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Improving Efficiency in Food Crop Production for Food Security in Nigeria

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Abstract: The study examined the factors determining the productivity and technical efficiency of yam production in Ondo State Nigeria, with a view to improving its production as a panacea for solving food security problems in the country. The data, mainly from primary sources were collected from 160 yam farmers selected from four local government areas in the state using multistage sampling techniques. The data were analysed using descriptive statistics, gross margin and stochastic frontier production function. The study revealed that yam production was very profitable in the study area and that while all the technical and socio-economic variables involved in yam production were in the efficient stage of resource allocation, educational level of the farmers was in the inefficient stage. The overall productivity of yam production, Return to Scale (RTS) was however in the irrational zone of the production function, thus giving room for future expansion in output and productivity. The Technical Efficiency (TE) of the farmers varied significantly with about 97% variation in their output caused by differences in the farmers TE. While type of farming led to increase in TE, source of land, type of labour and distance of yam farm led to decrease in TE.

Key words: Food-security, Nigeria, production-function, productivity, technical-efficiency, yam

INTRODUCTION

Nigerian agriculture has not been able to provide adequate food in quantity and quality to feed the ever-growing population. While domestic food supply increases at the rate of 2.5%, food demand increases at a rate of 3.5% due to the population growth rate of 2.83%[1]. Nigeria is therefore plagued with food shortages, hunger and undernourishment. With a deficit of about 1% on an annual basis between food production and demand the following problems are evident:

- A widening gap between domestic food production and demand.
- An increasing resort to food importation and its drain on the nation's foreign reserves.
- High rates of increase in food prices
- Inadequate nutrients in the diets of most Nigerians.
- Malnutrition starvation and ill-health

Agricultural production has been unable to keep pace with the increasing demands of increasing population and rising incomes. In Nigeria, there is low level capacity for agriculture to satisfy the food and fibre needs of the country[2]. The declining trend in agricultural production in the face of population increase can be attributed to the following:

- Low level of technology in farming. There is shortfall in the supply of essential farm inputs such as fertilizers, agro-chemicals and farm implements The resultant effect of this situation is increased cost of production and the use of primitive tools.
- Poor implementation of policies and strategies of government.
- Mass illiteracy among the rural dwellers and especially the farming population.
- Poor genetic quality of seed and animal stock.
- Poor pricing policy

Consequently, annual food shortages have grown dramatically over the past few decades. To meet the shortfalls between domestic production and demand, the government has resulted to massive importation of food. The value of food imports has risen from an annual average of ₦45 million for the period 1960-65 to an average of
₦ 1.3 billion between 1982 and 1984[2].

Various governments in Nigeria in the past were preoccupied with various challenges of diversifying the economy in order to reverse the poor performance of the agricultural sector. Successive governments in the country had embarked on several programmes aimed at boosting agricultural production. These programmes include: River Basin Development Authority (RBDA), Agricultural Development Projects (ADP), Agricultural Credit Guarantee Scheme, Green Revolution Programme, Directorate of Food, Roads Rural Infrastructure. One of the central objectives of these programmes was to increase food production thereby solving the problem of food insecurity and poverty. Unfortunately most of these programmes suffered one defect or the other and the desired results could not be got and thus the problem of food insecurity and poverty incidence lingers on. The major root cause of poverty is food insecurity. According to world food council report, a growing number of lives are being lost due to hunger and malnutrition. It was estimated that the rate of increase in the number of hungry people in the world in the 1980,s was five times what it was in the 1970's. By 1989, the total number of chronically hungry people was estimated at 550 million people. Africa was reported to have experienced the largest increase in hunger cases between 1970 and 1989.

The implication of these projections is that poverty in Nigeria is likely to increase as we approach the year 2010. If this is to be averted, a drastic step has to be taken to achieve a sustained growth in food sector output. This can only be achieved by the articulation of a food production or food self-sufficiency policy package that is self-sustaining and which will have the expected impact on the nutritional status of the people. One of such self-sufficiency policy packages is to improve the productivity and efficiency in food crop production with the resultant increase in production. Therefore, this study examined the profitability, productivity of factors of production and technical efficiency in food crop production with a view to increasing production and guarantee food security in the country.

ANALYTICAL FRAMEWORK

The Stochastic Frontier Production Function (SFPF) in efficiency studies is employed in this study. In the SFPF the error term is assumed to have two components parts V and U. The V covers the random effects (random errors) on the production and they are outside the control of the decision unit while the U measures the technical inefficiency effects, which are behavior factors that come under the control of the decision unit. They are controllable errors if efficient management is put in place.

The stochastic frontier approach is generally preferred for agricultural research for the following reasons: The inherent variability of agricultural productions due to interplay of weather, soil, pests, diseases and environmental failures and many firms are small family-owned enterprises where keeping of accurate records is not always a priority hence available data on production are subject to measurement errors.

The stochastic frontier production function model is specified as: $Yi = f(Xi\beta)+\varepsilon_i$

Where, Y is output in a specified unit, X denotes the actual input vector, β is the vector of production function parameters and ε_i is the error term that is decomposed into two component parts, V and U. The V is a normal random variable that is independently and identically distributed (iid) with zero mean and constant variance (σ_v^2). It is introduced to capture the white noise in the production, which are due to factors that are not within the influence of the producers. It is independent of U. The U is a non-negative one-sided truncation at zero with the normal distribution[4]. It measures the technical inefficiency relative to the frontier production function, which is attributed to controllable factors (technical inefficiency). It is half normal, identically and independently distributed with zero mean and constant variance. The variances of the random errors (σ_v^2) and that of the technical inefficiency effects (σ_u^2) and overall model variance (σ^2) are related thus: $\sigma^2 = \sigma_u^2 + \sigma_v^2$

And the ratio: $\gamma = \sigma_u^2 / \sigma^2$ is called gamma. It measures the total variation of output from the frontier, which can be attributed to technical inefficiency. The Technical Efficiency (TE) of an individual firm is defined in terms of the observed output (Y_i) to the corresponding frontier output (Y_i^*). The Y_i^* is maximum output achievable given the existing technology and assuming 100% efficiency. It is denoted as: $Y_i^* = f(X_i\beta)+V$, that is, $TE = Y_i/Y_i^*$

Also the TE can be estimated by using the expectation of U_i conditioned on the random variable (V-U) as shown by Battese and Coelli[5], that is

$$TE = \frac{f(X_i)+V-U}{f(X_i)+V}$$

And that $0 \le TE \le 1$

MATERIALS AND METHODS

The data used in this study were collected from a cross-sectional survey of yam farmers from four local government areas (Akure South, Owo, Akoko North East and Ondo West) in Ondo State of Nigeria. The state is one of the 36 states in Nigeria. Ondo state has three distinct ecological zones. The mangrove forest to the south, the rain forest in the middle and the guinea savanna to the north. The state shares boundaries with Osun and Ogun states in the west, Ekiti and Kogi states in the north, Edo and Delta states in the east and Atlantic Ocean in the south. Ondo state has a population of about 2,249,548 people according to the 1991 census with a total land area of 14,793,189 square kilometers[6]. The annual rainfall varies from 2000 mm in the southern parts to 1500 mm in the northern areas with high annual temperature of about 30°C. The people are predominantly peasant farmers cultivating mainly food crops such as yam, cassava, maize, pepper, while sweet potatoes, rice, plantain, beans and cocoyam are grown in some localities in commercial quantities. Other major crops include rubber, cashew, cola-nut and coffee. They live mostly in organized settlements, towns and cities with the important towns being Akure, Ondo, Owo, Ikare and Okitipupa.

Data collection and sampling techniques: The data, mainly from primary sources were collected from 160 yam farmers selected from four local government areas Akure south, Owo, Akoko North East and Ondo west using the multistage sampling techniques. The four LGAS were purposively selected because they were mainly in the guinea savanna belt, which is well suited for yam production. The second stage involved a simple random selection of 40 yam farmers from each of the four local government areas; thus making up 160 respondents. Data were collected with the use of a set of well-structured questionnaire assisted with the use of interview schedule. Information was collected on output of yam in monetary value (naira), inputs involved in yam production and prices of output and inputs. Information collected on inputs includes farm size measured in hectares, labour expended on land preparation (clearing, burning and heap making), maintenance (weeding, mulching, fertilizer application, staking and stem tendering of yam) and harvesting (uprooting and storage)

Method of data analysis: Descriptive statistics (means, standard deviation and frequency Table), gross margin and stochastic frontier production function analyses were used to analyze the profitability and productivity and technical efficiency, respectively. The production technology of the farmers was specified by the Cobb-Douglas frontier production function of the form:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 \ln X_{6i} + V_i - U_i$$

Where Y_i = Total farm value of yam tubers (N) of ith farmers, X_1 = Farm size (ha),

X_2 = Total labour (hired and family measured in man-days), X_3 = Operating expenses, X_4 = Cost of yam setts, X_5 = Age of farmers, X_6 = Educational level of farmers measured as years of schooling, V = Random errors as previously defined and U = Technical inefficiency effects as previously defined.

The technical inefficiency effects (U) was defined by:

$$U = \delta_o + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4$$

Where, Z_1 = type of farming measured as a dummy variable with 10 for tree crop with food crops and 11 for only food crops, Z_2 = Source of land measured as a dummy variable with 10 for those that hired their farmland and 11 for those who owned their farmland, Z_3 = type of labour, measured as a dummy variable with 10 for hired labour and 11 for family labour and Z_4 = actual distances of farm from town or settlement

The inefficiency model and variables were included so that the effects of these variables could be studied on the technical efficiencies of the yam farmers. b and δ are scalar parameters to be estimated. The estimates for all the parameters of the SFPF are obtained using the Program Frontier Version 4.1c[7].

For this study, two different models were specified. Model 1 assumed that the traditional response function was an adequate representation of the stochastic frontier model and there were no inefficiency effects in the production process, that is, H_o: $\gamma = 0$. Model 2 assumed that inefficiency effects were present and involved all the parameters estimated, that is, H_a: $\gamma \neq 0$. This is the full frontier production function, which involves no restrictions. It thus assumed that the traditional response function was not an adequate representation of the stochastic frontier model. In model 1, the measure of the variation in the yam output that are due to technical inefficiency effects is assumed to be zero, that is, $\gamma = 0$ and that any variation in output is due only to stochastic error. Whereas model 2, assumed that gamma is not zero, $\gamma \neq 0$ and that variations in output are both due to technical inefficiency effects (which could be controlled with efficient management of both human and material resources) and random error which do not come under the control of the efficient management.

Various tests of hypothesis on the significance of the parameters of the frontier model were conducted using the student's t-ratio and generalized likelihood ratio tests.

The generalized likelihood ratio is defined by the chi-square distribution, x^2

X^2= -2 in (L(Ho) / L(Ha)) ……………(Battese *et al.*[1])

Where L (Ho) is the value of the likelihood function for the frontier model I in which parameter restriction specified by the null hypothesis (Ho) was imposed such that,

Ho: $\gamma = 0$, that is, there were no technical inefficiency effects in the production operations of the yam farms. L (Ha) is the value of the likelihood function for model 2 in which there were no restrictions that is, $\gamma \neq 0$ indicating there were technical inefficiency effects in the production operations. The X^2 has a mixed chi-square distribution with the degree of freedom (df) equals to the number of parameter restrictions. If the computed chi-square (X_c^2) is less than or equal to the tabulated chi-square the null hypothesis (H_0) is accepted and rejected if chi-square computed is greater than chi-square tabulated.

RESULTS AND DISCUSSION

Summary statistics of variables: The summary statistics of variables used in the stochastic frontier model is presented in Table 1. The age range of between 16 and 74 years shows that both young and old people were involved in yam production but with more young people involved as shown by the mean age of 43years and 75.5% of the respondents below 50 years old. This finding negates the a-priori assertion that small-scale farmers in Nigeria are old and ageing[8]. The relatively young people in yam production is due to some rigorous operations, such as, heap making, staking and harvesting, that demand some measures of energy from the operators. And thus, only or relatively young people that are very energetic could venture into yam production. The household size varied significantly and was large with mean household size of 8 members and standard deviation of 5 members. This finding has implications for labour sources, productivity and efficiency of yam production.

Most of the yam farmers depended on family labour for most of the operations in yam production. About 42.9% used mainly family labour and 11% used hired labour where 46% used both labour sources Table 2. The inefficiency analysis revealed that labour was unproductively used and contributed to decrease in TE of yam production. The yam farmers were well experienced with the mean years of experience of 20 years. This implies a significant level of specialization and expertise in yam production and thus, a willingness to adopt any measure that could lead to improved productivity, production and over all efficiency in yam production. The farm size was small and ranged between 0.02-2 ha with a mean farm size of 0.388 ha. The mean farm locations were 2. The findings on farm size and locations further confirmed the works of many empirical studies on agricultural production in the developing countries that farmers operate small farm size scattered in smallholdings over short or long distances from each other[9].

The farm distances from the farmers' settlements/towns varied significantly between 0.2 and 20 km with a mean of about 4.56 km. This finding confirmed the work of Ojo[11] that yam farmers travelled long distances to and fro their yam farms usually on daily basis with its adverse implications on productivity, production and farmers overall efficiency. The labour usage of average of 395.58 mandays for an average 0.388 ha of yam farm translates to about 200 mandays per ha. This further confirms that yam production is labour intensive because almost all the operations involved in its production could only be performed manually[1].

Table 1: Summary statistics of variables of SFPF.

Variables	Mean	Std. Dev	Minimum	Maximum
Age (years)	43	14.4	16	74
Household size	8	5	1	25
Farming experience	20	13	1	50
Farm size (ha)	0.388	0.40	0.02	2
Farm distance (km)	4.56	3.29	0.2	20
Labour (m.d)	395.58	382.06	26	2367
Yam setts (N)	26762.62	26868.50	800	120000
Operating expenses	8363.21	5881.73	1000	31450

Table 2: Summary of socio-economic variables of yam farmers

	Variables	Responses	Percent
(1)	Type of farming	Food crop farming only	66.7
		Food crop+tree crop	33.3
		Total	100
(2)	Major occupation	Farming	92.9
		Non-farming	7.1
		Total	100.0
(3)	Source of land	Owned	55.6
		Hired	44.4
		Total	100.0
(4)	Source of labour	Hired	11.1
		Family	42.9
		Both hired and family	46.0
		Total	100.0
(5)	Educational level	No formal education	41.2
		Primary education	27.8
		Secondary education	31.0
		Total	100.0

Table 3: Profitability analysis of yam production

Variables	Mean
Output of yam (tubers)	3710
Farm size (ha)	0.388
Labour cost (₦)	149218.10
Cost of yam setts (₦)	26762.62
Transportation cost (₦)	5853.57
Operating expenses (₦)	8363.21
Total variable cost (₦)	190247.50
Revenue (₦)	256249.50
Gross margin	66002.00
Gross margin ha^{-1}	169235.90

Table 2 presents the summary of other socio-economic variables involved in this study. The yam farmers had low educational level with about 69% having no formal education or primary education. The finding agreed with a-priori expectation that Nigerian small-scale farmers have low educational level and thus the adoption rate of innovations and new technologies is low[10]. The yam farmers were mainly into food crop farming with about 66.7% in this category, while about 33.3% were into food and tree crops production. About 55.6% of the food crop farmers owned the land they used for farming while about 44.4% hired or leased their farmlands.

The study revealed that about 92.9% of the yam farmers had farming as their major occupation. It was observed that it was not convenient to combine food crop farming with other occupations because it requires very close maintenance attention for weeding, fertilizer application and other cultural operations, which in the case of yam production include staking mulching, stem tendering and harvesting.

Profitability analysis: The profitability analysis is presented in Table 3. Yam production was profitable in the study area with the gross margin per ha greater than zero. The cost variables showed that labour cost was the most significant, followed by the cost of yam setts (planting materials). The labour cost accounted for about 78.4% of Total Variable Cost. This confirms the dependence of yam production on manual labour as most operations are yet to be mechanized.

The total value of output (TR) of ₦256249.50 gives a breakdown of about ₦ 70 per an average tuber of yam. The gross margin was ₦ 66002 per farmer and about ₦169235 per hectare. Therefore investing in yam production apart from solving the immediate food problem of the farmer and his household members, would contribute significantly to his income generation, thereby affording him the opportunity to acquire some non-farm commodities of his choice.

Estimates of Stochastic Frontier Production Function (SFPF) models: The estimates of the SFPF models used for test of presence of inefficiency effects and productivity analysis are presented in Table 4.

Presence of technical inefficiency: The generalized likelihood ratio test rejected the null hypothesis that there was no technical inefficiency effect in yam production, that is, H_o: γ = o, rather it accepted the alternative hypothesis, H_a: γ≠o, that there was technical inefficiency effect in yam production. This is because the computed chi-square, X^2 of 69.40 was greater than the tabulated chi-square, $X^2_{(0.05,\ 7)}$ of 14.07. Model 1 of the SFPF was not adequate representation of the yam farmers' production function; therefore, model 2 was chosen for further econometric and economic analyses.

Productivity analysis: The estimated coefficients in the general model of Model 2 were also elasticities of production of the included variables of the SFPF because of the cobb-douglas functional form used. All the variables except educational level of the yam farmers had decreasing return to factors. Elasticity of production was between zero and unity, that is, $0 \le ep < 1$. Allocation of variables was in stage 2 of the production function for the variables and thus was efficiently allocated. Farm size,

Table 4: Estimates of stochastic frontier production function

Variables	Model 1	Model 2
General model		
Constant	2.83 (5.65)	4.33 (11.24)
Farm size	0.44 (5.26)	0.78 (12.12)
Labour	0.05 (0.67)	0.03 (0.60)
Operating expenses	0.14 (1.78)	0.09 (1.51)
Yam setts	0.41 (5.15)	0.17 (2.85)
Age	0.13 (0.62)	0.20 (1.36)
Educational level	-0.04 (-0.98)	-0.001 (-0.03)
Inefficiency model		
Constant	0	-2.13 (-3.45)
Type of farming	0	-0.53 (-3.70)
Source of land	0	0.25 (2.39)
Type of labour	0	0.58 (3.30)
Distance of farm	0	0.62 (2.56)
Variance parameters		
Sigma squared	0.03	0.15 (7.42)
Gamma	0.64	0.97 (227.07)
Loglikelihood function	38.45	73.15
Mean T.E		0.91

Figures in parentheses are t-ratios, * Estimate is significant at 5 percent level of significance.

Table 5: Elasticity of production and return to scale

Variables	Elasticity of production
Farm size	0.78
Labour	0.03
Operating expenses	0.09
Cost of yam setts	0.17
Age of farmer	0.20
Educational level	-0.001
RTS	1.269

operating expenses and cost of yam setts were significant variables at 5% level of significance in yam production. The coefficient of educational level was negative implying its allocation was in stage 3 of the production function. This is as a result of the low level of education of the respondents.

The Return To Scale (RTS) analysis is presented in Table 5. The RTS is the summation of the elasticities of production of variables of the production function. The RTS of 1.269 indicates that yam production was in the irrational stage (stage 1) of the production function and thus yam production was not efficient in the study area. To improve on this, over-all production should be intensified and expanded so that yam production could move to stage 2 (rational zone) of the production surface. Allocating more of the variable inputs that had decreasing return to the factors could do this.

Technical efficiency analysis: The TE of the yam farmers varied significantly as confirmed by the value of gamma, γ = 0.97 indicating that about 97% variation in the output of yam production was due to differences in the farmers' technical inefficiency. The TE values ranged between 0.35 and 0.99 with a mean TE of 0.91. The decile range of the frequency distribution of the TE showed that about 96% of the yam farmers had TE > 0.70. This implies that yam farmers in the study area were relatively technically efficient. This finding agreed with the study of Ojo[1] that yam farmers were relatively technically efficient given the available technology.

Technical inefficiency analysis: The signs and magnitude of the coefficients of variables of the inefficiency model in Table 4 are important in the analysis of the determination of TE of the yam farmers.

The coefficient of type of farming was negative indicating that as the yam farmers become more specialized in yam production by facing mainly food crop production without combining it with tree crop production, their TE increases. The specialization on food cropping will give room for paying the needed attention to the essential operations required by the different food crops. The coefficients of source of land, type of labour and distance of yam farm had positive signs implying that these variables would cause TE to decrease as their values increase.

Source of land: The main source of land for farming was land owned by the farmers with about 55.6% of the farmers owning their farm lands and only 44.4% hiring theirs. A-priorily, direct owning of land was expected to lead to increase in TE but the study observed that farmers owning their farmlands were not as technically efficient as those who hired or got their farmlands on leasehold. This phenomenon arose because farmers who hired the farmland would ensure the land was used more productively so that they could recoup all they invested on it. That is, they were under pressure, not only to break even but also to make some surplus, whereas farmers who owned their farmland were not under any pressure whatsoever and as such were content with whatever output they got from the farm.

Farm distance: The distance of yam farms to the farmers' settlements was expected to have an inverse relationship with TE and even productivity. This finding corroborated the work of Ojo and Afolabi[9] on effects of farm distance on productivity of farms in Nigeria. The result of which showed that the output, profit and productivity of farms with shorter distances from the farmers' settlements were higher than those with longer distances. It also found out that elasticity of production of farm distance was a negative function to the factor. The longer the distance of farms to the settlements, the more expenses on transportation of labour and materials, while the workers going to work on the farms used up much energy before actually getting to work on the farms. Therefore productivity of labour reduces and TE of farmers in allocating scarce resources also reduces.

Type of labour: The type labour used was mainly from family source with about 42.9% of the yam farmers using mainly family labour and another 46% using both family and hired. Apart from family labour not being used productively due to lack of adequate control during use because there was no immediate cost involvement, the tendency to over use labour from this source can not be ruled out. Therefore for labour to be used productively and efficiently, there should be awareness of financial commitment which only hired labour can ensure. Thus hired labour should be encouraged for improved technical efficiency.

CONCLUSION

The study revealed that yam production was very profitable in the study area and that while all the technical and socio-economic variables involved in yam production were efficiently allocated, education was inefficiently allocated. The overall productivity of yam production (RTS) was however in the irrational zone of the production function (stage 1) giving room for future expansion in output and productivity. The TE of the farmers varied significantly with about 97% variation in their output caused by differences in the farmers TE. Therefore to ensure improvement in yam production (output, productivity and technical efficiency), that will invariably lead to solving food security problems, the following policy issues are recommended.

- Breeding of high yielding yam varieties to improve on the productivity of yam setts (planting material)
- Improving the educational status of the farmers through adult education, encouragement of school leavers into food crop farming through financial empowerments of participants of these government schemes:- back to farm, youth in agriculture, poverty alleviation programmes and farmers congress.
- With farm distance on the increase due to pressure on land for building and other construction projects, effective road repairs/rehabilitation programmes to open up the inaccessible roads in the farms thus reducing wastage of farm produce especially during harvesting peiods and also reduce cost of transportation on labour and other resources.

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