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DETERMINANTS OF YAM PRODUCTION AND ECONOMIC EFFICIENCY AMONG SMALL-HOLDER FARMERS IN SOUTHEASTERN NIGERIA

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ABSTRACT

The determinants of yam production in Southeastern Nigeria were investigated using a stochastic frontier production function, which incorporates a model of inefficiency effects. Farm-level data were collected from a sample of 120 yam farmers in Enugu State and used for the analysis. The results indicate that labour and material inputs are the major factors that influence changes in yam output. The effects of selected farmer-specific socio-economic characteristics on observed inefficiencies among the farmers were also examined. Farmer-specific variables, such as education, farming experience and access to credit, were the significant factors implicated for the observed variation inefficiency among yam producers.

KEYWORDS: small-holder farmers; yam production; stochastic frontier model; economic efficiency; socio-economic factors

INTRODUCTION

Food yams are members of the genus dioscorea which contain about 600 species of which only six are important as staples in the tropics [5, 12]. The economically important species grown are Dioscorea rotundata (white guinea yam) D. alata (yellow yam), D. bulbifera (aerial yam) D. esculenta (Chinese yam) and D. dumenterum (trifoliate yam).

Although yams are grown throughout Africa, Nigeria is said to be the world's largest producer of yam, accounting for over 70-76 percent of the world total output [16, 12]. FAO [10] reported that Nigeria alone in 1985 produced 18.3 million tonnes of yam from 1.5 million hectares, representing 73.8 percent of 28.8 million tonnes of yam produced in Africa.

Yam can be grown in nearly all tropical countries provided water is not a limiting factor. In Nigeria it is grown within the coastal region up to latitude 12^0N and corresponds to the rain forest, wood savanna and southern savanna belt. This is the region where the annual rain fall exceeds 800mm in amount and 4 months in duration [8].

In Enugu State Nigeria, yam cultivation still depends largely on labour intensive, traditional hoe-cutlass techniques of production. Many aspects of production like clearing, planting, weeding, staking and harvesting require considerable inputs of labour. However, as rural labour becomes more scarce and expensive, and the price of inputs increase, the cost of yam in the market increases making it a luxury food rather than a staple [12].

Roots and tuber crops, especially yam, generally require loose soil for better performance. This is because of the manner in which the roots form and penetrate into the soil [16]. Although yams can be grown on the flat soil, holes, ridges or mounds, it is traditionally planted on mounds in Enugu State. The sizes of the mounds vary from place to place depending on the size of the set and the hydromorphic nature of the soil.

The most important part of the yam plant is the tuber. The yam tuber is a good source of energy derived mainly from their carbohydrate content, since its low in fat and protein, Vitamin C has been found in unpeeled yam slices [5]. Yam could be eaten as boiled yam, fufu or fried in oil. Yam has other uses other than food. Yam tuber is said to contain some pharmacologically active substances including dioscorine saponin and sapogenin. According to [7], dioscorine which is the major alkaloid in yam is medicinally a heart stimulant. Moreover, yam is also a source of industrial starch, the quality of which varies with the species; although the quality of starch of some species is said to be comparable to cereal starch [17]. Due to the high cost of yam, non-edible species of it could be channelled towards industrial starch production.

The importance of yam as a crop in rural South eastern Nigeria is more than its economic value. Considerable amount of ritualism has developed around the production and utilization of yam. The most important manifestation of this ritualism is in the new yam festival celebrated at the beginning of the harvest season. No other crop has taboo and festivity as yam [16]. Yam is currently being exported from West Africa and Caribbean countries to Europe and North America where sizable population of yam consumers are found.

The problems of small-scale agriculture include the use of traditional technology of low productivity, extension services that are inadequately funded, and poor distribution of agricultural inputs. The resources that are employed by yam farmers range from land to seed yams, chemicals, and fertilizers. The literature is scanty on studies of the efficiency or otherwise of the use of these inputs in yam production in Nigeria. Most of the studies on yam production in Nigeria have focused on agronomic issues [16, 6, 12]. The objective of the study therefore, was to examine the economic efficiency of yam production in South eastern Nigeria, and to identify the sources of inefficiency among small-scale yam farmers.

MATERIALS AND METHODS

The study area is Enugu State, which is one of the five States in South eastern Nigeria.

The State lies between latitude 5^0 56'N and 7^0 06' N and longitude 6^0 53' E and 7^0 55' E, occupying a land area of about 802,295km^2 and has a population of 2.5 million, with a population density of 248 persons per square kilometre [15, 9]. It is characterised by small farm holdings with yam and cassava as the dominant crop. Enugu State comprises 17 Local Government Areas (LGAs) divided into three agricultural zones, namely Awgu, Enugu and Nsukka. Two LGAs were selected from each of the zones. The selected local government areas are Aninri, Awgu, Nkanu East, Nkanu West, Udenu and Uzo-Uwani. From each of the LGA, two communities were randomly selected giving a total of 12 communities. From the list of yam farmers prepared for each of these communities, 10 farmers were randomly selected giving a total of 120 farmers used for the study. Data collected include material input (input purchase cost), labour supply and use, sources of credit, farm size, output of yam and their farm-gate and market prices. Data on social characteristics of yam farmers such as age, farming experience as well as level of education and contact with extension agents, were also collected.

The Econometric Model

The stochastic frontier production function model used by [18], which in turn, derives from the composed error model of [1], [14], and [11] was applied in the analysis of data. The stochastic frontier analysis concerns the estimation of frontiers, which envelop data, rather than with functions which intersect data [13].

The frontier production model begins by considering a stochastic production function with a multiplicative disturbance term of the form:

$$Y_t = f(X_t; \beta)\, e^{\varepsilon} \qquad (1)$$

Where:

Y = the quantity of agricultural output;

X_a = a vector of input quantities;

B = a vector of parameters; and

e = error term.

Where ε is a stochastic disturbance term consisting of two independent elements υ and ν,

$$\text{where; } \varepsilon = \upsilon + \nu \qquad (2)$$

The symmetric component, ν, accounts for random variation in output due to factors outside the farmer's control, such as weather and diseases. It is assumed to be independently and identically distributed as $N\sim(0, \sigma^2 \nu)$. A one-sided component $\upsilon \leq 0$ reflects technical inefficiency relative to the stochastic frontier as $|N \sim (0, \sigma^2 \nu)|$, i.e. the distribution of υ is half-normal.

The stochastic production frontier model can be used to analyze cross-sectional data. The frontier of the farm is given by combining (1) and (2)

$$Y = f(Xa; \beta)\, e^{(\upsilon+\nu)} \qquad (3)$$

Measures of efficiency for each farm can be calculated as:

$$TE = \exp.[E\{\upsilon \mid \varepsilon\}]. \qquad (4)$$

And υ in equation (4) is defined as:

$$\upsilon = f(Z_b; \delta) \qquad (5)$$

where: Z_b = a vector of farmer-specific factors, and

δ = a vector of parameters

The Empirical Stochastic Frontier Production Model

The empirical stochastic frontier production model that was applied to the analysis of data is specified as follows:

$$\text{In } Y_{ij} = \beta_0 + \beta_1 \text{In } X_{1ij} + \beta_2 \text{In } X_{2ij} + \beta_3 \text{In } X_{3ij} + V_{ij} - U_{ij} \qquad (6)$$

Where subscripts ij refers to the j^{th} observation of the i^{th} farmer;

In = logarithm to base e;

Y = revenue from yam output in Naira;

X_1 = area under yam cultivation (in hectares)

X_2 = labour used in yam production (valued in Naira)

X_3 = material inputs of fertilizer, pesticides and yam seeds (valued in Naira). It is assumed that the inefficiency effects are independently distributed and U_{ij} arises by truncation (at zero) of the normal distribution with mean u_{ij} and variance σ^2, where u_{ij} is defined by the equation:

$$u_i = \delta_0 + \delta_1 \text{In } Z_{1ij} + \delta_2 \text{ In}Z_{2ij} + \delta_3 \text{In}Z_{3ij} + \delta_4 \text{In}Z_{4ij} \qquad (7)$$

where:

u_i = economic efficiency of the i^{th} farmer

Z_1 = years of experience of the i^{th} farmer in yam production;

Z_2 = years of formal education of the i^{th} farmer;

Z_3 = amount of credit available to the farmer (in Naira);

Z_4 = number of meetings with extension agents per cropping season.

The β and δ-coefficients are unknown parameters to be estimated, by the method of maximum likelihood, using the computer program FRONTIER version 4.1 [4].

RESULTS AND DISCUSSIONS

A summary statistics of the socio-economic characteristics of the yam farmers is as given in Table 1. The age of the farmers studied ranged between 21 to 68 years with an average age of 43 years. The results imply that farmers in the area are relatively old, a condition that may affect their overall efficiency, since their production is labour-intensive.

Estimates of the Parameters of the Production Factors

The parameters and related statistical test results

Table 1. Summary Statistics of Socio-economic Characteristics of Yam Farmers

Variable	Mean	Standard deviation	Minimum value	Maximum value
Revenue/farm (Naira)	38,000.00	9100	21,000.00	125,000.00
Farm size (hectare)	1.2	1.7	0.8	4.0
Labour/farm (Naira)	7,260.00	500.0	3,640.00	26,400.00
Fertilizers/farm (kg)	250	125.0	50	840
Pesticide/farm (Naira)	500.00	3.5	0	2000.00
Age (years)	43.2	32.0	21.0	68.0
Farming experience (years)	7.5	4.8	2.0	20.0
Education (years)	4.8	4.9	0	15
Credit (Naira)	23,651.50	1,282	5000.0	96000.00

Source: Survey data, 2004.

Table2: Maximum Likelihood Estimates of the Parameters of the Stochastic Production Function

Variable	Parameter	Coefficient	Standard Error
Production Factor			
Constant	B_0	5.16	2.38
Land	β_1	0.12	0.43
Labour	β_2	0.39	0.18**
Material inputs	β_3	0.44	0.21**
Inefficiency effects			
Constant	δ_0	-12.84	3.13
Farming experience	δ_1	2.13	1.22***
Education	δ_2	-7.35	3.62*
Credit	δ_3	-2.75	0.31***
Extension	δ_4	-1.45	3.19
Diagnostic Statistics			
Likelihood ratio	-112.22		
Sigma-squared (σ^2)	33.68		5.05***
Gamma (γ)	0.99		0.005***

*** Significant at the 0.01 level; ** at the 0.05 level; * at 0.1 level
Source: Computed from Survey data, 2004.

obtained from the stochastic frontier production function analysis are presented in Table 2. All the coefficients in the model have the expected a priori signs and they are mainly significant. The estimated coefficient for labour is positive, and statistically significant at the 5-percent level. Yam production is labour-intensive from cultivation to harvesting. Thus, the 0.39 elasticity of labour with respect to revenue implies that a 1% increase in labour, ceteris paribus will lead to an increase of 0.39% in the farm revenue and vice versa.

Similar results were obtained for material input which is statistically significant at the 5-percent level. Expenditure on seed yams, fertilizer and chemicals, which constitute the material input variable, is shown by the frontier production function to positively affect farm revenue. The significance of the material input variable derives from the fact that fertilizer, a component of the material input, is a major land-augmenting input that increase crop yield per hectare by improving the fertility and productivity of the soil.

Sources of Inefficiency

The sources of inefficiency were examined by using the estimated δ-coefficients associated with the inefficiency effects in Table 2. The inefficiency effects are specified as those relating to farming experience, education, credit and extension. The estimated coefficient of farming experience is positive and statistically significant at 1 percent level. This indicates that farmers with more years of farming experience are relatively less efficient

Table 3: Generalized Likelihood Ratio Test of Hypothesis for the Parameters of the Stochastic Frontier Production for Yam Farmers in Enugu State

Null Hypothesis	Likelihood	X^2 statistics	X^2 v.0.95	Decision
1.Ho: $\gamma = 0$	-159.39	56.71	7.05*	Reject Ho
2.Ho:$\delta_1 + \ldots + \delta_4 = 0$	-112.22	94.34	11.07	Reject Ho

*This value is obtained from Table 1 of Kodde and Palm (1986), which gives critical values for test of null hypothesis involving parameters having values in the boundary of the parameters space. If the null hypothesis y=o is true, then there are two other parameters μ and η, which are present. Hence, the degrees of freedom of appropriate critical value in Table 1 of Kodde and Palm (i986) is q + 1 where q = 2.

in yam production, and vice versa. The farmers' years of experience correlates with their ages. And since labour productivity decreases with age, younger farmers tend to be more productive than their older compatriots, because of the arduous nature of farm operations. Furthermore, younger farmers are seemingly more progressive, as they demonstrate a greater willingness to adopt new practices that raise their overall level of efficiency.

The estimated coefficient of education variable is appropriately signed though sparingly significant at the 10 percent level. The implication is that farmers with more years of formal schooling tend to be more efficient in yam production, presumably due to their enhanced ability to acquire technical knowledge, which makes them closer to the frontier output. Besides, farmers who had some level of education respond readily to the use of improved technology, such as application of fertilizers, use of pesticides and improved planting materials, thus producing closer to the frontier.

The estimated coefficient of access to credit is negative according to a priori expectation and statistically significant at the 1 percent level. This suggests that farmers who have greater access to credit tend to be more efficient in yam production. Because yam production is highly labour-intensive, substantial part of available credit is used to hire labour, especially for mound making and harvesting operations. Also, the availability of credit helps to finance the procurement of material inputs which have a positive effect on yam production. Although contact with extension agents have a negative effect on inefficiency, the result was not statistically significant. The result nevertheless implies that adoption of new innovations on yam production will increase the level of economic efficiency of farmers.

Test of Hypotheses and Diagnostic Statistics

Formal tests of hypothesis with the inefficiency effects are presented in Table 3. The first null hypothesis in the table is H_o: $\gamma = 0$, which specifies that the inefficiency effects in the stochastic frontier production are not stochastic. The null hypothesis is rejected. This implies that the traditional average response function is not an adequate representation for yam production in South eastern Nigeria, given the specification of the stochastic frontier and inefficiency model, defined by equations 6 and 7.

The second null hypothesis is H_o: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$, which specifies that the explanatory variables in the model for the inefficiency factors have zero coefficients. This null hypothesis is rejected. Thus, it can be concluded that the explanatory variables in the model contribute significantly to the explanation of efficiency in yam production in South eastern, Nigeria.

Efficiency Estimates of the Farmers

Given the specification of the Cobb-Douglas frontier production function in equations 6 and 7, the economic efficiencies of yam farmers in Enugu State were calculated. The predicted efficiencies differ substantially among the farmers, ranging between 0.07 and 0.85, with mean efficiency of 0.41. The low mean economic efficiency is an indication of inefficiency in resource use by yam farmers in South eastern Nigeria. Also, there exists a wide gap between the efficiency of best economically efficient farmer and that of the 'average' farmer. This type of wide variation in farmer-specific efficiency levels is a common phenomenon in developing countries [2]. Furthermore, the varying socio-economic characteristics of the sampled farmers such as farming experience, educational level, access to credit and contact with extension agents, must have influenced the farmers' ability to use available technology; a situation that must have contributed to the observed variation and low level of efficiency amongst them.

CONCLUSION

Stochastic frontier production function was estimated for yam production in Enugu State, Nigeria with land, labour and material inputs as explanatory variables. Labour and material inputs were however found to be the significant factors that influence yam output.

In order to ascertain the level of economic efficiency of yam production, a model of inefficiency effects in the frontier function which included farmer-specific variables such as farming experience, education, extension visits and access to credit was also estimated. All the farmer-specific variables except extension visit, significantly accounted for the observed variation in efficiency level among yam producers in South eastern, Nigeria.

The implication of the study therefore, is that the level of efficiency among small-scale yam producers in Nigeria could be increased by 59 percent through better utilisation of available resources, given the current state of technology.

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