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Relative Technical Efficiency of Cassava Farmers in the Three Agro-Ecological Zones of Edo State, Nigeria

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Abstract: This study employed the use of the Stochastic Frontier Production Function in the comparative economic analysis of the relative technical efficiency of cassava farmers in the three agro-ecological zones of Edo State. A multi-stage random sampling technique was used to select 156 cassava farmers from the three agro-ecological zones of the State and the differences in the results obtained were discussed. The empirical estimates showed individual technical efficiency values that ranged from 23 to 95%, 43 to 97% and 52 to 98% with a mean of 72, 83 and 91%, for Edo South, Edo North and Edo Central agro-ecological zones, respectively. This shows that systemic differences in relative technical efficiency levels exist between the three zones and these differences were shown to be related to particular farmer's characteristics. Non-physical factors that served as determinants of technical inefficiency in the three zones were, farmers level of education, age, farming experience and variety of planting materials used. Gender and family size were however, not found to be significant determinants of the technical inefficiency of cassava farmers in the State. Apart from this estimates serving as a guide to potential investors in the cassava industry in the State, the relative variations in technical efficiency is also an indication of the gaps that exist in the current production technologies employed by cassava farmers in the three agro-ecological zones of the State. The gaps should serve as intervention points for government and non-governmental agencies as well as other stakeholders in the emerging cassava industry in Nigeria.

Key words: Edo state, food security, maximum likelihood estimates, ordinary least square, production function, stochastic frontier, technical efficiency

INTRODUCTION

The gradual transformation of cassava (*Manihot esculenta*, *crantz.*) from a low-yielding famine-reserve crop to a high-yielding cash crop for both rural and urban consumers (Nweke *et al*., 2002), has implications for food security and industrialization in Nigeria. Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. The International Food Policy Research Institute (IFPRI, 2002) estimated that about eight million people go to bed hungry and 24,000 people die of hunger each day, even though the right to food remains a basic human right. Consequently, a determined and well-targeted effort must be made to improve on food security, especially in Sub-Saharan Africa, where the problem of hunger seems to be more severe. Cassava serves as a benchmark for food security in Africa and other parts of the world, as it remains a major staple in Africa, Latin America, Asia and the Caribbean. Demand for cassava is growing in Sub-Saharan Africa because it is an essential staple consumption food (Rosegrant, 2002). Using IFPRI (2002) base line data, the total world cassava use is expected to increase form 172.7 to 275 million tonnes in the period 1993-2020. A higher projection of demand and production growth puts the 2020 projection at 290 million tonnes. In both projections, cassava use in Africa alone is equivalent to 62% of total world production. As the commercial success of cassava continues to grow, its industrial relevance equally becomes more obvious. Today for instance, every aspect of the plant (from the proteinous leaves, through the energy-packed stems, down to the lignin-rich stumps and fleshy tubers) has industrial relevance both locally and in the international market. There has to be a tremendous increase in the current level of cassava output in the country in order to meet increasing demand both locally and internationally.

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The logical solution to enhancing the current level of output is to examine the technical efficiency of the farmers involved in cassava production in Nigeria. This is because productivity is reduced in the presence of technical inefficiency, whereas the more efficient a firm is, the higher its productivity, *Ceteris paribus* (Kumbhakar, 2004). A Comparative analysis of the technical efficiency of cassava farmers in the three agro-ecological zones of Edo State will therefore provide empirical evidence of gaps that may exist in the farmers current level of technical efficiency. These gaps would serve as intervention points for relevant stakeholders. It would also help to strengthen the decision variables of would-be investors in the emerging cassava industry in Edo State and Nigeria in general.

Thus the main objective of this study was to employ the use of the Stochastic Frontier Production Function (SFPF) in the comparative analysis of the relative technical efficiency of cassava farmers in the three agro-ecological zones of Edo State. Socio-economic characteristics of the farmers and non-physical factors that affect technical efficiency in the three zones were also examined. Technical efficiency as used in this study simply means a farmer's success in producing maximum output from a given set of inputs. Onyenweaku and Nwaru (2005), Oren and Alemda (2006) and several other researchers have applied the use of the SFPF in estimating technical efficiency for specific crops in the past, while Abang *et al.* (2001) applied the function in estimating the technical and allocative efficiencies of cassava farmers in Cross River State, but none of these studies was carried out in Edo State. In 2006, Emokaro and Erhabor applied the SFPF approach in estimating the technical efficiency of cassava producers in Edo State, however, the study treated the farmers on an aggregated basis and did not consider the comparative analysis of technical efficiency of cassava farmers in the three agro-ecological zones of Edo State. This particular study, which focused on the analysis of the technical efficiency of the farmers on a disaggregated basis, was thus designed to fill this gap.

MATERIALS AND METHODS

Study area: The area chosen for this study is Edo State, Nigeria. The State lies within the geographical co-ordinates of Longitude 05° 04` East and 06° 43` East and Latitude 05° 44` North and 07° 34` North of the Greenwich. It is bounded in the North by Kogi State, in the South by Delta State, in the West by Ondo State and in the East by Kogi and Anambra States.

The State is characterized by a tropical climate, which ranges from humid to sub-humid at different times in the year. The three distinct vegetations identified in the State are Mangrove Forest, Fresh Swamp and Savannah vegetations. The mean annual rainfall in the Northern part of the State is between 127-152 cm while the Southern part of the State receives about 252-254 cm of rainfall annually, with average temperature ranging from a minimum of 24°C to a maximum of about 33°C. The State has an estimated population of over three million people.

Sampling procedure: A multi-stage sampling technique was adopted in selecting the respondents for this study, which was carried out between March and December in the 2005 production season. Firstly, the study area was stratified into agro-ecological zones, based on Edo State Agricultural Development Programme delineation. That is, Edo South, Edo Central and Edo North, so as to give the study a State-wide coverage. Edo South zone is made up of seven Local Government Areas (LGAs), Edo Central has five LGAs and Edo North has six, making a total of 18 LGAs, which formed the blocks.

A total of nine blocks, were randomly selected from the zones, which represents 50% of the total number of blocks in the State (Oredo, Uhunmwode, Egor and Ikpoba-Okha from Edo South; Igueben and Esan South from Edo Central and Owan East, Owan West and Etsako East, from Edo North) i.e. four from Edo South, two from Edo Central and three from Edo North. Two cells were randomly selected from each block, for a total of 18 cells. These 18 cells made up the farming communities; with eight, four and six communities coming from Edo South, Edo Central and Edo North agro-ecological zones, respectively.

Finally, 10 farmers were randomly selected from each cell to make up a total of 180 respondents. Of the 180 respondents interviewed in this study, 157 or 87% presented data for this analysis. The data from the remaining 24 respondents could not be used due to obvious inconsistencies and perceived exaggerations in the information provided. The highest response rate of 100% was recorded in Edo Central, followed by Edo North with a response rate of 88% and Edo South with 79%, as presented in Table 1.

Analytical techniques

Technical efficiency: The Stochastic Frontier Production Function was used to determine the technical efficiency of each farmer (Greene, 1993; Aigner *et al.*, 1997).

Table 1: Response rate of respondents

Zones	Sample size	No. of respondents with useful data	Response rate (%)
Edo South	80	63	79
Edo Central	40	40	100
Edo North	60	53	88
Total	180	156	87

Source: Computed from field survey data, 2005

Frontier model:

$$\ln Y = \beta_0 + \beta_1 \ln X_1 i + \beta_2 \ln X_2 i + \beta_3 \ln X_3 i + \beta_4 \ln X_4 i + (v_i - \mu_i) \quad (1)$$

Where:

- i = ith farmer;
- Y = Total value of cassava output in tonnes,
- X_1 = Hectares of land planted to cassava,
- X_2 = Man-days of labour hired in respect of cassava production,
- X_3 = Man-days of family labour used in respect of cassava production,
- X_4 = Bundles of planting materials used in respect of cassava production,
- β_1-β_4 = Regression coefficients,
- v_i = A random error term or white noise assumed to be independent of μ_i, identical and normally distributed with zero mean and constant variance N (0, δ^2_v), intended to capture events beyond the control of the farmers, like topography, weather, uncertainties e.t.c.,
- μ_i = Disturbance term or technical inefficiency effects, which are assumed to be independent of v_i.

They are non-negative truncations at zero or half normal distribution with N (0, $\delta^2\mu$). If μ_i is zero, no allocative inefficiency occurs, the production lies on the stochastic frontier. If $\mu_i > 0$, the production lies below the frontier and is inefficient.

i = 1, 2, 3, ...N, β_i (where, i = 1...4), δ^2_v $\delta^2\mu$, δ^2 are unknown scalar parameters to be estimated.

Technical Inefficiency Model: Non-physical variables that accounted for the average level of technical inefficiency, measured by the mode of truncated normal distribution (μ_i) are defined as follows;

$$\mu_i = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 + \alpha_7 Z_7 \quad (2)$$

Where:

- μ_i = As earlier specified,
- Z_1 = Farmers years of formal education,
- Z_2 = Farmer's age,
- Z_3 = Household size (number of persons),
- Z_4 = Gender: male = 1, female = 0,
- Z_5 = Farming experience (in years),
- Z_6 = Weeding frequency: once = 0, more than once = 1,
- Z_7 = Variety cultivated: improved = 1, local = 0, α_j (where, j = 1...7) are unknown scalar parameters to be estimated.

The variance ratio of μ and v is given as;

$\gamma = \delta^2/\delta^2 s$ (since gamma (γ) must take a value between 0 and 1 (3)

Sigma squared (δ^2) which is the summation of μ and v variance is expressed as;

$$\delta^2 s = \delta^2 v + \delta^2 \mu \quad (4)$$

The parameters of SFPF model were obtained by Maximum Likelihood Estimates (MLE) method, using the computer programme FRONTIER (version 4.1), where Eq. 1-4 were jointly estimated (Coelli, 1996).

RESULTS AND DISCUSSION

Socio-economic characteristics of farmers: A summary of the socio-economic characteristics of farmers in the study area is presented in Table 2. The oldest farmer was from Edo South with 61 years, while the youngest was from Edo Central with 20 years. Farmers in Edo Central were therefore comparatively younger than those from Edo North and Edo South.

Farmers in Edo Central recorded the highest level of formal education with 23% of them having formal education up to tertiary level, followed by those in Edo North with 13%, then Edo South with 3%. Most of the farmers in Edo South had formal education only up to primary school level (64%), thereby making them the least in terms of formal Education.

About 92% of farmers in Edo South were males, with about 70 and 85% in Edo Central and Edo North, respectively. The result indicates that cassava farmers in the State were mostly males (84%) and only 16% or 25 of them were females.

Table 2: Socio-economic characteristics of cassava farmers in Edo State

Variables	Edo South	Edo Central	Edo North	State Average/Percentage
Age (Year)				
Oldest	61	52	58	61
Youngest	22	20	21	20
Average	58	47	51	52
Education (Years)				
Primary	40 (64%)	19 (47%)	31(57%)	90 (58%)
Secondary	21 (33%)	12 (30%)	15(28%)	48 (31%)
Tertiary	2 (3%)	9 (23%)	7 (13%)	18 (11%)
Farming experience (Years)				
Maximum	41	32	35	41
Minimum	13	9	11	9
Average	34	27	29	30
Household size (persons)				
Maximum	11	9	13	13
Minimum	5	4	6	4
Average	7	6	8	7
Gender (persons)				
Male	58 (92%)	28 (70%)	45(85%)	131 (84%)
Female	5 (8%)	12 (30%)	8(15%)	25 (16%)

Source: Computed from field survey data, 2005

Table 3: Estimated production function for cassava in the three agro-ecological zones of Edo State

		Edo South		Edo Central		Edo North	
Variables	Parameter	Average function (OLS)	Frontier function (MLE)	Average function (OLS)	Frontier function (MLE)	Average function (OLS)	Frontier function (MLE)
Constant terms	B_0	4.51 (1.25)	0.06 (5.2)***	5.05 (7.53)***	0.52 (4.39)***	3.14 (1.00)	0.06* (5.21)***
Farm size (X_1)	B_1	6.07 (2.15)**	0.40 (3.6)***	0.04 (0.94)	0.19 (1.22)	0.31 (0.62)	1.02 (0.65)
Hired labour (X_2)	B_2	38.66 (7.06)***	0.06 (2.29)***	0.06 (1.98)**	0.06 (2.04)**	0.11 (0.93)	50.47 (12.79)***
Family labour (X_3)	B_3	2.03 (1.87)**	-0.005 -(0.21)	0.04 (1.12)	0.01 (0.25)	0.05 (0.43)	1.22 (1.66)*
Planting material (X_4)	B_4	2.10 (0.90)	0.59 (8.51)***	0.78 (9.19)***	0.74 (6.76)***	0.58 1.58)*	0.15 (0.09)
Likelihood function		-250.60	-233.72	-234.25	-223.20	-145.30	-122.20
Sigma squared (δ^2)			0.44 (2.57)***		0.57 (1.70)**		1.22 (9.37)***
Gamma (γ)			0.88 (8.25)***		0.85 (6.59)***		0.99 (5.72)***

*Significant at 10% level, ***Significant at 5% level, ****Significant at 1% level, Source: Computed from field survey data, 2005

The least experienced cassava farmers were from Edo Central, with an average farming experience of 27 years, while farmers from Edo South were the most experienced, with an average of 31 years farming experience.

There was not much variation in household size as the average household size in the three zones centered round the mean of seven persons per family. These findings compare favourably with the findings of Onyenweaku and Nwaru (2005) with mean values of 55 years, 27 years and 10 persons for farmers age, farming experience and household size, respectively.

Estimated OLS and MLE functions: The estimated results of the Ordinary Least Square (OLS) and the MLE for cassava farmers in the three agro-ecological zones of Edo State, is presented in Table 3. The OLS model provides an average production function while the MLE model provides estimates of the SFPF.

The sigma squared (δ^2) shows a 'good fit' and the correctness of the specified distributional assumptions of the composite error term. The gamma estimates of $\gamma = 0.88$, 0.85 and 0.99 for Edo South, Edo Central and Edo North, respectively, indicates that the vast majority of error variations is due to the inefficiency error term μ_i (and not due to the random error term v_i). That is, 99, 85 and 88% variation in output for cassava farmers in Edo North, Edo Central and Edo South agro-ecological zones, respectively, is due to the inefficiency factor (μ_I).

The ratio of the likelihood function, which compares the joint effect of efficiency parameters on the output of farmers, was estimated for the three zones. The ratios for Edo South: Edo Central, Edo North: Edo Central and Edo South: Edo North were calculated and compared with the tabulated values. The results were all statistically significant at 1% level of significance, suggesting the presence of the one-sided error component. This means that the efficiency factors are significant in the SFPF and that the classical regression model of production function, based on OLS estimation techniques would have been an inadequate representation of the data. Thus the results of the diagnostic statistics confirm the relevance of the SFPF using the Maximum Likelihood Estimator.

Table 4: Zonal estimates of the technical efficiencies of cassava farmers in Edo State

Technical efficiency	Edo South	Edo Central	Edo North
Mean (%)	72	91	83
Maximum (%)	95	98	97
Minimum (%)	23	52	43
Sample size	63	40	53

Source: Computed from field survey data, 2005

Table 5: Decile range of frequency distribution of technical efficiency in cassava production in Edo State

Decile range of technical efficiency (%)	Edo South	Edo Central	Edo North
21-30	03	-	-
31-40	08	-	-
41-50	11	-	10
51-60	7	9	6
61-70	6	13	8
71-80	6	4	9
81-90	14	4	11
91-100	8	10	7
Total sample size	63	40	53

Source: Computed from field survey data, 2005

Estimates of the technical efficiency: The technical efficiency estimates for cassava farmers in the three agro-ecological zones of Edo State is presented in Table 4. Edo Central recorded the highest mean technical efficiency of 91% followed by Edo North with 83% then Edo South with 72%. The decile range of the frequency distribution of the technical efficiency is presented in Table 5. It suggests a high concentration of farmers with an individual technical efficiency index between 71 and 100 (i.e., 45%). This wide range in individual index of technical efficiency, both within and among the zones suggests the existence of gaps and intervention points for increased technical efficiency and by implication, increased productivity and profitability by cassava farmers in the State. The highest mean technical efficiency recorded in Edo Central indicates that, on the average, within the limits of statistical reliability, cassava farmers in Edo Central are technically more efficient than their counterparts in Edo North and Edo South. These values are higher than the average of 65% within a farming system and 60% relative to the most efficient farms obtained by O'Neill *et al.* (2000) in the measurement of productivity change and efficiency on Irish farms and

Table 6: Inefficiency parameters for cassava farmers in Edo State

Variables	Parameter	Edo South	Edo Central	Edo North
Constant term	δ_0	0.73 (0.09)	0.58 (0.85)	0.93 (7.14)***
Age (Z_1)	δ_1	10.81 (2.23)**	0.04 (2.37)***	0.54 (5.72)***
Education (Z_2)	δ_2	-2.96 -(2.34)**	-0.02-(2.39)**	-0.33 -(1.76)*
Farming experience (Z_3)	δ_3	0.29 (2.97)***	0.03 (2.92)***	0.33 (3.13)***
Weeding (Z4)	δ_4	-18.64-(1.66)*	-0.19-(2.51)***	-0.80-(2.91)***
Family size (Z_5)	δ_5	-0.86-(0.47)***	-0.05-(0.69)**	-0.09-(0.93)
Gender (Z6)	δ_6	18.41 (1.27)	0.71 (0.93)***	2.59 (3.21)***
Variety planted (Z_7)	δ_7	8.93 (3.59)***	1.15 (2.96)***	3.33 (6.93)***

***Significant at 1%, ** Significant at 5%, * = Significant at 10%, Figures in parenthesis are t-ratios, Source: Computed from field survey data, 2005

57% obtained by Onyenweaku and Nwaru (2005) who applied the SFPF in the measurement of technical efficiency in food crop production in Imo State, Nigeria. They however compare favourably with the findings of Taddese and Krishnarmoorthy (1997), who examined technical efficiency in paddy farms of Tamil Madu, India; Amara *et al.* (1999), who studied technical efficiency and farmers' attitude towards technological innovation among potato farmers in Quebec, Canada.

Determinants of technical inefficiency: Non-physical determinants of technical inefficiency in cassava production in the three agro-ecological zones of Edo State are presented in Table 6. Level of farmers education, weeding frequency and family size were negatively related to farmers technical inefficiency while farmers age, farming experience, gender and variety of planting materials used contributed positively to farmers technical inefficiency in all the zones.

The positive relationship between farmers age and technical efficiency confirms the view of experts that, learning-by-doing contributes little to the catch-up of inefficient farmers. This probably explains the direct relationship existing between farming experience and level of technical inefficiency of the farmers, as many farmers in the study area tended to rely on their experience and ignored more current production information and technologies. This also explains why variety of planting materials used was positively related to technical inefficiency. The farmers mainly used local unimproved planting materials, sourced from the previous seasons' harvest, a direct fall out from their age-long traditional practice.

These results compare favourably with the findings of Battesse and Tessema (1993) who applied the SFPF of time-varying technical inefficiencies in the analysis of four years panel data in the production of wheat in three selected districts of Pakistan. The general conclusion that resulted from their study was that the development of new and improved seed varieties should be a continuous process. They also harped on the need for improved agricultural extension services that would help familiarize farmers with new technologies and the best ways to use them.

CONCLUSION

This study showed that technical efficiency of cassava farmers in the three agro-ecological zones of Edo State ranged from a mean of 72% in Edo South to 91% in Edo Central. This suggests that reasonable gaps exist between the three agro-ecological zones of Edo State, with Edo South being the zone with the most serious need for intervention. Based on the direct relationship between technical efficiency and productivity, *Ceteris paribus*, substantial opportunities exist for improvement in the level of productivity in the other zones only if genuine effort is geared towards addressing the factors affecting the current level of technical efficiency. These factors include: (i) Improved level of farmers' education through capacity building and strengthening of existing extension services and (ii) Provision of larger quantities of high yielding, disease resistant planting materials, which are known to have increased farm level yield by over 40% without addition of fertilizer (Nweke *et al*., 2002). The resultant increase in productivity will help in strengthening the role of cassava as a poverty fighter, a benchmark for food security and a pivot for the industrial revolution in Nigeria.

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