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PROFIT EFFICIENCY OF SMALLHOLDER COCOYAM-BASED FARMERS AND ITS DETERMINANTS IN OSUN STATE, NIGERIA

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ABSTRACT

Cocoyam belongs to the indispensable food category that supplies calorie in the diet of the Nigerian populace. However, researches on its nutrition and economic values are scarce leading to low production and under consumption among the populace. Against the backdrop of the great potential of the Nigerian agriculture in cocoyam production, and the need for land use efficiency, sustainable development, poverty alleviation, attainment of food –security/ self-sufficiency and adequate resource allocation to the production of the crop, this study examined farm level profit efficiency and its determinants for smallholder cocoyam-based farmers in Osun State, South-west Nigeria, using Cobb-Douglas stochastic profit function. Multistage and random sampling techniques were used to select 180 smallholder cocoyam farmers during the 2014 growing season and data were collected from them on their socio-economic and production characteristics. Maximum likelihood estimates of the specified models revealed an average profit efficiency of 44.88 percent which indicated that the profit of the farmers can be increased by 55 percent with the same production cost. The study also found that the level of education of the farmers, access to credit, farming experience, household size, access to extension services, and marital status are factors affecting farm-level profit efficiency in the use of resources. Farm-level policies aimed at promoting the farmers education, access to credit, access to extension services and marital status are recommended for improved profit efficiency.

Keywords: Cobb-Douglas function, Profit efficiency, Resource-use, Smallholder farmers, Cocoyam-based farming system.

INTRODUCTION

Agriculture has continued to be an important sector for sustainable development, poverty reduction, attainment of household food -sufficiency and food- security at large in Sub –Saharan Africa (World Bank, 2008). This is based on the fact that large proportions of the populace are engaged in agricultural activities. Agriculture is considered the largest sector in Nigeria's economy. It is the largest non-oil export earner, a key contributor to wealth creation, poverty reduction, and the largest employer of labour (Central Bank of Nigeria, 2005). It employs 70 percent of the nation's labour force, contributes at least 40 percent of the gross domestic product and accounts for over three-quarters of the non-oil foreign exchange earnings (Ajekigbe, 2007). The agricultural GDP is made up by crops (85%), livestock (10%), fisheries (4%) and forestry (1%). The sector plays a very crucial role in the food security, poverty alleviation and human development chain in Nigeria (Aye and Oboh, 2006).

The current increase in demand for staple food is mostly attributed to the rapid population growth. With the population of over 140 million (NPC, 2006), there is an overwhelming need to increase agricultural production in the country. Root and tuber crops are among the most indispensable group of staple foods in many tropical African countries and constitute the largest source of calories for the Nigeria population (Olaniyan *et al.,* 2001). Cassava (*Manihot esculenta*) is the most important of these crops in terms of total production, followed by yam (*Dioscorea* spp), cocoyam (*Colocasia spp* and *Xanthosoma spp*) and sweet potato (*Ipomoea batatas*) (Olaniyan *et. al*., 2001). Cocoyam is second to cassava in terms of production in Cameroon and first in Ghana (Knipscheer and Wilson, 2000; Echebiri, 2004). In terms of volume of production, Nigeria is the largest producer of cocoyam in the world, accounting for about 40% of the total production (Eze and Okorji, 2003). Cocoyam (*Xanthosoma sp., Colocasia sp*.) is an important staple cultivated in the south-eastern and south western parts of Nigeria (Ojiako *et al.,* 2007). From 0.73 million metric tonnes in 1990, cocoyam production in Nigeria rose by 432.8% to 3.89 million metric tonnes in 2000 (Ojiako, *et al.,* 2007), and further rose by 30.3% to 5.068 million metric tonnes in 2007 (FAO, 2007). The main technology applied in cocoyam production, is the traditional cutlass and hoe technology which has been blamed for the low output levels of farmers.

A resource or input is said to be efficiently utilized when it is put to the best use possible and at minimum cost allowable (Wongnaa and Ofori, 2012). Following Farrell's (1957) work, there has been a proliferation of studies in the field of measuring efficiencies in all fields. But in the field of agriculture, the modelling and estimation of stochastic function, originally proposed by Aigner *et al.,* (1977) and Meeusen and van den Broeck (1977) has proved to be invaluable. A critical narrative of the frontier literature dealing with farm level efficiency in developing countries conducted by Battese (1992), Bravo-Ureta and Pinheiro (1993), Coelli (1995) and Thiam *et al.,* (2001) indicated that there are wide ranging theoretical issues that had to be dealt with in measuring efficiency in the context of frontiers and these included selection of functional forms and relevant approaches (parametric or non-parametric method).

This work draws largely from the following reviewed works. Pius and Inoni (2006) used Cobb-Douglas stochastic revenue function to estimate economic efficiency of yam farmers in south eastern Nigeria. An average economic efficiency of 41% was discovered. The study also showed that farmers' experience and access to credit are factors that significantly affect economic inefficiency of yam farmers.

Ogundari (2006) estimated Cobb-Douglas stochastic profit function for small -scale rice farmers in Nigeria. His results revealed that farm size, price of labour, fertilizer price, price of agrochemical and farm tools are production inputs that significantly affect farm level profit. An average economic efficiency of 0.601 was obtained for the study. Also, farmers' experience was identified as a major determinant of profit inefficiency.

Awoniyi and Bolarin (2007) studied production efficiency of upland and wetland yam-based enterprises in Ekiti State, Nigeria. The study obtained an average economic efficiency of 0.80 for wetland farmers, while farm size and planting material were found to affect wetland farmers' profit. Ogundari and Ojo, (2007) estimated Cobb-Douglas stochastic cost function of small -scale food crop production in Ondo State. They found an average economic efficiency of 68.38%. In addition, the results revealed that year of schooling, and access to credit affected economic inefficiency of the farmers.

Nwachukwu *et al.* (2007) applied translog stochastic profit function to measure efficiency of Fadama t*elfairia* production in Imo State, Nigeria. The empirical results revealed that age, farming experience, farm size, membership of cooperative society and household size have significant parameter estimates thus their variables are determinants of economic efficiency of the farmers. An average economic efficiency of 0.57 was obtained for the sampled farmers.

Ogunniyi, (2008) used translog stochastic profit function to examine profit efficiency of cocoyam production in Osun State, western Nigeria. He used data collected from120 cocoyam farmers, and the result of the analysis revealed an average profit efficiency of 12%. The results further revealed that accessibility to credit, family size, farm size and mulching were significant determinants of profit efficiency of cocoyam farmers in the region.

Awoyinka, (2009) examined the effect of Presidential Initiatives on Cassava (PIC) on productivity of cassava and technical efficiency in Oyo State, Nigeria. A stratified random sampling technique was used to select 290 farmers under PIC (RTEP and ADP) and non-PIC farmers and primary data were collected from them and analyzed with stochastic frontier function model. Farmers under PIC were found to be more technically efficient than non-PIC farmers, which confirmed that PIC programme positively enhanced cassava farmers' productivity and technical efficiency.

Oladeebo and Oluwaranti (2012) examined the profit efficiency in cassava production in South-western Nigeria. Their results showed that the mean level of profit efficiency was 79% which suggested that an estimated 21% loss in profit was due to a combination of both technical and allocative inefficiencies. The study further showed that household size and farm size were the major significant factors which positively influenced profit efficiency.

Empirical analysis of the profit efficiency among small-holder cocoyam farmers is imperative owing to the issue of food security, land use efficiency and resource allocation. This study therefore specifically investigated the profit efficiency of small-holder cocoyam farmers in Osun State, south-western Nigeria, using the normalized Cobb-Douglas stochastic profit function.

Materials and Methods

Study Area

The study was conducted in Osun State, SW Nigeria. The state is one of the 36 states in Nigeria and comprises 30 Local Government Areas. Osun State is one of the six states constituting the south-western geo-political zone of Nigeria. The state lies between latitude 7°30´N of the equator and longitude 4° 30´E of the Greenwich meridian on a land area of about 9,251km². The state shares boundaries with Kwara State in the North, Oyo State in the West, Ogun State in the South, and Ondo and Ekiti States in the East. Census (2006) reports revealed that population of Osun State stood at about 4.14 million people consisting mainly of the Yoruba ethnic group. There are two distinct geographical seasons in Osun State. These are the rainy season starting in late March and ending in October and the dry season from November to early March. The mean annual temperature varies between 21.1°C and 31.1°C. Annual rainfall ranges between 800mm in the derived savannah agro ecological zone to 1500mm in the rain forest zone (OSSADEP, 2004). Over 90 percent of the rural populace are involved in farming. The tropical climate in the area favours the growth of some varieties of annual crops, which include yam, cassava, cocoyam, maize, rice, cowpea, and perennial crops such as cocoa, kolanuts, plantain, and palm produce.

Sampling Techniques and Sample Size

Multistage and random sampling techniques were used to select 180 cocoyam farmers for the study. In stage one, three (3) ADP zones were purposefully selected for the study because cocoyam production was dominant in the areas. These ADP zones are Osogbo, Ife and Iwo. In stage two, two Local Government Areas were selected from each agricultural zone. The LGAs are Osogbo, Olorunda, Ife North, Ife South, Iwo and Isokan. In stage three, three (3) rural communities that are well known for cocoyam production were selected from each LGA making six communities from each agricultural zone. In stage four, a sample of 10 cocoyam farmers were randomly selected from each community and interviewed. Therefore, the sample was made up of 60 cocoyam farmers from each agricultural zone and a total of 180 cocoyam farmers from the state.

Data Collection

A well-structured questionnaire was used to collect data for this study in 2014 cropping season. Data collected were on the socio-economic characteristics of the farmers, cocoyam outputs for the season, amount of inputs used with their respective values. Data obtained were translated to standard units such as the total output measured in kilogram [kg], labour used in man-days, planting materials in kg, farm size in hectares, age of farmer in years, cost of labour in naira, cost of planting materials in naira and cost of farm tools in naira. Naira is Nigerian currency with ₦160 being the equivalent of a dollar.

Model Specification and Data Analysis

Stochastic Profit Function

The study analysed economic efficiency of farms derived from production frontier proposed by Farrell (1957). Economic or profit efficiency shows success of a given farm enterprise, as it indicates the ability of a farmer to obtain a maximum profit given a level of inputs and output prices including the level of fixed factors of production in the farm. From Farrell's analysis, a farm is economically efficient in resource use when it operates on the economic efficiency frontier. On the other hand, economic inefficient farmers operate below the efficiency frontier. The profit function model for the economic efficiency analysis is stated in the line with Nwachukwu and Onyenweaku (2007) as:

Profit efficiency function = $\pi = f\ (q_i, Z, exp\ \{v_i - u_i\}\ )$ ----------- --------------------(1)

Normalized Profit efficiency function= $\pi^* = \pi / P_y = f\ (q_i^*, Z, exp\ \{v_i - u_i\}\ )$

Where:

q_i = vector of variable inputs

Z = vector of fixed inputs

$exp\ \{v_i - u_i\}$ = exponent of composite error term

π^* = normalized profit of i[th] farmer
P_y = output price
q_i^* = normalized vector of variable inputs

The stochastic error term consists of two independent elements "v" and "u". The "v" component accounts for random errors in profit attributed to factors outside the farmer's control. The other element " u" is a one-sided component, $u \leq 0$ which reflects economic inefficiency as it relates to the frontier. When u = 0, it implies that farm profit lies on the efficiency frontier (i.e. 100% profit efficiency) and when u < 0, it implies that the farm profit lies below the efficiency frontier thus being inefficient. Both v and u are assumed to be independently and normally distributed with zero means and constant variances σ_v^2 and σ_u^2 respectively. Aigner, Lovell and Schmidt (1977) suggested that the maximum likelihood estimates of the parameters of the model be obtained in terms of parameterization, $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\lambda = \sigma_u / \sigma_v$ where λ is the ratio of the standard deviation of N(0, σ_u^2) distribution involved in specifying the distribution of the non-negative u_i's to the standard deviation of the symmetric errors, v_i's. Battese and Cora (1977) considered the parameter g = $\sigma_u^2 / (\sigma_v^2 + \sigma_v^2)$ which is equivalent to $\gamma = \sigma_u^2 / \sigma^2$, to be bounded between 0 and 1.

Thus economic efficiency index (EE) of an individual farmer is derived in terms of the ratio of the observed profit efficiency of the ith farmer to the corresponding frontier profit efficiency given the price of outputs, the price of the variable inputs and the level of fixed factors of production of the farmers.

$EE =$ (observed farm profit of the ith farmer) /(frontier farm profit of the ith farmer)

$$EE = f(q_i; Z) \exp(v_i - u_i) / f(q_i; Z) \exp(v_i) = \exp(-u_i) \quad \ldots\ldots\ldots \quad (2)$$

A stochastic Cobb-Douglas profit function was estimated in order to evaluate the economic efficiency of the cocoyam farmers. The choice of the model was based on the assumption of relatively constant elasticity of substitution among factors of production. This is based on the fact that the size of land available to smallholder cocoyam farmers are small and relatively constant over time. Hence factor shares are assumed to remain relatively unchanged irrespective of changes in factor prices.

Following Udoh, (2005) and Udoh and Sunday, (2007), a log-linear functional model of the stochastic frontier profit function was specified as :

$$Ln\,\pi^* = a_0 + a_1 Ln\,q_1^* + a_2 Ln\,q_2^* + a_3 Ln\,q_3^* + a_4 Ln\,q_4^* + a_5 Ln\,q_5 + v_i - u_i \quad \ldots\ldots\ldots\ldots(3)$$

Where: π_i^*= normalized profit of $i\,th$ farm

q_1^*= normalized average price of cocoyam setts (₦/kg)

q_2*= normalized average price of fertilizer (₦/ kg)
q_3* = normalized average price of labour (₦/manday)
q_4* = normalized average price of manure (₦/ kg)
q_5 = farm size (ha)
v_i and u_i are as earlier defined.

It is to be noted that output price (P_y) was used to normalize variables of π , q_1, q_2, q_3 and q_4 which are values in the model.

The economic efficiency model, m_i of small- holder cocoyam farmers was specified as:
$m_i = d_0 + d_1 AGE + d_2 GEN + d_{-3} EDU + d_4 CRED + d_5 EXP + d_6 HHS + d_7 EXTE + d_8 MSTAT + d_9 COOP + e_i$…….(4)
Where: m_i = efficiency index of the i^{th} farmer
AGE = farmer's age (year)
GEN = farmer's sex (1 for male and 0 for female)
EDU = level of education (years)
CRED = credit accessibility (1 for access and 0 for lack of access)
EXP = farming experience (years)
HHS = household size (number)
EXT = extension agents visit (Dummy variable, "1" for contact and "0" if no contact)
MSTAT =marital status (Dummy variable, "1" for married and "0" if otherwise)
COOP= membership of cooperative society (Dummy variable equals1 for membership and 0, if otherwise)

d_i's are model parameters to be estimated, i= 1, 2,......9
e_i = stochastic random errors assumed to be normally distributed with mean zero and a constant variance.

RESULTS AND DISCUSSION

Maximum likelihood estimates of the specified Cobb- Douglas stochastic profit function, (equation 3) is presented in Table I. The results revealed a sigma- square coefficient of 0.1749 that is statistically significant at 1% level. This indicates a good fit and correctness of the specified distribution assumption of the composite error term for the model. The variance ratio (g) is 0.9934 and its significant at 1% level. This means that about 99.34% of disturbance in the system is due to economic inefficiency. The value of the generalized likelihood ratio (LR) is 47.197 and it is highly significant. This confirms the presence of one sided error term in the specified model (Udoh *et al.*, 2001). This further validates the appropriateness of the specified stochastic model and the choice of maximum likelihood estimation technique..Coefficients of the variables in the estimated profit function exhibited expected negative signs for the prices of the inputs except the price of cocoyam sett. The results corroborate the findings of the previous works on similar issues but on other crops done by Ogundari (2006); Nwachukwu *et al.*, (2007); Akpan *et al.*, (2012) and Oladeebo and Oluwaranti, (2012) in other parts of Nigeria. The estimated profit function revealed that the price of fertilizer, wage rate, price of manure and farm size significantly influence the farm level profit of small-holder cocoyam farmers in the study area. The coefficients of price of fertilizer (-0.3915), wage rate (-0.2456) and price of manure (-0.6816) had negative significant values which corroborate their inverse relationship with farm profit. A ten percent increase in these factor prices will bring about a marginal decrease in farm profit by 3.91, 6.82 and 2.45 percent respectively. The slope coefficient of farm size of value 0.581 shows that the variable- farm size, has a positive significant relationship with the farm profit. This implies that one percent increase in farm size will also increase farm-level profit by 0.581 percent.

Table 1: MLE of Cobb-Douglas Stochastic Profit Function of Small holder Cocoyam-based Farmers.

Variable	Parameter	Coefficient	T-value
Constant	a_0	9.3460**	17.4480
Price of cocoyam setts	a_1	0.3509	1.5628
Price of fertilizer	a_2	-0.3915**	-3.9358
Price of labour	a_3	-0.2456**	-10.4132
Price of manure	a_4	-0.6816*	-1.9680
Farm size	a_5	0.5814**	9. 22401
Diagnostic statistics			
Sigma Square	$\sigma^2 = \sigma_v^2 + \sigma_u^2$	0.1749**	7.9852
Gamma	$g = \sigma_u^2 / \sigma^2$	0.9934**	125.1104
Log-likelihood	-191.33881		
LR Test	47.1974		

Asterisk * and ** represent 10% and 1% significance levels respectively.
Computer Analysis of Field Survey Data, 2014

Efficiency Model

The estimated coefficients of efficiency model are presented in Table 2. The results revealed that the estimated slope coefficients of the level of farmer's education (0.731), access to credit (0.1115) farming experience (0.5634), household size (0.3421), contact with extension agents (6890) and marital status (0.0104) are positive and statistically significant.. This means that, these variables are positive determinants of economic or profit efficiency of the small-holder cocoyam farmers in Osun State. The implication is that, increases in these variables aforementioned will result in increase in profit efficiency of small holder cocoyam famers. Ogundari (2007) obtained similar results for farming experience, Ogundari and Ojo (2007) for education, Nwachukwu et al (2007), for farming experience. The parameter of age though positive was not statistically significant, the positive sign however corroborates the fact that profit efficiency increases with the farmers' age. The estimated coefficients for gender (-0.0191) and membership of cooperative society (0.0123) were not statistically significant. The implication of the negative coefficient for gender is that women had higher profit efficiency than their men counterpart. The results buttress the fact that cocoyam farms are better managed by women. The coefficient of membership of cooperative society (0.0123) had the expected *a priori* positive sign but was not statistically significant..

Table 2: Efficiency Model of Small holder Cocoyam-based Farmers

Variable	Parameter	Coefficient	T-value
Constant	δ_0	3.1341***	10.8042
Age	δ_1	0 .03634	1.5628
Gender	δ_2	-0.0191	-1.3258
Education	δ_3	0.7310***	2.7132
Access to credit	δ_4	0.1115*	1.8124
Farming Experience	δ_5	0.5634***	2.9901
Household size	δ_6	0.3421**	2.2024
Extension contact	δ_7	0.6890**	1.9823
Marital status	δ_8	0.0104*	1.7634
Membership of Cooperative society	δ_9	0.0123	0.9235

Asterisk *, ** and *** represent 10%, 5% and 1% significance levels respectively.
Source: Field Survey Data analysis, 2014

Profit Efficiency Distribution

The distribution of respondents by efficiency class interval is presented in Table 3. The results revealed that the profit efficiency indices of the small -holder cocoyam farmers varied widely with a minimum of 0.0126, maximum of 0.9538 and an average value of 0.4488. The extent of variation in profit efficiency among the cocoyam farmers shows that a significant amount of cocoyam is not produced by the farmers because of economic inefficiency in the use of some specified farm resources. The least profit efficient small-holder cocoyam farmer needs an efficiency gain of 98.87% [i.e., {1.00 – (0.0126/0.9538)} x100 percent] in the use of specified farm resources if such farmer is to attain the profit efficiency of the best farmer in the region. Likewise, for an average efficient farmer, he will need an efficiency gain of 52.29% [i.e. {1.00 – (0.4488/0.9538)}x100 percent] to attain the level of the most efficient farmer. Also, the most profit efficient farmer in the study area needs about 4.62% [i.e (1.0- 0.9538)x100 percent] gain in economic efficiency to be on the profit frontier .

CONCLUSION

The study estimated profit efficiency and its determinants among smallholder cocoyam-based farmers in Osun State, south western region of Nigeria. Maximum likelihood estimates of the specified Cobb- Douglas profit function and economic efficiency model revealed that the individual farmer's efficiency varied between 0.0126 and 0.9538 with an average of 0.4488. The results revealed that farmers' profit efficiency deviated from the efficiency frontier. Therefore, the small holder cocoyam farmers' profit efficiency can be increased by 55.12 percent using the best technology available to them. Significant factors affecting profit efficiency of small-holder cocoyam farmers in the south-west region were farmer's education, farming experience, marital status, household size and contact with extension services.

The findings call for relevant farm-level policies aimed at promoting rural education through effective extension delivery program. This could be achieved by promoting adult education and extension services in the rural areas where the small-holder cocoyam farmers operate. The policy, if well implemented might increase agricultural innovation adoption among farmers in the state in particular and in Nigeria in general.. The long term benefit of such policy might be improved farm level profit which would encourage favourable resource allocation to cocoyam production and consequently better productivity, output, food security and poverty alleviation among the faming populace.

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