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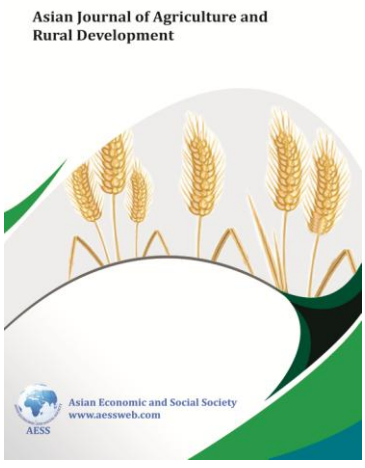

Stochastic Profit Efficiency of Homestead based Cassava Farmers in Southern Nigeria

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Abstract

The study used Cobb-Douglas stochastic profit function to estimate farm-level profit function, economic efficiency and it determinants among homestead based cassava farmers in the south-south region of Nigeria. Two-stage random sampling method was used to select 300 homestead based cassava farmers in the study area. Maximum likelihood estimates of the specified models reveal an average economic efficiency of 61.22%. The study also found that farmer's education, experience, household size, level of farming involvement, extension agent visit, soil management method adopted by farmers and farm size are significant factors affecting farm-level economic or profit efficiency in resource use among homestead based cassava farmers. Farm-level policies aimed at promoting farmer's education, extension services and family planning among farmers as well as reduction in production constraints was recommended.

Keywords: Cassava; homestead farming; efficiency; farmer; production

Introduction

The current increase in demand for staple food produce mostly attributed to the rapid population growth and increase in alternative land uses has prompted many urban and semi-urban households in Nigeria to cultivate vacant land areas around their homes (Etim *et al.*, 2005, Akpan and Aya, 2009 and Akpan *et al*, 2012)). Crops produced in the homestead farms are usually used to augment family food supply and income. With the population of over 140 million (NPC, 2006); there is an overwhelming need to increase agricultural production in the country. Given the current level of land use intensification in the country especially in the highly populated South–South region and the corresponding soil deterioration; homestead farming offered an alternative source of agricultural production especially among urban and semi-urban dwellers (Oyekale, 2007).

Cassava (*Manihot spp*) is one of the most popular food crops grown in the Southern part of Nigeria, specifically in the Niger Delta region (oil rich region of Nigeria). It is one of the widely consumed root crops in the country. Cassava root can be processed into granulated substance called "garri" that is consumed by almost every Nigerians. Cassava and its derivatives also has excellent potentials in livestock feed formulation, textile industry, plywood, paper, brewing, chemicals, pharmaceutical and bakery industries (Sanni *et al.*, 2008; Adebowale *et al.*, 2008). The leaves are edible while the root is a good source of ethanol and is rich in minerals, vitamins, starch and protein (Adegbola *et al.*, 1978; IITA, 1990; Smith, 1992; Ravindran, 1992). The crop is propagated by stem and usually planted in flat land, ridges or moulds (Okeke, 1989). Cassava is used to prepare tapioca which is a special delicacy that is widely consumed among the Efik's and Ibibio's tribes in the South-South Zone of Nigeria (Oyewole *et al.*, 2003; Adebowale *et al.*, 2008). Following the important of cassava to the Nigerian economy, the Presidential Initiative on Cassava Production in Nigeria was inaugurated in 1999 with the aim of achieving on annual basis five billion dollars from export of cassava (Presidential Initiative on Cassava Reports,

2003). Thus, with these, cassava production capacity needs to be increased such that rising demand will be met. One of the ways by which this could be achieved is to improve the profits accruing to the producers (Awoyinka, 2009).

Cassava production in the Southern region of Nigeria is characterized by the use of less productive tools and is affected by uncertainties of rain as well as other endogenous constraints inherent in arable crop production. Many aspects of cassava production activities like clearing, planting, weeding and harvesting are not mechanized thus labour intensive (Akpan and Essien, 2011). With the increasing rural – urban migration among young Nigerians (Wosu and Anele, 2010 and Afolabi, 2007), the relative scarcity of rural labour posed a serious restraint to cassava production in the area (Afolabi, 2007). The extent an individual farmer is able to cope with economic constraints in production in addition to the level of resource endowment and technology determined the level of investment in cassava production (Udoh and Sunday, 2007).

Homestead based cassava production arose as a complementary farming system especially for the urban and Peri-urban dwellers and involves planting cassava around residential homes. The advantage of the farming system lies on easy accessed to farm products at convenience as well as complementing family food supply and income. This practiced has been going on for ages among dwellers in the southern region of Nigeria. Since production is basically the process of allocating scare farm resources subject to production constraints to achieve economic goal like profit maximization; then it is right to assume that homestead based cassava farmers in the Southern Nigeria are constantly faced with the problem of farm resource allocation and usage. This implies that homestead based cassava farmers have being achieving various levels of economic efficiencies, which is presumed to be one of the major reasons for continuous cultivation of cassava around homes in the region. In an environment of highly unstable factors and output price of staple crops, couple with price elasticity of demand of crop outputs; some factors might influence homestead based cassava farm level objective of profit maximization given scare farm resources available to farmers in the region. What are these factors and the magnitude of their effect on farm level profit constitute the fundamental questions this study sought to answer. Empirical analysis of the profit efficiency among homestead based cassava farmers is imperative owing to the issue of food security and land use efficiency. Therefore, the study specifically estimates the normalized Cobb-Douglas stochastic profit function and economic efficiency function of homestead based cassava farmers in the southern Nigeria.

Stochastic Profit Function

The study is based on the analysis of economic efficiency of farms derived from production frontier proposed by Farrel (1957). Economic or profit efficiency shows success of a given farm enterprise, as it indicates the ability of a farm to obtain a maximum profit given a level of input and output prices including the level of fixed factors of production in the farm. From Farrel analysis, a farm is economically efficient in resource use when it operates on the economic efficiency frontier. On the other hand, economic inefficient farms operate below the efficiency frontier.

The profit function model for the economic efficiency analysis was described as follows (Nwachukwu and Onyenweaku, 2007):

$$\pi = {}^{\pi}/_{\rho} = f(q_i, Z)\, exp(V_i - U_I) \ldots\ldots\ldots (1)$$

Where
π = normalized profit of i_{th} farmer
q_i = vector of variable inputs
Z = vector of fixed inputs
ρ = output price
$exp(V_i - U_I)$ = composite error term

The stochastic error term consist of two independent elements "V" and "U". The element V account for random variations in profit attributed to factors outside the farmer's control. A one sided component $U \leq 0$ reflects economic efficiency relatives to the frontier. Thus, when U = 0, it implies that farm profit lies on the efficiency frontier (i.e. 100% economic efficiency) and when U < 0, it implies that the farm profit lies below the

efficiency frontier. Both V and U are assumed to be independently and normally distributed with zero means and constant variances. Thus economic efficiency of an individual farmer is derived in terms of the ratio of the observed profit to the corresponding frontier profit given the price of variable inputs and the level of fixed factors of production of farmers.

$$EE = \frac{observed\ farm\ profit\ for\ i_{th}\ farmer}{frontier\ farm\ profit\ for\ i_{th}\ farmer} = \frac{f(q_i; Z)\exp(V_i - U_i)}{f(q_i; Z)\exp(V_i)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$EE = \frac{\exp(V_i - U_i)}{\exp(V_i)} = exp(-U_i) \ldots\ldots\ldots (3)$$

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 shows that farmer's experience and accessed to credit are factors significantly affecting economic inefficiency of yam farmers. Ogundari, (2006) estimated Cobb-Douglas stochastic profit function for small scale rice farmers in Nigeria. His results reveal that farm size, price of labour, fertilizer price, price of agrochemical and farm tools are production inputs that is significantly affecting farm level profit. An average economic efficiency of 0.601 was discovered in the study. Also, Farmer's experience was identified as a major determinant of profit inefficiency of farmers. Awoniyi and Bolarin, 2007) study production efficiency of upland and wetland yam based enterprises in Ekiti State, Nigeria. The result shows an average economic efficiency of 0.80 for wetland farmers, while farm size and planting material significantly affected wetland farmer's 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 reveal that year of schooling, and accessed to credit significantly affected economic inefficiency of farmers. Nwachukwu *et al.*, (2007) applied translog stochastic profit function to measure efficiency of Fadama Telfairia production in Imo State, Nigeria. Their empirical results reveal that age, farming experience, farm size, membership of cooperative society and house hold size are significant determinants of economic efficiency of the farmers. An average economic efficiency of 0.57 was discovered for the sample farmers. Ogunniyi, (2008) used translog stochastic profit function to examine profit efficiency of cocoyam production in Osun State, western Nigeria. He used 120 cocoyam farmers for data collection, and the result of the analysis revealed an average profit efficiency of 12%. The results further reveal accessibility to credit, family size, farm size and mulching as 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 was used to collect primary data from 290 farmers under PIC (RTEP and ADP) and non-PIC farmers; and analyzed with stochastic frontier function model. Farmers under PIC are more technically efficient than non-PIC farmers, which confirm that PIC programme positively enhances cassava productivity and technical efficiency. Oladeebo and Oluwaranti, (2012) examined the profit efficiency in cassava production in Southwestern Nigeria. Results showed the mean level of profit efficiency of 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 influenced profit efficiency positively.

Materials and Methods

Study area Sampling Technique: The study was conducted in Calabar municipality and Odukpani Local Government areas of Cross River State. These areas are located in the southern part of Nigeria and fall within the humid tropics region; and have two distinct seasons (i.e. the dry and wet season). In this study, we defined homestead based cassava farmers as those farmers that cultivate cassava around their residential houses, either as sole or

mixed cropping. Two-stage random sampling method was adopted and a total of 300 homestead cassava farmers were used for the data collection. Data were collected with the aid of well structured questionnaires. Data collected include, price of production inputs, output price and area of cultivated land.

Empirical model: A linearized stochastic Cobb-Douglas profit function was used to estimate the economic efficiency of 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 sizes of land available to homestead based cassava farmers are small and relatively constant over time. Hence factor shares are assumed to remain relatively unchanged irrespective of changes in factor prices. Following Syed and Kalirajan, (2000), Udoh and Sunday, (2007) and Udoh, (2005) we specify a log-linear functional model of the stochastic frontier profit function as follows.

$$Ln\pi^{*} = a_0 + a_1 Lnq^{*1} + a_2 Lnq^{*2} + a_3 Lnq^{*3} + a_4 Lnq^{*4} + a_5 Lnq_5 + V_i - U_i \ \ldots\ldots\ldots\ldots (4)$$

Where
π_i^*= normalized profit of i_{th} farm
q^{*1}= normalized average price of cassava bundle (₦/kg) $\delta\pi/\delta\, q^{*1} < 0$
q^{*2}= normalized average price of fertilizer (₦/kg) $\delta\pi/\delta\, q^{*2} < 0$
q^{*3} = normalized average price of labour (₦/Manday) $\delta\pi/\delta\, q^{*3} < 0$
q^{*4} = normalized average price of manure (₦/kg) $\partial\delta\pi/\delta\, q^{*4} < 0$
q_5 = area of land cultivated (ha)
Note: Output price was used to normalize variables in the analysis.

The determinant of economic efficiency of homestead based cassava farmers was specified as follows:

$$\mu = \gamma_0 + \gamma_1 AGE + \gamma_2 GEN + \gamma_3 INVOL + \gamma_4 EDU + \gamma_5 CRED + \gamma_6 RAINF + \gamma_7 EXP + \gamma_8 HHS + \gamma_9 SMGT + \gamma_{10} EXTE + \gamma_{11} FSIZE + V_i \ \ldots\ldots\ldots\ldots (5)$$

Where
μ = efficiency of i_{th} farmer
AGE = farmer's age (year)
GEN = farmer's sex (1 for male and 0 for female)
INV = level of involvement in farming (0 for part time, 1 for full-time)
EDU = level of education (year)
CRE = credit accessibility (1 for accessed and 0 for non-accessed)
RAI = ability to predict rainfall (1 for yes, 0 for no)
EXP = farming experience (year)
HHS = household size (number)
SMG = soil Management technique (1 for mould, 0 for zero mould)
EXT = extension agents visit (number of times)
FSI = farm size (ha)
V_i = stochastic error term

Equation (4) and (5) were jointly estimated by maximizing the likelihood function using the computer program frontier version 4.1MLE (Coelli, 1994)

Results and Discussion

Maximum Likelihood estimates: Maximum likelihood estimates of the specified Cobb-Douglas stochastic profit function (Table I) revealed a sigma square coefficient of 0.1204 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 (λ) of 0.9167 is significant at 1% level. This means that about 91.67% of disturbance in the system is due to economic inefficiently while 8.33% is due to normal stochastic error. The value of the generalized likelihood ratio (LR) of 70.3268 is highly significant. This confirms the presence of one sided error term in the specified model (Yao and Liu, 1998 Udoh *et al.,* 2001). Thus this further validates the appropriateness of the specified stochastic model and the choice of maximum likelihood estimation.

Table 1: ML estimates of Cobb-Douglas stochastic profit function of home stead cassava farmers in Cross River State

Variable	Parameter	Coefficient	Std. error	t-value
Constant	α_0	0.2772	0.1779	1.558
Price of cassava bundle	α_1	-0.1544	0.0473	-3.264***
Price of fertilizer	α_2	-0.1718	0.0899	-1.911*
Price if manure	α_3	-0.3091	0.0677	-4.566***
Price of labour	α_4	-0.2039	0.0675	-3.021***
Area of land	α_5	0.5947	0.0622	9.561***
Diagnostic statistics				
Sigma Square	∂^2	0.1204	0.0429	2.807***
Gamma	λ	0.9167	0.0360	25.464***
Log-likelihood	- 0.5128			
LR Test	70.3268			

Note: Asterisk *, ** and *** represent 10%, 5% and 1% significance levels respectively. Variables are as defined in equations (4).

Coefficient of variables in the estimated profit function exhibited expected signs. The results corroborate the findings of the previous works on similar issues done by Ogundari (2006); Nwachukwu *et al.,* (2007); Ogunniy, (2008) and Oladeebo and Oluwaranti, (2012) in other parts of Nigeria. The estimated function reveals that price of fertilizer, price of manure; wage rate and farm area significantly affected the farm level profit of homestead cassava farmers in the study area. The coefficient of fertilizer price (-0.1718), manure price (-0.3091) and wage rate (-0.2039) has negative significant relationship with farm profit. Ten percent or ten naira increase in these factor prices will bring about a marginal decrease in farm profit of 1.72, 3.10 and 2.04 naira respectively. The slope coefficient of farm size (0.5947) shows that the variable has a positive significant relationship with the farm profit. This implies that a unit increase in farm size will also increase farm-level profit by ₦0.5947.

Efficiency model

The estimated coefficients of efficiency model are presented in Table 2. The result reveals that the slope coefficient of the level of farmer's involvement in cassava production (0.2409), farmer's education (0.8532), farmer's experience (0.6069), soil management technique (0.6031), extension agent visit (0.1499) and farm size (0.9713) are positive and statistically significant. This means that, these variables are positive determinants of economic or profit efficiency of homestead based cassava farmers in the Southern Cross River State. The implication is that, increase in these aforementioned variables will result to increase in profit efficiency of homestead based cassava farmers. Ogundari, (2007) obtained similar results for farming experience; Awoniyi *et al.,* (2007) for farm size; Ogundari and Ojo, (2007) for education; Nwachukwu *et al.,* (2007) for experience and farm size and Ogunniyi, (2008) for farm size, soil management practice and Oladeebo and Oluwaranti, (2012) for farm size.

Table 2: Efficiency model of Homestead based cassava farmers in Southern Cross River State

Variable	Parameter	Coefficient	Std. error	t-value
Constant	γ_0	0.6469	0.1286	5.030***
Age	γ_1	0.2157	0.6041	0.357
Sex	γ_2	0.1081	0.8626	0.125
Level of farming involvement	γ_3	0.2409	0.1012	2.380**
Education	γ_4	0.8532	0.2881	2.961***
Credit	γ_5	-0.4164	0.9357	-0.445
Ability to predict rainfall	γ_6	-0.5847	0.9389	-0.623
Farming experience	γ_7	0.6069	0.2820	2.152**
Household size	γ_8	-0.9112	0.4137	-2.203**

Soil management technique	γ_9	0.6031	0.3564	1.692*
Extension agent visit	γ_{10}	0.1499	0.0902	1.661*
Farm size	γ_{11}	0.9713	0.2392	4.061***

Note: Asterisk *, ** and ** represent 10%, 5% and 1% significance levels respectively. Variables are as defined in equations (5).

On the other hand, the coefficient of household size (-0.9112) has a negative significant impact on economic efficiency of homestead based cassava farmers. An increase in the farmer's household size could exert considerable pressure on the relatively finite land area meant for cassava cultivation, as part or whole might be converted to alternative land uses (Ogunniyi, 2008). This would reduce available land for cassava cultivation. Hence economic efficiency of the farmer will be reduced as good proportion of revenue will be lost. Also, increased family size could increase the quantity of farm produce consume by the family in addition to increase family consumption expenditure. All these factors tend to reduce farmer's income, farm investment and eventually economic efficiency in farm resource utilization.

From the analysis of economic efficiency model, it could be infer that increase in household size, ability to predict rainfall pattern, and credit accessibility increase economic inefficiency among homestead based cassava farmers in the study area; while increase in other variables in the model reduce economic inefficiency.

Economic Efficiency Distribution

The distribution of respondents according to efficiency class interval, frequency and percentage of each class interval is described in Table 3.

Table 3: Frequency distribution of Economic Efficiency Indices of Homestead Cassava Farmers in Cross River State

Efficiency class	Frequency	Percentage
0.001 – 0.10	10	3.33
0.101 – 0.20	20	6.67
0.201 – 0.30	15	5.00
0.301 – 0.40	20	6.67
0.401 – 0.50	15	5.00
0.501 – 0.60	30	10.00
0.601 – 0.70	55	18.33
0.701 – 0.80	55	18.33
0.801 – 0.90	60	20.00
0.901 – 1.00	20	6.67
Total	**300**	**100.00**
Minimum economic efficiency	0.0429	
Maximum economic efficiency	0.9380	
Mean economic efficiency	0.6122	

Source: Computed from output generated from frontier 4.1 MLE.

Table 3, reports the frequency distribution of economic efficiency indices of homestead cassava farmers in southern Cross River state. Homestead based cassava farmers showed varied economic efficiencies ranging from the lowest 0.0429 to the highest 0.9380 with an average of 0.6122. The extent of variation in economic efficiency among farmers shows that a significant proportion of cassava is not produced by the farmers because of economic inefficiency in the used of the specified farm resources. About 3.33% of farmers were very far from the efficiency frontier, while 6.67% of farmers were much closed o the efficiency frontier. However, the least economic efficient homestead based cassava farmer needs an efficiency gain of 95.43% (i.e., 1.00 – 0.0429/0.9380)100 in the use of specified farm

resources if such farmer is to attain the economic efficiency of the best farmer in the region. Likewise for an average efficient farmer, he will need an efficiency gain of 34.73% (i.e., 1.00 – 0.6122/0.9380)100 to attain the level of the most efficient farmer. Also, the most economic efficient farmer in the study area needs about 6.20% gains in economic efficiency to be on the frontier efficiency.

Conclusion

The study estimated economic efficiency and it determinants among homestead based cassava farmers in South- South region of Nigeria. Maximum likelihood estimates of the specify Cobb- Douglas profit function and economic efficiency model reveal that individual farmer's efficiency varied from 0.0429 to 0.9380 with an average of 0.6122. The results further revealed that farmer's economic efficiency has not reached the efficiency frontier. Therefore, homestead cassava farmers' economic efficiency can still be increased by 38.8% using the best technology available to them. Significant factors affecting economic efficiency of homestead based cassava farmers in the south-south region are farmer's education, experience, household size, soil management technique adopted, extension agent visit, level of farming involvement and farm size.

The findings call for relevant farm-level policies aims at promoting rural education through effective extension delivery program. This could be achieved by imposing free and compulsory education to the citizenry. The policy, if well implemented might increase agricultural innovation adoption among farmers in the region. On the other hand, increase household size reduced profit efficiency of homestead cassava farmers in the region; as such there is need to increase public awareness on the, on-going family planning programme in the country and also incorporates into school curriculum, the basic techniques of birth control. The long term benefit of such policy might be positively related to farm level profit efficiency. The findings also indicate the need to intensify research on appropriate soil improvement techniques suitable for less productive land in the region; as such strategy will push the farmer's efficiency nearer to the frontier efficiency. Finally, the review of the land use Act of 1990 may be imperative to ease difficulties associated with land acquisition for agricultural production in the area. If farmers have more accessed to agriculture land, their efficiencies would increase as well as the productivity which is the major objective of the federal government agricultural policy.

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