$ )

v = is the two-sided, normally distributed random error.

u = is the one-sided efficiency component with a half-normal distribution.

<sup>1</sup> As at December 2004, 1 US\$ equals ₦ 132.5 (₦ = Naira).

### 2.4 Multiple regression model

To model the technical efficiency effects, a regression model was fitted to the dataset.

$$V_i^* = \beta Z_i + E_i \quad (5)$$

$$i = 1, 2, \dots, n \text{ farm}$$

Where,

$V_i^*$  = Technical efficiency level

$Z_i$  = Technical efficiency effects

$\beta$  = Vector of unknown parameters

$E_i$  = Independently distributed error term.

The explanatory variables include:

$Z_1$  = Environment effect (e.g. soil fertility, rainfall, and soil erosion)

$Z_2$  = Management effect (i.e. educational level, access to extension services and work force)

### 2.5 Environment

Environmental factors include rainfall, soil type, humidity, temperature, erosion and vegetation. These factors are location specific. In most socio-economic surveys, these factors are represented by ordinal scales such as good/bad, high/medium/low, etc. (Lomperis, 1991; Yanaihara, 1993; Flaherty & Jengalern, 1995). For more meaningful modelling, Odulaja and Kiros (1996) transformed these to continuous scales using the uniform-rank transform method. This is performed by ranking the data for each variable in ascending order and then dividing by the total sample size. The mean of the uniform-ranks over all the environmental variables is then obtained for each sample to represent the environmental index. Hence, the environmental index, E, is distributed in the interval [0, 1]. In the study, soil fertility level, rainfall condition and gravity of erosion constituted the environment effect.

### 2.6 Management

Various factors that describe management include both physical properties and personal qualities possessed by the farmers. These include number of work implements, work

force, literacy level, and external assistance on production. Uniform-rank transform method was also used to obtain the management index (M) since many of them are measured on ordinal scales. In the study, educational level, access to extension services and work force constituted the management effect.

## 2.7 Simulation analysis

To investigate the effect of changing the management level on technical efficiency, a simulation analysis was carried out.

## 2.8 Results and discussion

Summary statistics of some important socio-economic variables are presented in Table 1.

The mean age of 52 years shows that the farmers are relatively old based on the average life span of 49 years for Nigeria (WHO, 1991), with a relatively small range in age ( $CV\% = 22\%$ ). This could have serious implication on the future of plantain cultivation in the study area. The literacy level is low among the sampled farmers with an average of four years of formal education and a high variation between farmers. This could affect their choice of inputs, the utilisation of existing inputs, and their willingness to adopt improved technologies. Mean income made by plantain farmers was ₦61272.18/ha per harvesting season. This is high when compared to mean income of ₦51976.74/ha made by rice farmers in Ogun State (Awotide, 2004).

**Table 1**  
Summary statistics of some socio-economic variables of the respondents

Variable	Mean deviation	Standard Variation %	Coefficient of
Education (years)	4.15	0.0404	97
Experience in plantain production (years)	10.24	0.0620	61
Age (years)	51.87	0.1141	22
Farm size (ha)	1.348	0.0077	57
Income (₦)	61272.18	100.49	41

Source: Field data 2003

### 2.8.1 Technical efficiency estimates: results from half-normal model

The maximum likelihood (ML) estimates of the Cobb-Douglas stochastic production model are presented in Table 2. From the ML estimates for the production frontier, the coefficient of

land (0.276) is statistically significant. The estimate of  $\lambda$  (1.69) and  $\sigma$  (0.64) are large and significantly different from zero at 1 per cent. These indicate a good fit and the correctness of the specified distribution assumptions for the decomposed error term.

**Table 2**  
Stochastic production frontier for plantain in the study area

Variable	Stochastic Frontier	
	Parameters	t-values
Constant	3.194 (0.402)	7.951***
Materials (K)	0.063 (0.111)	0.565
Land (R)	0.276 (0.086)	3.217***
Labour (L)	0.364 (0.150)	2.417**
Lambda $\lambda$	1.691 (0.805)	2.101**
Sigma $\sigma$	0.64 (0.063)	10.141***
Log likelihood	-21.038	

\*\*\*Significant at 1%

\*\*Significant at 5%

Source: Field data 2003

The numbers in parenthesis are standard error

### 2.8.2 Returns to scale

There is evidence of decreasing returns to scale for the underlying technology as the elasticity of the production function with respect to the factors of production is less than one ( $\Sigma b_1 = 0.063 + 0.276 + 0.364 = 0.703$ ). This implies that the farmers are in stage II in the production function curve. At this stage, every addition to the production inputs would lead to less than proportionate addition to the output. This

suggests that it pays the farmers to continue to operate at this stage.

### 2.9 Technical efficiency

The frequency distribution of the predicted technical efficiency of the farmers is presented in Table 3. The mean technical efficiency for the sample is 66.3 per cent, with a clustering in the 51 to 90 per cent efficiency range. There is gap of 33.7 per cent to get to the frontier. The implication of this is that plantain farmers can increase their output using the existing resources.

**Table 3**  
Frequency distribution of the predicted technical efficiency of plantain farmers

Efficiency levels	Frequency	Percentage	Cumulative
10 – 20	2	2.67	2.67
21 – 30	4	5.33	8.00
31 – 40	5	6.67	14.67
41 – 50	8	10.66	25.33
51 – 60	9	12.00	37.33
61 – 70	9	12.00	49.33
71 – 80	15	20.00	69.33
81 – 90	14	18.67	88.00
>90	9	12.00	100.0
Total	75	100.0	

Source: Field data 2003

## 2.10 Simulation analysis results

Out of the two effects, management level of farmers is probably the most controllable of the two independent variables in the multiple regression model. It is against this backdrop that management effect was used in the simulation analysis. This was carried out by varying the management levels, M, within interval [0, 1]. Simulation results show how changes in these factors and their combination would affect technical efficiency (Table 4). In this simulation analysis, educational level and extension assistance were used because they could easily be classified and varied. Table 4 shows that the environmental index is not significant in all the management levels. The

results of the management index are of great interest. The management index in all the management levels carries the expected positive sign except in M8. The results reveal that farmers' educational level alone will not significantly influence technical efficiency. But extension assistance received once in three months and once in a month will significantly influence technical efficiency. The combination of educational level and extension assistance will significantly affect the technical efficiency of plantain production in the study area. Note that this applies with the assumption that workforce (the third variable in the management effect) remains constant.

**Table 4**  
Multiple regression results and changes in management levels  
given changes in some management factors

Variable	Management level	Mean value	Increase in Management level	Constant	Environmental index	Management index
Normal (as obtained from data)	M	0.644	–	0.438 (1.95)*	–0.0066 (–0.030)	0.357 (1.433)
Ed. level (=6)	M1	0.667	0.023	0.501 (2.101)**	0.0091 (0.41)	0.233 (0.896)
Ed. level (7-12)	M2	0.744	0.100	0.483 (1.949)*	0.0091 (0.41)	0.233 (0.896)
Ed. level (>12)	M3	0.821	0.177	0.465 (1.735)*	0.0091 (0.041)	0.233 (0.896)
Ext. asst. (4)	M4	0.681	0.037	0.235 (0.921)	0.016 (0.073)	0.611 (2.137)**
Ext. asst. (5)	M5	0.758	0.114	0.188 (0.690)	0.016 (0.073)	0.611 (2.137)**
Ed. Level (6) and Ext. asst. (4)	M6	0.704	0.060	0.015 (0.04)	0.047 (0.217)	0.890 (2.144)**
Ed. level (7-12) and Ext. asst. (4)	M7	0.781	0.137	–0.067 (–0.179)	0.0474 (0.222)	0.890 (2.144)**
Ed. level (>12) and Ext. asst. (4)	M8	0.857	0.213	2.019 (2.659)***	–0.109 (–0.265)	–1.694 (–2.163)**
Ed. level (=6) and Ext. asst. (5)	M9	0.781	0.137	–0.067 (–0.179)	0.047 (0.217)	0.890 (2.144)**

Ed. level (7-12) and Ext. asst. (5)	M10	0.857	0.213	-0.135 (-0.336)	0.0474 (0.217)	0.890 (2.144)**
Ed. level (>12) and Ext. asst. (5)	M11	0.934	0.290	-0.204 (-0.472)	0.0474 (0.217)	0.890 (2.144)**

The figures in parenthesis are t-values

Source: Computed from field data 2003

\*\*\*Significant at 1%    \*\*Significant at 5%    \*Significant at 10%

Ed. refers to the years of formal education and Ext. asst. refers to the frequency of which farmers receive extension agents: (4) = once in three months and (5) = once in a month.

### 3 Conclusion

The investigations reported in this paper show the sensitivity of technical efficiency to management factors. Given the production resources at their disposal, and the output levels, plantain farmers in the study area are fairly efficient in the use of their resources. Management effect was found to be significant at higher management levels. This implies that management effect has a significant influence on the technical efficiency of plantain farmers. From the simulation analysis, it could be concluded that if the variables describing management effect were improved upon, either separately or in combination, the management level would increase with consequential increase in technical efficiency of plantain farmers. This has positive implication on self-sufficiency in plantain production and ensuring food security for farm household in the study area and in Nigeria as a whole. Improving the management level cannot be achieved without additional cost; therefore, it is recommended that policies that would help farmers to improve on their management level at a reduced cost would go a long way to sustain plantain production in the study area.

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