A TRANSLOG STOCHASTIC FRONTIER ANALYSIS OF PLOT SIZE AND COST INEFFICIENCY AMONG SMALLHOLDER CASSAVA FARMERS IN SOUTH-EAST AGRO-ECOLOGICAL ZONE OF NIGERIA

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ABSTRACT
A stochastic frontier translog cost function model was used to measure the level of cost efficiency and its determinants in small-holder cassava production in South-east Agro-Ecological Zone, Nigeria. A multi-stage random sampling technique was used to select 320 cassava farmers in 2008. The parameters of the stochastic frontier cost function were estimated using the maximum likelihood method. The result of the analysis shows that individual farm level cost efficiency was about 69%. The study found age and farm size to be negatively and significantly related to cost efficiency at 1.0%. Farming experience and membership of cooperative societies had a positive relationship with cost efficiency. There is need for policies aimed at encouraging the youths who are agile and stronger as well as the experienced to increase production. Land re-distribution policies are advocated to make lands available to the small-holder farmers who form the bulk of the farming population.

KEYWORDS: Translog stochastic frontier, plot size, cost inefficiency.

INTRODUCTION

Improvement in the efficiency of agricultural production, including productivity growth, is an essential component of any rural growth strategy. In sub-Saharan Africa, where price-based adjustment policies have not led to broad-based economic growth, gain in the efficiency of agricultural production is viewed as necessary for economic growth and the alleviation of rural poverty (Hazarika and Alwang, 2003).

Since Farrell's original work in 1957, the frontier methodology has become a widely used tool in applied production analysis, due mainly to its consistency with the textbook definition of a production, profit or cost function (i.e. with the notion of maximization or minimization) (Thiam et al., 2001). This popularity is evidenced by the proliferation of methodological and empirical frontier studies over the last two decades.

Cost efficiency results from both technical efficiency and allocative efficiency. Technical efficiency refers to a producer's ability to obtain the highest possible output from a quantity of inputs (Onyenweaku and Okoye, 2007). Consider a unit isoquant with capital and labour as the inputs. Allocative efficiency refers to a producer's ability to maximise profit given technical efficiency (Okoye et al., 2007). A producer may be technically efficient but allocatively inefficient. For example, a producer in the preceding paragraph may put forth a unit of output using a combination of capital and land that lies on the unit isoquant but that is more expensive than a different combination of inputs on the isoquant. The cheapest input combination would, of course, be the point of tangency between an isocost line and the unit isoquant. Allocative efficiency also refers to the ability to produce a given level of output using cost-minimising input ratios (Hazarika and Alwang, 2003).

In most small holder production there is dichotomy between the farm house holder and the food crop farm. According to Ajibefun and Aderinola (2004), small holder food producers face two major types of risks and uncertainties-yield (output) and price uncertainties. The former has to do with the environment and the nature of agricultural production while the latter is linked partly with seasonality of production and partly infrastructural facilities and government policies. Technical and allocative efficiencies are necessary, and when they occur together, are sufficient conditions for achieving economic efficiency (Lau and Yotopoulous, 1971).

The problem of economic efficiency in the utilization of resources has been the greatest concern of production economists (Awoke and Okorji, 2003). Efficient utilization of productive resources may be affected by factors such as government policies, customs and institutions or cultural configuration, cost structures, resource management, ownership patterns, resource administration and services (Upton, 1976; Nweke, 1979). According to Ogunfowara and Olayide (1981), resources are not efficiently utilized or allocated under the small scale farming which is mainly traditional in style, empirical studies by Onyenweaku et al (2000) gave a similar picture. Lau and Yotopoulos (1971), Hazarika and Alwang (2003), Okoye and Onyenweaku (2007) found out that smaller farms were economically more efficient than larger farms within the range of output studied.

The study is a Translog Stochastic Frontier Analysis of Plot Size and Cost Inefficiency among Smallholder Cassava Farmers in South-South Nigeria. Several studies, from both developing and developed countries, have used the CobbDouglas functional form to analyse farm efficiency despite its well-known limitations (Battese, 1992; Bravo-Ureta and Pinheiro, 1993). Koop and Smith (1980) concluded that functional form has a discernible impact on estimated efficiency. Ahmad and Bravo-Ureta (1996) rejected the CobbDouglas functional form in favour of a simplified translog form. For the cost function to be Cobb Douglas, the coefficients of all the second order terms should be zero. The rejection of this hypothesis in the translog function is a confirmation of the fact that the translog function is more suitable for the data and model specification than the Cobb Douglas (Onyenweaku and Okoye, 2007).

METHODOLOGY

The Econometric Model

The stochastic cost function is based on the composed error model (e.g. Aigner et al., 1977):

$$InC_i = \alpha_0 + \alpha InQ_i + \sum^{n}_{j=1}\alpha_j In\, P_{ij} + \varepsilon_i \qquad i = 1, 2 \ldots n \text{---------------------------------} \quad (1)$$

Where,

C_i = Represents the minimum cost associated with cassava production

P_{ij} = Price of variable input

Q_i = Cassava output adjusted for statistical noise

α = Vector of parameters

ε_i = Composite error term consisting of two independent variables as follows:

$$\varepsilon_i = V_i + U_i \text{---} (2)$$

Vi, assumed to be independently and identically distributed as $N(0, \sigma^2_V)$, represents random variation in cost per hectare due to extraneous factors such as the weather and crop diseases. The term Ui is taken to represent cost inefficiency relative to the stochastic cost frontier, $\alpha_0 + \alpha InQ_i + \sum^{n}_{j=1}\alpha_j In\, P_{ij} + V_i$ It is, therefore, one-sided as opposed to being symmetrically distributed about the origin. In other words, Ui = 0 if costs are, ceteris paribus, as low as can be, and Ui > 0 if cost efficiency is imperfect. Ui is assumed to be identically and independently distributed as truncations (at 0) of the normal distribution $N(\mu, \sigma^2_U)$. The stochastic cost function (1) may be estimated by maximum-likelihood. Given the above distributional assumptions,

$$E\,(U_i/\varepsilon_i) = \sigma\lambda\,/[1 + \lambda^2)\,(\o(\mu^*_i)/1 - \Phi(\mu^*_i) - \mu^*_i] \text{---}(3)$$

Where ø and Φ denote, respectively, the standard normal probability density function and the standard normal cumulative density function, $\lambda = \sigma U/\sigma V$,

$\sigma = \sqrt{\sigma^2_U + \sigma^2}$, and $\mu^*_i = (\varepsilon_i\lambda/\sigma) + (\mu/\sigma\lambda)$. Replacing ε_i in the above expression by the regression residual and the other parameters by their ML estimates yields an estimate, Ui, of farm-specific cost inefficiency (Jondrow et al., 1982).

Next, the equation,

$$Ui = Ai\gamma_1 + Xi\gamma_2 + ei \text{---} (4)$$

is estimated simultaneously with (1), where Ai denotes household i's cassava acreage, variables Xi consist of other farm and household characteristics, and ei denotes the regression error.

The Empirical Model

In this study, the economic efficiency was measured using stochastic translog cost frontier function for cassava production. The function is specified as follows:

$$\mathrm{Ln}\, C_i = \alpha_0 + \alpha_1 \mathrm{Ln}\, P_1 + \alpha_2 \mathrm{Ln}\, P_2 + \alpha_3 \mathrm{Ln}\, P_3 + \alpha_4 \mathrm{Ln}\, P_4 + \alpha_5 \mathrm{Ln}\, P_5 + \alpha_6 \mathrm{In}\, Q_6 + 0.5\alpha_7 \mathrm{In}\, P_1^2 + 0.5\alpha_8 \mathrm{In}\, P_2^2 + 0.5\alpha_9 \mathrm{In}\, P_3^2 + 0.5\alpha_{10} \mathrm{In}\, P_4^2 + 0.5\alpha_{11} \mathrm{Ln}\, P_5^2 + 0.5\alpha_{12} \mathrm{Ln}\, Q_6^2 + \alpha_{13} \mathrm{Ln}\, P_1 \mathrm{In}\, P_2 + \alpha_{14} \mathrm{Ln}\, P_1 \mathrm{Ln}\, P_3 + \alpha_{15} \mathrm{In}\, P_1 \mathrm{Ln}\, P_4 + \alpha_{16} \mathrm{Ln}\, P_1 \mathrm{Ln}\, P_5 + \alpha_{17} \mathrm{Ln}\, P_1 \mathrm{Ln}\, Q_6 + \alpha_{18} \mathrm{Ln}\, P_2 \mathrm{Ln}\, P_3 + \alpha_{19} \mathrm{Ln}\, P_2 \mathrm{Ln}\, P_4 + \alpha_{20} \mathrm{Ln}\, P_2 \mathrm{Ln}\, P_5 + \alpha_{21} \mathrm{Ln}\, P_2 \mathrm{Ln}\, Q_6 + \alpha_{22} \mathrm{Ln}\, P_3 \mathrm{Ln}\, P_4 + \alpha_{23} \mathrm{Ln}\, P_3 \mathrm{Ln}\, P_5 + \alpha_{24} \mathrm{Ln}\, P_3 \mathrm{Ln}\, Q_{6+} \alpha_{25} \mathrm{Ln} P_4 \mathrm{Ln}\, P_5 + \alpha_{26} \mathrm{Ln} P_4 \mathrm{Ln} Q_6 + \alpha_{27} \mathrm{Ln}_5 P \mathrm{Ln} Y_6 + V_i U_i \quad (5)$$

Where $\mathrm{Ln}C_i$ represents the minimum cost associated with cassava production P_1 is average daily wage rate per manday, P_2 is price of fertilizer per kg, P_3 is land rent in naira per hectare, P_4 is price of planting materials in naira per kg, P_5 is capital input in naira made up of depreciation charges on farm tools and equipment, interest on borrowed capital and rent on land, Q is output of cassava in kg adjusted for statistical noise, $\alpha_0\ \alpha_1\ \alpha_2 \ldots\ \alpha_{27}$ are regression parameters to be estimated while Vi and Ui are as defined earlier.

Determinants of Cost Inefficiency

In order to determine factors contributing to the observed cost inefficiency in cassava production, the following model was formulated and estimated jointly with the stochastic frontier model in a single stage maximum likelihood estimation procedure using the computer software Frontier Version 4.1 (Coelli, 1995).

$$CEi := ao + a_1Z_1 + a_2Z_2 + a_3Z_3 + a_4Z_4 + a_5Z_5 + a_6Z_6 + a_7Z_7 + a_8Z_8 + a_9Z_9 \quad (6)$$

Where CEi, is the cost inefficiency of the i-th farmer; Z_1 is farmers age in years; Z_2 is farmers level of education in years; Z_3 is contact with extension in numbers; Z_4 is farmer's farming experience in years; Z_5 is farm size in hectares; Z_6 is credit access, a dummy variable which takes the value of unity if the farmer has access to credit and zero otherwise; Z_7 is membership of farmers associations/cooperative societies, a dummy variable which takes the value of unity for members and zero otherwise; Z_8 is family size; while $a_0, a_1, a_2 \ldots a_8$ are regression parameters to be estimated.

The Data

The study was carried out in the Abia, Imo, Cross-River and Akwa-Ibom States in the South-East Agro-Ecological Zone of Nigeria using a multi-stage randomized sampling technique. At the first stage, two agricultural zones were randomly selected in each state, giving a total of 8 zones for the study. At the second stage, 2 Local Governments were randomly selected in each Zone giving a total of 16 LGA's. At the third stage, two communities were randomly selected in each LGA giving a total of 32 communities. At the fourth stage 10 farmers were randomly selected from each community, giving a total of 320 respondents for detailed study. Data were collected by means of well structured questionnaires on their production activities in terms of inputs, output and their prices for the year 2008.

RESULTS AND DISCUSSION

Estimated Production Function

The Maximum Likelihood (ML) estimates of the translog stochastic frontier cost parameters for cassava in the South-East Ecological Zone of Nigeria are presented in Table 1. The coefficients of wage rate, price of fertilizer, land rent and price of cassava bundles have a direct relationship with the total cost of production as expected and are highly significant at 1% level of probability. This implies that any increase in any of these variables would lead to an increase in total cost of production. The coefficient for capital and adjusted output was positive and negative respectively but was not significant but not statistically significant even at 10% level. Most of the interaction terms were significant. For the cost function to be Cobb Douglas, the coefficients of all the second order terms would be zero. The rejection of this hypothesis in the translog function is a confirmation of the fact that the translog function is more suitable for the data and model specification than the Cobb Douglas

(Onyenweaku and Okoye, 2007).

The estimated variance (^{2}) is statistically significant at 44% indicating goodness of fit and the correctness of the specified distribution assumptions of the composite error term. Gamma () is estimated at 0.5036 and is statistically significant at 1% indicating that 50.36% of the total variation in cocoyam output is due to cost inefficiency.

Table 1: Estimated Translog Stochastic Frontier Cost Function for Cassava in South-East Ecological Zone of Nigeria, Nigeria.

Production Factors	Parameter	Coefficient	Standard Error	t-value
Constant Term	α_0	26.2658	0.9829	26.7216***
Wage rate	α_1	6.4475	0.9297	6.93487***
Price of fertilizer	α_2	9.4372	0.8763	10.7688***
Land rent	α_3	4.5542	0.8521	5.34453***
Price of cassava bundles	α_4	6.0631	0.7430	8.16006***
Depreciation on tools	α_5	0.3983	0.6570	0.60630
Output (Q)	α_6	-0.4312	0.2903	-1.4854
Wage rate^2	α_7	0.8797	0.2458	3.5777***
Price of fertilizer^2	α_8	-1.4093	0.2453	5.743***
Land rent^2	α_9	-1.4081	3.3347	-0.4222
Price of bundles^2	α_{10}	0.1340	0.0181	7.4040***
Depreciation^2	α_{11}	1.5501	0.2560	6.0531***
Output(Q)^2	α_{12}	0.3980	0.1775	2.2413**
Wage rate x Price of fertilizer	α_{13}	1.5724	0.1785	8.8091***
Wage rate x land rent	α_{14}	0.9778	0.1663	5.8771***
Wage rate x price of bundles	α_{15}	2.4820	0.2503	9.9136***
Wage rate x Depreciation	α_{16}	-1.3770	0.1386	-9.9321***
Wage rate x Output (Q)	α_{17}	0.1150	0.1342	0.8564
Price of fertilizer x land rent	α_{18}	0.1316	0.1011	1.3007
Price of fertilizer x Price of bundles	α_{19}	-0.0342	0.1135	0.3018
Price of fertilizer x Depreciation	α_{20}	-0.0528	0.0734	0.7194
Price of fertilizer x Output (Q)	α_{21}	-0.0656	0.0193	3.4029***
Land rent x Price of bundles	α_{22}	-1.7306	0.5950	2.9083***
Land rent x Depreciation	α_{23}	-0.1139	0.2572	-0.4429
Land rent x Output (Q)	α_{24}	1.5905	0.2626	6.0555***
Price of bundles x Depreciation	α_{25}	0.4685	0.3652	1.2827
Price of bundles x Output (Q)	α_{26}	2.5025	0.5816	4.3028***
Depreciation x output (Q)	α_{27}	-0.8799	0.3240	2.7151***
Diagnostic statistics				
Log – likelihood function		0.4416		
Total Variance	(σ)	0.5036	0.0041	10.6353***
Variance Ratio	(γ)	0.3161	0.1730	2.9110***
LR Test				
Cost Inefficiency				

Source: Computed from frontier 4.1 MLE results/Surveys data, 2008, * and ** are significant levels at 1.0% and 5.0%.**

Sources of Cost Inefficiency

The estimated determinants of cost inefficiency in cassava production are presented in Table 2. the data shows that age and farm size had a negative and significant effect on efficiency, which agrees with a priori expectation at 1.0% level of probability. This implies that increase in age farm size would lead to increase in cost inefficiency. This confirms Yotopoulous and Lau (1973) and Okoye and Onyenweaku (2007) who found out that commercial farms could become significantly more efficient if they become smaller. The older a farmer becomes, the more he or she is able to combine his or her resources in an optimal manner given the available technology (Idiong, 2005) and Okoye and Onyenweaku (ibid). The coefficient for farm experience and membership of cooperative societies had a positive influence on cost inefficiency. This implies that increase in these coefficients would lead to decrease in cost inefficiency. Members of farmers' associations or cooperative societies have more access to agricultural information and other production inputs. Farmers who have long years of farming experience tend to combine their resources better in an optimal manner. The coefficients for education and family size were negative but not significant. The coefficient for credit access was positive but also not significant.

Table 6: Maximum likelihood Estimates of the Determinants of Cost Inefficiency in Cassava Production.

Variable	Coefficient	Standard Error	t-value
Constant Term	0.8529	0.3015	2.8290***
Age	-0.0216	0.0060	-3.5529***
Education	-0.0008	0.0069	-0.1186
Extension Visit	0.0727	0.0098	7.3570***
Farm Experience	0.0152	0.0087	1.7467*
Farm Size	-0.4491	0.0221	-20.2875***
Credit Access	0.2198	0.2114	1.0394
Membership if Crop	0.1265	0.0588	2.1492*
Family size	-0.0047	0.0478	-0.0996

CONCLUSION

The study has indicated that cost inefficiency in the study area was 31%. The farmers were 69% cost efficient. This inefficiency requires considerable potential for enhanced profitability by reducing costs through improved efficiency. Important factors indirectly related to cost efficiency are age and farm size. Other factors were, credit access and farm size which were directly related to cost efficiency. These results call for policies aimed at encouraging new entrants especially the youths to cultivate cassava and the experienced ones to remain in farming. Policies in terms of land re-distribution should be targeted at the small-holder farmers.

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