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Economic Efficiency and Returns to Scale of Yam Production in Southwest Nigeria

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Abstract – **Economic efficiency and returns to scale of yam production in Southwest Nigeria were investigated using a Cobb-Douglas stochastic frontier production function which incorporated a model of inefficiency effects. Multistage and random sampling techniques were used to select 320 yam farmers. Farm level data were collected from the farmers using pre-tested interview instruments. Results indicated mean economic efficiency levels of 0.94, 0.96 and 0.93 for all farms (wetland & upland farms together), upland and wetland farms respectively. Production factors of labour and material inputs significantly influenced yam output. Farm specific variables such as educational level, household size and farm size were significant factors implicated for the observed variations in inefficiency. Returns to scale analysis showed constant, increasing and decreasing returns to scale for all farms, upland and wetland farms respectively. Further improvement in economic efficiency would be achieved through increased variable inputs utilization by the upland farmers and otherwise for the wetland farmers, and the expansion of extension services to accommodate integrated farming system and more efficient management skills.**

Keywords – **Economic Efficiency, Yam Production, Stochastic Frontier Model, Southwest Nigeria.**

I. Introduction

Yams are produced on five million hectares in about 47 countries in Tropical and Sub-Tropical regions of the world, with yields of about 11 tonnes per lecture in the major countries of West Africa (International Institute for Tropical Agriculture (IITA), 2009). According to Asumugha and Njoku (2007), West and central Africa account for about 93% of the world's total yam production of 38 million tonnes. In 2011, world production figure rose to 56 million tonnes with Nigeria producing about 37.1 million tonnes representing 67% of world production (Food and Agricultural Organization (FAO), 2011).

The edible varieties of yam are important food crops and serve as important carbohydrates staple for millions of people in Nigeria (Adetunji et al, 2010). According to United State Department of Agriculture (USDA) (2009), 100g of yam contain nutrient value of carbohydrate 27.88g, protein 1.53g, dietary fibre 4.10g, niacin 0.55mg, riboflavin 0.03mg, thiamin o.11mg, vitamin A 138 iv, vitamin C 17.10mg, vitamin E 0.35mg vitamin K 2.30mg, calcium 17mg, magnesium 21mg, phosphorus 55mg, and zinc 0.24mg. Yams are more nutritious than cassava and sweet potato having higher levels of proteins and vitamins (Kizito, 2006). Babaleya (2006) noted that yam contributes more than 200 dietary calories per capita daily for more than 150 million people in West Africa and at the same time it is an important source of income generation and trade. In many yam producing areas of Nigeria yam is food which the people can eat more than three times a day (Osunde 2008; Reuben and Barau, 2012). In addition to its importance in the diet, it is prominent in traditional festivals, marriages, burials and indeed in almost all social, cultural, and religious gatherings.

In Southwest Nigeria, yam is commonly cultivated by most farm households both in the upland and/or wetland farms (Barmine and Amujoyegbe, 2005). The product is, therefore, expected to be readily available and affordable. However, prices of yam tubers seem to be on the increase due to rising demand resulting from inadequate supply. This development may be attributed to high population growth rate, subsistence nature of its production, rising cost of production, and inappropriate land improvement techniques (Ugwumba and Omojola, 2012). The problems of subsistence agriculture such as the used of traditional techniques, inadequate extension services, lack of credit facilities and poor distribution of agricultural inputs, also could lead to production inefficiency, poor output and lagging supply (Ike and Inoni, 2006).

To achieve economic optimum output and thus profitability, resources have to be optimally and efficiently utilized. Also, the ability of yam producers to adopt new technologies and achieve sustainable production level depends on their level of economic efficiency since efficiency increment is a factor for productivity growth (Ugwumba, 2011). Improvement in yam productivity can be achieved with a proper study that will determine the levels of economic efficiency of yam farmers, determinants of inefficiencies, and returns to scale in yam production, hence this study conducted in Southwest Nigeria to generate information for policy formulation and decision making by the farmers, government and private interests.

II. Materials and Methods

The study was conducted in Southwest Nigeria consisting of Ekiti, Lagos, Ogun, Ondo, Osun and Oyo States. The area lies between longitude 2^0 $31'$ and 6^0 00' East and latitude 6^0 21^0 and 8^0 37' North of equator (Agboola, 1979), with a total area of 77, 818 Km^2 and projected population of 27,340,254 people (National Population Commission (NPC), 2006). The area represents two ecological zones - forest regrowth and southern guinea savannah ecological zones. The mean annual temperature ranges from 21.1^0C to 31.1^0C and the annual rainfall ranges of 800mm to 1500mm in the rainforest belt.

Multistage, purposive and random sampling methods were used to select 320 respondents for the study. In the first stage, two States (Ekiti and Osun) were purposively selected from the six states in the area. The selection was based on the preponderance of upland and wetland yam farmers evidenced from pre-survey study. Stage II involved random selection of two LGAs each from the two agricultural zones in Osun State and two LGAs from the two agricultural zones in Ekiti State to arrive at four LGAs. At stage III, two communities were randomly selected from each of the four selected LGAs to arrive at eight communities. Finally, simple random method was used to select twenty (ie ten each of upland and wetland) yam farmers from each of the eight selected communities to arrive at 320 respondents at stage IV.

Data for the study were collected from primary sources using well structured and pre-tested questionnaire and personal interview schedule. Data were collected on socio-economic characteristics of the farmers, production variables and current market price. Collected data were analyzed using descriptive statistics and single-step Cobb-Douglas stochastic frontier production function.

III. Specification of Model

The stochastic frontier production model derived from Kumbhaker and Lovell (2000), Ike and Inoni (2006) and Adetnnji and Adeyemo (2012) was used for the study. The frontier production model begins by considering a stochastic production function with a multiplicative disturbance term of the form:

$$Y_i = f(X_i; \beta_i)\varepsilon$$

Where:
Y_i = Total value of farm output (₦)
X_i = A vector of input quantities (₦)
β_i = A vector of parameters
ε = stochastic disturbance term

The stochastic disturbance term, ε, consists of two independent elements μ and υ (ie ε = μ and υ). The symmetric component, υ, accounts for random variation in output due to factors outside the farmers control, such as weather and diseases. It is assumed to be independently and identically distributed as $|N{\sim}(O, \sigma v2)|$. A one-sided component $\mu \leq 0$ reflects technical inefficiency relative to the stochastic frontier as $N{\sim}(O, \sigma_v^2)$, that is, the distribution of μ is half normal. The stochastic production frontier model can be used to analyze cross sectional data. An individual farm-firm is defined in terms of the observed output (Yi) to the corresponding frontier output (Yi*) given available technology, that is,

$$TE = Yi / Yi^* = \frac{f(Xi; Bi)exp(Vi - Ui)}{f(Xi; Bi)exp(Vi)}$$

$$TE = Exp(-Ui)$$

So that, 0≤ TE ≤1. An estimated value of technical efficiency for each observation can be calculated from the equation. If TE = 1, the firm is said to be technically efficient and its output level is on the frontier. Otherwise, i.e. if TE <1, the firm is technically inefficient because it could have produced more outputs with the given level of inputs irrespective of input prices.

According to Coelli (1996), Ike and Inoni (2006) and Adetunji and Adeyemo (2012), economic efficiency can be measured by substituting monetary values for physical quantities of output and inputs used in the model of technical efficiency. The empirical stochastic frontier production model that was applied to the analysis of data is, therefore, specified as:

$$ln Y_{ij} = \beta_0 + \beta_i ln X_{1ij} + \beta_2 ln X_{2ij} + \beta_3 ln X_{3ij} + v_{ij} - u_{ij}$$

Where: subscript ij refers to the jth observation of the ith farmer.
In = Logarithm to base e
Y_{ij} = Value of yam output (₦)
X_1 = Rental value of land (₦)
X_2 = Labour cost (₦)
X_3 = Material inputs of fertilizer, agro chemicals and yam seeds (₦)

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:

$$U_{ij} = \varsigma_0 + \varsigma_1 Z_{1ij} + \varsigma_2 Z_{2ij} + \varsigma_3 Z_{3ij} + \varsigma_4 Z_{4ij} + \varsigma_5 Z_{5ij}$$

Where:
Uij = economic inefficiency of the ith farmer and jth observation of the farmer
Z_i = Years of experience of the ith farmer in yam production
Z_2 = Years of formal education of the ith farmer
Z_3 = Amount of credit available to the farmer (₦)
Z_4 = Number of meetings with extension agents per farming season.
Z_5 = Land type (dummy: upland=1; wetland=2)

The β and ς coefficients are unknown parameters to be estimated by the method of maximum likelihood, using the computer program Frontier version 4.1c (Coelli, 1996).

IV. Results and Discussions

Economic efficiency scores of the yam farmers

Distribution of the yam farmers' economic efficiency scores by farm groups is shown in Table 1. The result indicated that majority (71.87%) of the all farm group fell within the economic efficiency range of 0.91 – 0.98; 25% of them attained economic efficiency levels below or equal to 0.90 while the remaining 3.13% recorded above 0.98 in economic efficiency. A maximum of 0.83 and average of 0.94 economic efficiency levels were computed for the all farm group. This implied that the yam farmers were economically efficient in yam production, however, mean economic efficiency gap of 0.06 or 6% still exists in the area.

The maximum efficiency score for upland farms in the Southwest was 0.99 and wetland farms 0.98 while minimum and mean efficiency scores of 0.89 and 0.78, 0.96 and 0.93 were computed for the upland and wetland farms respectively. This finding is contrary to Ike and Inoni (2006) which concluded that yam farmers in Southeast Nigeria were economically inefficient. Yam farmers in Southwest Nigeria were economically efficient in yam production probably because they had easier access to cheap productive resources and improved technologies, and adopted more efficient resource allocation and managerial strategies in order to operate closer to the frontier. A similar result of economic efficiency was posited by Balogun *et al.* (2011) on yam production in Oyo State of Nigeria.

Table 1: Distribution of yam farmers economic efficiency scores by farm groups

Economic Efficiency Score	All farms (Upland and Wetland farms)		Upland farms		Wetland farms	
	Frequency	%	Frequency	%	Frequency	%
< 0.90	80	25 .00	45	28 .13	35	21 .87
0.90 – 0.94	118	36 .87	53	33 .12	65	40 .63
0.95 – 0.98	112	35 .00	62	38 .75	50	31 .25
> 0.98	10	3 .13	-	-	10	6.25
Mean	-	0.94	-	0.96	-	0.93
Minimum	-	0.83	-	0.89	-	0.78
Maximum	-	0.98	-	0.99	-	0.98

Source: Field Survey, 2013. Note: % = Percentage.

The hypothesis, means of economic efficiency levels of upland and wetland farms are not significantly different, was tested using Paired-Samples-T–Test of the MINITAB STATISTICS. The result is shown in Table 2. The result indicated that there was no statistically significant difference between the means of economic efficiencies of the upland and wetland farmers at the 5% level. This implied that the upland and wetland yam farmers in the area, on the average, attained the same economic efficiency level and hence were operating at the same frontier space.

Table 2: Difference in means of economic efficiencies of wetland and upland farm groups

Farm group	Mean Economic Efficiency	Difference between group means	T-ratio	P	DF
Wetland	0.96				
Upland	0.93	0.3	1.07ns	1.27	316

Source: Field survey, 2013. Notes: P = probability. DF = Degree of freedom. ns = Not significant.

Estimated parameters of the Cobb-Douglas stochastic frontier production function

The parameters and related statistical test results obtained from the stochastic frontier production function analysis for yam using maximum likelihood estimation (MLE) technique are presented in Table 3. All coefficients of the production variables (land, labour and material inputs) in the model exhibited the expected positive *a priori* sign, however, only the coefficients of labour and material inputs for all farms, wetland and upland farms had positive and statistically significant effect on output at the 5% level of probability. This implied that the farmers who increased the quantities of labour and material inputs used were likely to have significant increase in their output.

Table 3: Maximum likelihood estimates of parameters of the Cobb Douglas stochastic frontier production function for yam production in Southwest Nigeria

		All farms		Upland farms		Wetland farms	
Variable	Parameter	Coef.	T- ratio	Coef.	T-ratio	Coef.	T-ratio
Production factor							
constant	β_0	0.21	0.45	0.16	0.55	0.38	1.42
Land	β_1	0.04	0.84	0.02	0.64	0.06	0.62
Labour	β_2	0.31	2.65**	0.31	2.39**	0.62	2.14*
Material inputs	β_3	0.65	5.37**	0.70	7.72**	0.56	6.28*
Inefficiency Model							
Constant	δ_0	0.16	0.56	- 0.75	- 0.86	0.15	0.45
FAE	δ_1	0.00	0.68	0.02	0.82	0.00	0.60
EDU	δ_2	- 0.07	- 1.82*	- 0.15	1.76*	0.18	1.49*
ACO	δ_3	0.01	0.42	0.02	0.88	0.06	0.51

EXV	δ_4	0.00	0.02	- 0.00	0.56	-0.005	- 0.08
AGE	δ_5	- 0.01	- 1.16	- 0.01	- 0.71	- 0.11	- 1.26
HOS	δ_6	0.13	3.18**	0.20	2.70**	0.17	3.15**
FAS	δ_7	0.52	3.14**	0.40	2.90**	0.42	3.64**
Diagnostic Statistics							
Likelihood ratio			95.68		101.88		105.76
Sigma–squared (δ^2)			6.75**		7.16**		8.35**
Gamma ($\propto$)			0.96**		0.93**		0.94**

Source: Computed from survey data, 2013. Notes: Coef = coefficient. * = significant at the 0.01 level. ** = significant at the 0.05 level. FAE, EDU, ACO, EXV, AGE, HOS, and FAS are as earlier defined.

Determinants of inefficiency

The sources of inefficiency were examined by using the estimated δ- coefficients associated with the inefficient effects in Table 3. The inefficiency effects are specified as those relating to farming experience, educational attainment, amount of credit obtained, extension visit, age, household size and farm size. Out of the seven predictors included in the model, three (educational level, household size and farm size) were statistically significant while the rest four (farming experience, amount of credit obtained, extension visit and age) were not significant.

The estimated coefficient of educational attainment was appropriately signed and significant at 1% 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. Besides, farmers who have some level of formal education respond readily to the use of improved technologies such as application of fertilizers, use of pesticides and improved planting materials, thus producing closer to the frontier. This result corroborates (Adetunji and Adeyemo, 2012) which reported positive relationship between educational attainment and economic efficiency.

The estimated coefficients of household size and farm size were positive and statistically significant at 5% level. This implied that the yam farmers who had large household and farm sizes were less economically efficient, presumably due to their inability to manage large farm and human resources. This result is contrary to the findings of Ajibefun and Daramola (1999), Adetunji and Adeyemo (2012) who reported a negative but significant effect of household size on economic inefficiency.

The estimated value of sigma square (δ^2) of 6.75 for all farms group in the area was large and significant at 5% level, an indication of a good fit for the model and correctness of the specified distributional assumptions.

Elasticity of production and returns to scale

Returns to scale is the response of output to proportionate change in the inputs. This study calculated returns to scale as the sum of individual elasticity of output with respect to land, labour and material inputs (seeds, fertilizers and pesticides) which represented factors or farm specific characteristics that affected economic efficiency. If the sum of input elasticities is equal to one ($\sum X_i = 1$) as exemplified in Table 4, then there is constant returns to scale, that is doubling the inputs will double the output, tripling the inputs will triple the output, and so on. If the sum of input elasticities is less than one ($\sum X_i < 1$), there is decreasing returns to scale – doubling the inputs will less than double the outputs. Finally, if sum of input elasticities is greater than one ($\sum X_i > 1$), there is increasing returns to scale – doubling the inputs will result into more than double the output.

Table 4: Estimated output elasticities and returns to scale for yam production

	All farms	**Upland farms**	**Wetland farms**
Land	0.04	0.02	0.06
Labour	0.31	0.31	0.31
Material inputs	0.65	0.71	0.56
RTS	1.00	1.04	0.93
	Constant	increasing	Decreasing

Source: Field survey, 2013. Note: RTS= Returns to scale.

The analyses of output elasticities and returns to scale were done using Cobb-Douglas model. Result of the analysis of yam production output with respect to land, labour and material inputs, and values of their returns to scale presented according to the farm groups is shown in Table 4. For the Southwest (all farms group), it could be seen from the table, that holding labour and material inputs constant, a 1% increase in land led on the average to about 0.04% increase in output. Holding land and material inputs constant, a 1% increase in labour yielded 0.31% increase in output; and holding land and labour constant, a 1% increase in material inputs led to 0.65% increase in output. Addition of the three output elasticity values of land, labour and material inputs (0.04 + 0.31 + 0.65) gave 1.00 for all farms (upland and wetland farms put together) in the area, that is, a situation of constant returns to scale.

Further result of the analysis showed increasing returns to scale for the upland farms and decreasing returns to scale for the wetland farms. The existence of decreasing returns to scale among the wetland farmers in the area meant over utilization of resource inputs and that the level of yam production in the area had exceeded the maximum sustainable yield level, hence addition of resources would not bring corresponding yield increase. The upland farmers in the area experienced increasing returns to scale meaning that additional use of variable inputs while holding the fixed inputs constant, would yield more than corresponding output, *ceteris paribus.* This development corroborates Awoniyi and Omomona (2006), Izekor and Olumeze (2010), and Dung *et al*. (2010) that most farmers are not efficient in resource allocation and utilization in Nigeria.

V. Conclusion

Yam farmers in Southwest Nigeria were economically efficient in their production and operating close to the frontier. However, the existing inefficiency gap should be addressed so as to optimize productivity by the acquisition of skills in favour of integrated farming system that reduces human resource utilization and farm (land) size while adopting best management and technological practices to maintain high efficiency, output and profit.

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