DETERMINANTS OF TECHNICAL EFFICIENCY IN GARI PROCESSING IN DELTA STATE NIGERIA

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ABSTRACT

In order to determine the technical efficiency of Gari processing in Delta State, Nigeria, panel data were collected over 6 months period from 100 processors, using multi – stage random sampling technique. A translog stochastic frontier model incorporating inefficiency effects was employed to analyse the data, using the computer program FRONTIER 4.1 developed by [6]. The results indicate that there is a wide variation in the level of technical efficiency in Gari processing, ranging from 25% to 88%, with a mean efficiency level of 65%. The technical inefficiency level of processors is attributed to socio – economic characteristics including age of processor, family size, level of formal education, access to production credit, availability of alternative sources of income and membership of Gari Processing Associations. The inefficiency of individual processors was negatively related to all factors and were statistically significant ($P < 0.05$), except age of processor.

Key words: Gari processing, Technical efficiency, Translog Frontier production function, Socio-economic factors.

INTRODUCTION

The importance of cassava in bridging the food gap in Nigeria cannot be overemphasised. It is reputed for being a hardy crop, producing economic yields under conditions of drought, low soil fertility, locust attack, poor husbandry and other adverse production conditions, where other crops cannot survive [1, 8, ; 12; 24; 16; 9; 10; 14; 20]. As a result of its hardiness and high food producing potentials, the crop has assumed a place of prominence among other staple food crops in West Africa in general and Nigeria in particular. It is the most paramount staple, food – security crop in the Sub – Saharan Africa and a mainstay of the rural and increasingly also the urban population [9]. Famine rarely occurs in a community where cassava is widely grown, because in some places they are harvested continuously through out the year, thus tidying farmers over hungry seasons after other crops have been planted but are not yet mature [8; 16; 12]. Cassava appeals to low income households because it offers the cheapest source of food calories. Compared with grains, fresh and dried cassava roots are very cheap sources of calories.

Cassava food products followed by yams are the most important staples of rural and urban households in southern Nigeria both in terms of food and cash income generation. In terms of cash income generation, [18] reported the percentage contribution to cash income of food crop producing households in Southern Nigeria, which indicate that cassava ranks highest among all food crops (see Figure 1).Yam consumption in most of the south is seasonal, being highest in the months of November to January, the period of harvest. Thereafter, cassava products and other supplementary foods take over. Calories are significantly cheaper from fresh roots of sweet cassava varieties than from maize in various rural village market centers in Nigeria. Similarly, calories derived from dried cassava roots are significantly cheaper than when they are derived from maize in various rural market centers in Ghana [17].

Nigeria ranks first among cassava producing nations of the world, with annual output of about 34 million tonnes of the root crop, which is mainly for local consumption of which gari (granular form) accounts for about 70% of total demand [9; 19]. It is increasingly becoming a commercial activity, the processing of which generates income and employment for the rural populace and urban petty – traders as well as foreign exchange for the nation in general [1; 8; 10; 20]. According to [16], cassava generates about 25% of cash income from all food crops grown, constituting the most important single source of cash income. Of recent, following the interest of foreign nations in buying cassava products from Nigeria, the prospects for enhanced foreign exchange earnings from their export is becoming a significant high.

To realise this goal of earning reasonable amount of foreign exchange through the export of cassava, the difference between the total output of cassava tubers and its domestic demand for food, has to be significantly high. This can be achieved mainly in two ways. The first being that output has to increase through expansion of the hectarage under cultivation and better management practices. Secondly and perhaps most importantly, the extent to which gari processors are technically efficient, will determine how much of the cassava tubers will be left for export and other uses. This is because gari constitutes over 70% of the consumable processed form cassava in Nigeria. It is the most common form in which cassava is consumed and marketed [7; 15]. Gari, a local staple, is a convenient product, being stored and marketed in a form in which it is ready to eat. It can be soaked in hot or cold water depending on the type of meal being prepared. Gari has a long shelf-life, a year or more as long as it is not exposed to moisture, it is therefore attractive to urban consumers [17]. Gari appeals mainly to low income households because it offers the cheapest source of food calories compared to grains.

To make gari, cassava roots are peeled, grated, fermented and drained of effluent, then toasted in a pan over an open fire. Nearly all the gari is produced by women, and a lot of rural women spend a great deal of their time producing it with the traditional manual methods. The value added and the marketing margin shared by the processors are the major inducements into gari processing.

The marketing margin shared by processors is to a great extent affected by the how technically efficient they are. While some studies have been made on efficiency of gari processing in general [18], not much of such studies have been specifically made to establish the degree of technical efficiency of the gari processors particularly in Delta State. It is to this end that this study was undertaken with the view to examine the economics of gari processing, with focus on the level of and factors affecting the technical efficiency of the system in Delta State, Nigeria. The knowledge gained from such study will serve as useful guidelines in policy formulation.

METHODOLOGY

In order to estimate and analyse the technical efficiency of gari processors, the Stochastic Frontier analysis (SFA) was used. It is an econometric analytical technique, which allows for variation in output of individual producer from the frontier of maximum achievable level to be accounted for by factors which cannot be controlled by the firm.

The concept of efficiency flows directly from the

Table 1: Socio – Economic Characteristics of Gari Processors (n = 100)

Variable	Mean	Standard deviation	Minimum	Maximum
Gari output (₦)*	1352.68	954.08	348	5183
Capital input (₦)	419.25	337.09	76	1880
Labour input (₦)	592.46	410.15	120	2769
Age (Years)	40.29	6.9	24	61
Formal Ed. (Years)	7.86	4.48	0	18
Family size(No.)	7.12	3.87	2	21
Credit to total cost ratio	0.23	0.18	0	0.77
Gari to total revenue ratio	0.43	0.05	0	3.57
Membership of gari Processing association (dummy)	0.46	0.50	0	1

* 2005 average exchange rate was a €1 to ₦163.584

Source: Authors' survey data, 2004

Table 2: Distribution of Gari Processors by Degree of Involvement, Level of Educational Attainment and Use of Credit (n = 100)

Variable		Percentage Response
Extent of involvement		
(i)	Full – time	5
(ii)	Primary occupation	31
(iii)	Secondary occupation	64
Level of educational attainment		
(i)	No formal education	25
(ii)	Primary education	35
(iii)	Secondary education	28
(iv)	Tertiary education	12
Use of credit in gari processing		
(i)	No	79
(ii)	Yes	21
Membership of gari Processors Association		
(i)	No	83
(ii)	Yes	17

Source: Authors' survey data, 2004

microeconomic theory of the firm. Perhaps the most basic concept is that of the production frontier, which indicates the minimum inputs required to produce any given level of output for a firm operating with full efficiency. Technical efficiency is concerned with how closely the production unit operates to the frontier of the production possibility set. The productive efficiency of a production unit refers to the ratio of actually-achieved aggregate output to optimal aggregate output it can achieve with the same level of aggregate input.

Formally, the level of technical efficiency is measured by the distance a particular firm is from the production frontier. Thus, a firm that sits on the production frontier is said to be technically efficient. This concept is important to firms because their profits depend highly upon their value of technical efficiency. Two firms, which have identical technologies and same inputs, but with different levels of technical efficiency will have different levels of output leading higher revenue for one firm although both have the same costs, thus, obviously generating a larger profit for the more efficient firm.

A general stochastic production frontier model following from [21] can be given as:

$$\ln Q_i = f(\ln X) + v_i - u_i \quad \text{...(1)}$$

where Q_I is the output produced by firm i, X is a vector of factor inputs, v_i is the stochastic (white noise) error term and u_i is a one-sided error representing the technical inefficiency of firm i. Both v_i and u_i are assumed to be independently and identically distributed (iid) with variance σ^2_u and σ^2_v respectively. Given that the actual production of each farm - firm i can be estimated as:

$$\ln \hat{Q}_i = f(\ln X) - u_i \quad \text{(2)}$$

while the efficient (expected) level of production (i.e. no inefficiency) is expressed as:

$$\ln Q^*_i = f(\ln X) \quad \text{(3)}$$

then technical efficiency (TE) can be given by:

$$\ln TE_i = \ln \hat{Q}_i - \ln Q^* = -U_i \quad \text{(4)}$$

Hence, $TE = e^{-u_i}$ and is constrained to be between zero and one in value. The u_i is not observable, and so, to compute the farm – specific technical efficiency requires adopting the approach employed by [11] who estimated the firms specific inefficiency as the conditional mean exp $(-U_i)$ given as:

$$E = \frac{\exp(Q_i \setminus U_i)}{\exp(Q_i \setminus U_i = 0)} = \frac{f(X_i, \beta)\exp(-U_i)E[\exp(v_i)]}{f(X_i, \beta)E[\exp(v_i)]} = \exp(-U) \quad \text{(5)}$$

By expectation, the conditional mean lies within the range $0 \leq -U_i \leq 1$. The closer it is to zero, the more efficient is a firm. If u_i equals zero, then TE equals one, and production is said to be technically efficient. Technical efficiency of the ith firm is therefore a relative measure of its output as a proportion of the corresponding frontier output.

Panel data collected from 50 gari processors were used for the analysis. The data were collected on monthly basis over a period of 6 months. Panel data has been found to have some advantages over cross sectional data in the estimation of stochastic frontier models. The application of penal data increases the number of degrees of freedom used in the estimation procedure. The respondents were selected using three – stage sampling technique. The first stage involved the selection of 5 out of the 25 local government areas of Delta State, were cassava is produced in large quantities. See Figure 2 for location study area. Secondly, 5 gari producing communities were selected from each of the 5 LGAs. Finally, 4 gari processors were selected from each of the communities, given total sample respondents of 100. With 6 monthly observations on each respondent, total sample observation was 600, which constituted the final sample size for the study. Data collected relate to quantities of cassava root tubers processed (kg), corresponding gari output (kg), inputs of labour (₦), capital (annual cost of fixed inputs, consumable inputs and interest on loans and advances where applicable), socio – economic characteristics of respondents (such as age, number of years of gari processing experience, level of formal educational attainment, volume credit used, membership of gari producers association, family size, and alternative sources of income and other socio – economic characteristics of the processors.

Data were analysed using Stochastic Frontier Model specified in translog functional form with inputs namely capital (C) and labour (L) as:

$$\begin{aligned} \ln Q_i = {} & \beta_0 + \beta_c \ln C_i + \beta_l \ln L_i + \beta_c \ln C_i \ln C_i \\ & + \beta_b \ln C_i \ln L_i + \beta_l \ln L_i \ln L_i + v_i - u_i \end{aligned} \quad \text{(6)}$$

where Q_i is output of gari by the ith firm. The βs are the unknown parameters to be estimated. As noted above, the error term is separated into two components, where v_i is the stochastic error term and u_i is an estimate of technical inefficiency.

The translog function is a second order (all cross-terms included) log-linear form. It is a relatively flexible functional form, as it does not impose assumptions about constant elasticities of production nor elasticities of substitution between inputs. It thus allows the data to indicate the actual curvature of the function, rather than imposing a priori assumptions.

To account for factors that affect the processors level of efficiency, an inefficiency model, which is jointly estimated with the frontier model, was included as follows:

$$\begin{aligned} \mu_i = {} & \delta_0 + \delta_1 AG_i + \delta_2 FS_i + \delta_3 ED_i \\ & + \delta_4 CR_i + \delta_5 K'_i + \delta_6 GT_i + \omega_i \end{aligned} \quad \text{(7)}$$

where AG is processor's age (years);

FS is processor's family size;

ED is the number of years of formal education attained by the processor;

CR is the ratio of production credit to total cost of production;

GT is the ratio of gari to total annual income of processor (as a measure of engagement in other non

Table 3: Maximum Likelihood Estimates for the Parameters of the Stochastic Frontier Production Function

Variables	Parameters	Coefficients	Standard errors	*t – ratios*
Constant	β_0	5.4962	1.5928	*3.4506**
Ln (Capital)	β_c	–1.1322	0.5478	*–2. 2075**
Ln (Labour)	β_l	1.2126	0.5598	*2.1662**
[ln (Capital)]^2	β_{cc}	0.1548	0.0765	*2.0245**
[ln (Labour)]^2	β_{ll}	– 0.0670	0.0215	*– 0.5838*
ln (Capital) x (lnLabour)	β_{cl}	0.0529	0.0246	*2.4654**
Inefficiency Effects				
Constant	δ_0	- 0.8044	1.3910	*- 0.5783*
Age	δ_1	0.0605	0.0243	*2.4940**
Family size	δ_2	- 0.3617	0.1519	*- 2.3808**
Education	δ_3	- 0.0412	0.0186	*- 2.2106**
Membership of Gari Processors Association	δ_4	- 0.2208	0.2576	*- 0.8570*
Credit – Cost ratio	δ_5	- 0.4.413	0.7011	
Gari – annual income ratio	δ_6	- 0.2249	0.0925	*- 2.4311**
Variance Parameters				
Sigma – squared	σ^2	0.4207	0.1243	*3.3846**
Gamma	Υ	0.8312	0.1314	*6.3269**
	Log – likelihood	*–101.63*		

* Significant at 5% level of significant.
Source: Authors' computations

Table 4: Summary of test of Hypotheses regarding the General Model, Inefficiency Effects and Returns to Scale

Null Hypotheses Tested	Log likelihood Under Null Hypotheses	No. of Restrictions	Test Statistics	Critical Value	Decision
1. $\beta_{cc} = \beta_{ll} = \beta_{cl} = 0$	– 106.32	3	9.36	7.82	**Reject H$_0$**
2. $\gamma = \delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = 0$	– 115.97	8	28.66	22.88*	**Reject H$_0$**
3. $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = 0$	– 109.72	6	16.16	12.59	**Reject H$_0$**
4. $\beta_c + \beta_l = 1$, $2\beta_c + \beta_{cl} = 0$, $2\beta_l + \beta_{cl} = 0$.	– 105.98	3	8.68	7.82	**Reject H$_0$**

Source: Authors' Computations.
All tests were made at 5% level of significance.
* The critical value for this was obtained from Table 1 of Kodde and Palm (1986) [13], with degree of freedom, equal to the number of restriction plus one. Other critical values were obtained from the normal χ^2 table with degree of freedom equal to the number of restrictions.

– gari processing jobs) and

PA is membership of gari producers Association (dummy).

The δs are also parameters to be estimated while ω is error term.

The parameters of the model are estimated by Maximum Likelihood Estimation (MLE). Estimation of the maximum value of the logged likelihood function is based on a joint density function for the split error term $e_i = v_i - u_i$.

A translog stochastic frontier model incorporating inefficiency effects was analysed using the computer program FRONTIER 4.1 developed by [6]. FRONTIER 4.1 is a single purpose package specifically designed for the estimation of stochastic production frontiers and technical efficiency. The relevant tests of hypotheses were carried out using the Likelihood Ratio (LR) tests.

RESULTS AND DISCUSSION

The basic socio – economic characteristics of the Gari Processors and the variables included in the stochastic frontier model are presented in Tables 1 and 2. On the average, each processor produced gari worth about ₦ 1353 with average capital and labour input of about ₦ 419 and ₦ 592 respectively. This indicates that on the average, net revenue of about ₦ 342 is made for each batch of gari processed. That is about €2.09 using the year 2005 Euro to Naira (Nigeria Currency (₦)) average exchange rate of a €1 to ₦163.584, Given that batch processing takes about two days to complete, then net revenue per day of gari processed of ₦ 171 or about €1.05 is made. On a monthly and yearly bases, Processors make net incomes from the business of about ₦5130 (€31.36) and ₦61560 (€376.32) respectively. Capital inputs include cost of cassava tubers processed other consumable items and depreciated values of gari processing fixed inputs. Labour includes imputed cost of family as well as hired labour.

The average age, formal level of educational attainment, family size, credit – total cost ratio and gari – total revenue ratio were about 40, 8, 7, 0.23 and 0.43 respectively. These indicate that gari processors are relatively of low educational status, with about 60% of them attaining below secondary education. They are relatively advanced in age in addition to having large family sizes. Most of the processors indicated processing gari mainly to feed their families. As indicated in Table 2, up to 65% take it as secondary occupation. In addition, about 79% of the respondents did not borrow any money for the purpose of processing gari, thus limiting them to using less capital intensive and traditional methods, which is a similar result as reported by [19].

The maximum likelihood estimates of the parameters of the stochastic frontier model of equations (6) and (7) are presented in Table 3. The estimates were obtained using the Computer Program FRONTIER Version 4.1 developed by [6]. Four null hypotheses were tested regarding the frontier model. The formulation of the hypotheses and the result of the tests are given in Table 4. All hypotheses were tested using the generalised likelihood – ratio statistic, which is given as:

$$\lambda = -2[L(H_0) - L(H_1)]$$

where, $L(H_0)$ and $L(H_1)$ are the values of the log likelihood function of the frontier model under the null, H_0 and alternative, H_1 hypotheses respectively. For each of the hypotheses, $L(H_1) = -101.64$ as earlier given in Table 3. All tests were conducted at 5% level of significance. The first hypothesis relates to appropriateness of Cobb – Douglas in preference to translog functional form. The second hypothesis specifies that there are inefficiency effects. That is to say, the traditional OLS specification is a better representation of the data and that there is no technical inefficiency among the processors. The third hypothesis specifies that the technical inefficiency effects, where they exist are not related to the inefficiency variables specified for the analysis. The last but not the least hypothesis states that the production frontier used to characterise the gari processing industry exhibits globally constant returns to scale. That is to say, the sum of the output elasticities with respect to each input is equal to unity.

The four null hypotheses were rejected at 5% level of significance. The first indicates that translog functional form is a better formulation than the Cobb – Douglas formulation. The second implies that deviation of observed output from expected cannot be attributed only to random errors but also to inefficiency which exist among the gari producers. Rejection of the third null hypothesis implies that the observed inefficiency among the processors can be attributed to the inefficiency variables as specified for this study. The result of the fourth hypothesis shows that the processors are not scale efficient. The elasticity estimates for capital and labour were 1.08 and 0.67 respectively. The returns to scale (RTS) estimate was 1.75. This implies that the Processors operate in the region of increasing returns to scale. They could be made to be scale efficient by increasing their scale of operation, which can be achieved if they employ more input to bring about increased output.

The elasticities of output with respect to capital and labour inputs and the resulting returns to scale estimate were obtained as follows:

Table 5: Summary of Technical Efficiency of the Processors

Parameter	**Efficiency**
Mean	65.36
Standard deviation	15.74
Minimum value	25
Maximum value	86
Number of Processors	100
Number of observations per unit	6
Total number of observations	**600**

Source**:** Computed from survey data, 2004

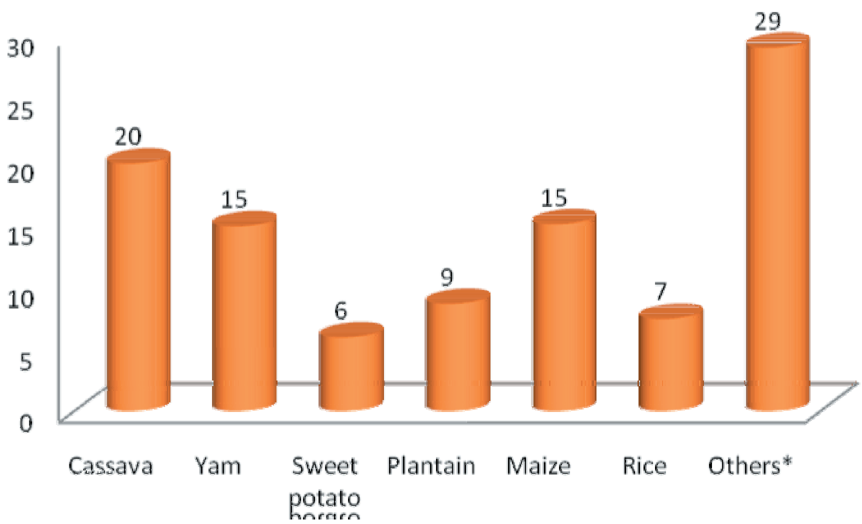

Figure 1: Percentage Contribution of food crops to cash income of households producing major crops in Southern Nigeria
**Others include millets, sorghum, beans and peas*
Source: Adapted from *Nweke et al., 1997*

$$\xi_c = {}^{\ln Q_t}/_{\ln C_t} = B_c + 2B_c \ln C_t + B_l \ln L_t \ldots\ldots$$
(8)

$$\xi_l = {}^{\ln Q_t}/_{\ln L_t} = B_l + 2B_l \ln L_t + B_l \ln C_t \ldots\ldots$$
(9)

$$RTS = \xi_c + \xi_l \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$
(10)

where ξ_c and ξ_l are the output elasticity with respect to capital and labour respectively. For the assumption of constant returns to scale ($\xi_c + \xi_l = 1$) to hold, the following conditions must hold:

$\beta_c + \beta_l = 1$; $2\beta_{cc} + \beta_{cl} = 0$; $2\,\beta_{ll} + \beta_{cl} = 0$.

Thus three restrictions were imposed on the frontier model of equations (6) and (7) to enable hypothesis number 4 to be tested. Using the estimated parameter values of the frontier production function of equation (4) and (5), predictions were made for the technical efficiencies of individual gari producing unit, the summary of which is given in Table 5. The table shows that there is a wide range of variation in technical efficiency in gari processing, ranging from 25% to 86%, with the mean level of

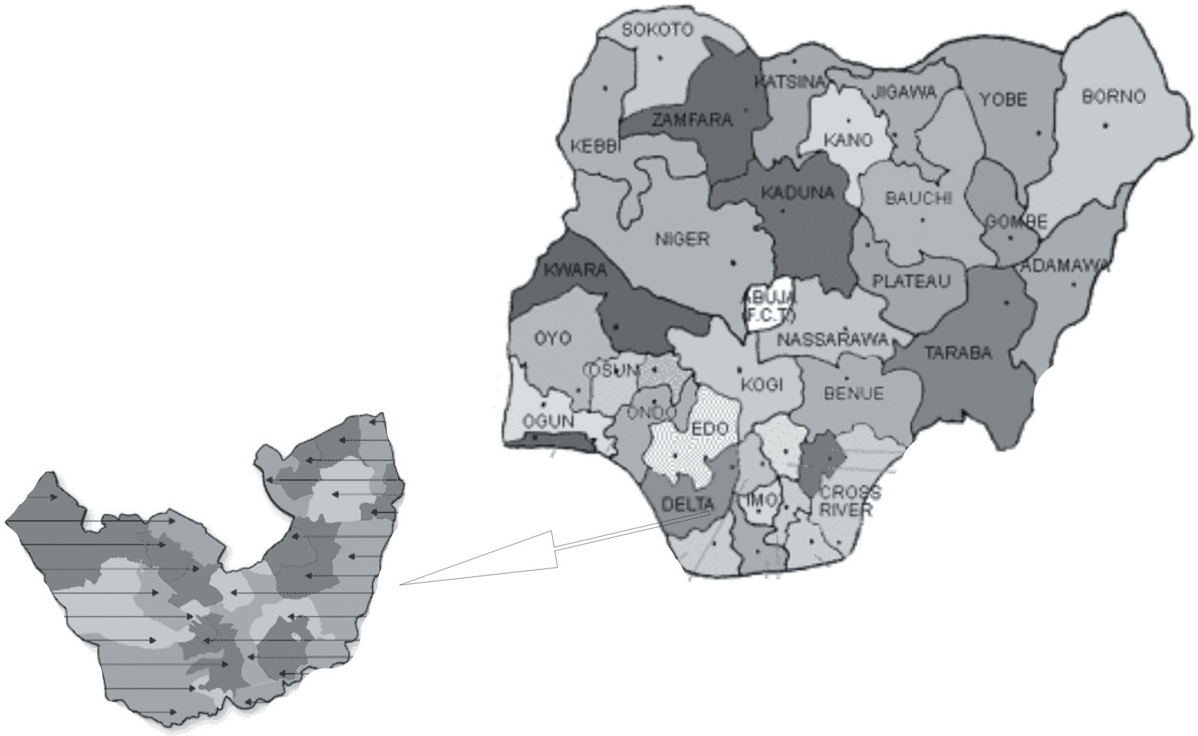

Figure 2: Map of Nigeria, showing Delta State, the location of the study

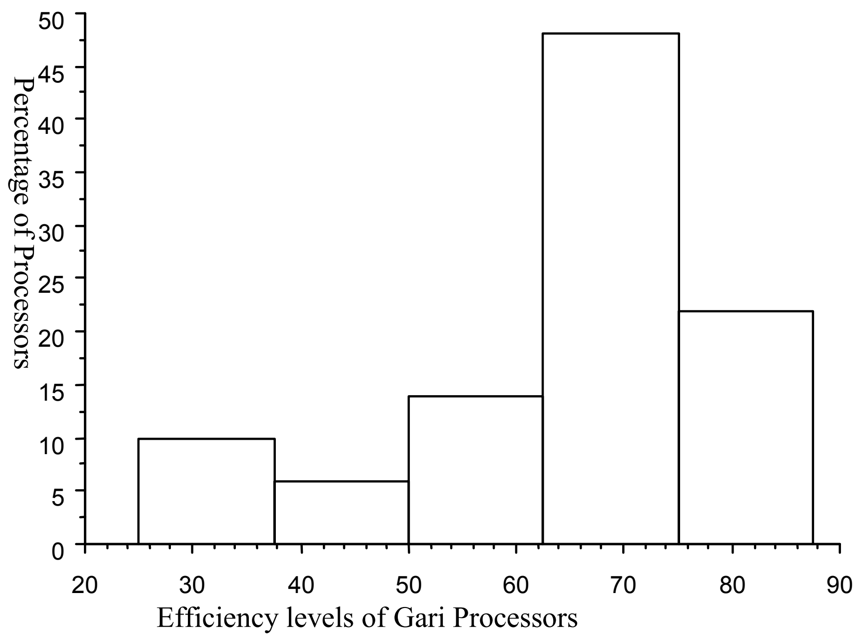

Figure 3: Distribution of the Technical Efficiency of Processors

efficiency being about 65%. This suggests that about 35% of gari revenue is lost due to technical inefficiency in the processing system. The wide distribution of technical efficiency of the processors calls for policy measures to improve the production activity of the producers. The distribution of the processors according to their levels of technical efficiencies is shown in Figure 3. About 10% recorded less than 37% efficiency while about 48% of respondents recorded between 63 and 75%. Only about 22% had efficiency of more than 75%.

The variation in the predicted technical efficiency/ inefficiency among the processors can be explained by variation in their ages, levels of formal educational attainments, volume of production credit used, family size, extent of involvement in gari processing as measured by the ratio of gari to total annual income of the processors and membership of gari processors association. A negative inefficiency coefficient signifies a positive relationship with technical efficiency and vice – versa. From Table 3, it could be seen that with the exception of age of processors, all variables explaining inefficiency were negatively related with inefficiency. These implies that higher level of educational attainment, use of credit in gari processing, engagement in gari processing on full – time basis, pressure to feed more people and membership of gari processors association encourage better utilisation of resources employed in gari processing. Education encourages adoption of better management systems by producers and promotes the consciousness to maximise the full benefit of resource use, which is in agreement with the findings of [3], who found that education brings about choice of better input combinations and use of existing inputs. The use of credit puts more pressure on the part of the processors to produce more output and therefore more income in order to meet personal cash needs and be able to pay back what ever was borrowed. Also, Processors with large family sizes are equally under pressure to provide for the household needs of calorie and to produce marketable surpluses in order to generate needed cash income for the family. The higher the gari – annual income ratio a processor has, the lower the income he or she earns from alternative employment. Full – time involvement in gari processing implies little or no income from other sources and vice – versa. In other words, those who are into gari processing on full – time basis are technically more efficient than part – time processors. [23] obtained similar result, when he found that households who have opportunity to engage indifferent occupations at the same time, fail to pay adequate attention to any, thus bringing about technical inefficiency, even though they may earn higher income on the aggregate. Definitely a boost in the selling price of gari would encourage more people to engage in its production on full – time basis. Gari Producers Association is a quasi – cooperative society. As a result, the training they give to their members with respect to better management practices tend to encourage more efficient use of resources. This finding is in line with the observation of [5], who noted that members of cooperative societies are able to adopt better techniques of production than non – members because of the greater awareness created and encouragement given to their members.

Age has positive effect on technical inefficiency of processors, indicating that the older ones are less efficient than the younger ones. [4] attributed this trend to the fact that older people are less willing to adopt new ideas of doing things.

CONCLUSION

Translog stochastic frontier production function was applied in the estimation and analysis of panel data collected from gari processors with a view to estimating their levels of technical efficiency and the factors which affect them. The empirical result revealed that inefficiency exists in the production system. Among the factors which were found to significantly influence the level of inefficiency and therefore, the level of efficiency among the processors were, level of educational attainment, family size, engagement in non – gari processing activities and membership of Gari Processing Association. In order to enhance efficiency of gari processing, the authors recommend the provision of extension education in food processing to increase the quantity and quality of final products , the formation of gari processors into cooperative societies, and the adoption of policies that will guarantee higher prices for their product by all tiers of government.

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