Journal of Agriculture and Food Sciences
Volume 11 Number 1, April 2013 pp. 19-31.

ESTIMATING PRODUCTION TECHNICAL EFFICIENCY OF IRVINGIA SEED (OGBONO) SPECIES FARMERS IN NSUKKA AGRICULTURAL ZONE IN ENUGU STATE, NIGERIA

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ABSTRACT
This study estimated the production technical efficiency of irvingia seed (Ogbono) farmers in Nsukka agricultural zone in Enugu State, Nigeria. This is against the backdrop of the importance of efficiency as a factor of productivity in a growing economy like Nigeria where resources are scarce and opportunities for new technologies are lacking. Primary data were collected using a set of pre-tested questionnaire from 200 irvingia seed producers who were selected through multistage random sampling from four Local Government Areas in Nsukka agricultural zone. Data were analyzed using descriptive statistics and the Stochastic Frontier model. Results showed that irvingia seeds are produced by ageing farmers who managed only small number of trees. Frontier estimates showed that farm size (number of trees) fertilizer and labour significantly influenced irvingia seed productivity while farmer's education, farming experience and access to credit reduced production inefficiencies in irvingia farms. With a mean technical efficiency of 67.8%, there is ample opportunity to improve irvingia seed productivity in the area using the current production systems. Thus, directing efforts towards proper farmer education on relevant agro-forestry practices and extending credit to farmers are important policy strategies for increased irvingia seed production.

Keywords: Technical efficiency, *irvingia* seeds, stochastic frontier, Nsukka agricultural zone
http://dx.doi.org/10.4314/jafs.v11i1.2

INTRODUCTION

The crucial role of efficiency in increasing agricultural output has been widely recognized by researchers and policy makers alike (Iwala et al, 2006; Ike and Inoni, 2007; Akinleye 2007; Bamire et al, 2007; Agbo and Ojo 2012). Indeed, considerable efforts have been devoted to the analysis of farm level efficiency in developing countries. An underlying premise behind most of the work of efficiency is that if farmers are not making efficient use of existing technologies, then efforts designed to improve efficiency would be more cost-effective than introducing new technologies as a means of increasing agricultural output (Shapiro. 1983).

In a factor product relationship, the production function presupposes technical efficiency whereby maximum output is obtained from a given level of input combination. One important assumption that relates to efficiency is that the efficient farms operate on the outer bound of the production function, that is, on their frontier, while inefficient farms are those operating below the production frontier. The amount by which a farm lies below its production frontier is a measure of its inefficiency.

Irvingia seeds (Ogbono) are got from *irvingia* species (*wombolu* and *gabonensis*) which are forest trees found in most West African countries. Referred to as dika nut/bush mangos in Cameroon the species are valued for their wood and edible nuts. While the kernels (Ogbono) are used as thickening agent in traditional soups and stews in West and Central Africa (Leaky *et al*, 2002) they are also source of oil for making soap and for medicinal purpose (Abbiw 1990). International Center for Research in Agro-forestry (ICRAF) (1995) puts the volume of trade in *irvingia* seed products in the West African sub region to be about $US50 million. Falconer (1990) put the figure of *irvirgia* seeds marketed in Nigeria annually at over 78.000 tonnes.

Processed kernels of *irvingia* are traded within Nigeria and between countries in west and Central Africa. The products are also transported to Europe and the United States and to other areas where African immigrants abound in large numbers (Lapido and Boland, 1994). The volume of production and trade in *irvingia* seeds and their contribution to the sustenance of livelihoods of the rural households in the study area has been tremendous over the years. In spite of this scenario, there is still room for increase in the output of *irvingia* seed if the rural small scale producers are to improve on the efficiency of their utilization of input resources.

The *irvingia* seed farmers in the study area produce the seeds under the village agro-forestry practices in which the trees are deliberately planted in crop farms. However, due to the long life span of the *irvingia* trees, the seeds can also gathered from the wild by descendants of the original owners. Efforts are currently being made by the State ministry of Agriculture through the Agricultural Development Programme (ADP) to educate farmers on how to improve their livelihood through incorporating high income yielding economic trees into their arable farm lands.

Research work on the efficiency or otherwise of these farmers in the practice of agro-forestry technology for the production of *irvingia* seeds is yet to be undertaken in the area, hence this study. The specific objectives of the study therefore are to:

(i) examine the socioeconomic characteristics of farmers engaged in *irvingia* seed production,
(ii) ascertain the determinants of technical efficiency in *irvingia* seed farms, and
(iii) estimate the technical efficiency of *irvingia* seed farms in the study area.

METHODOLOGY

Study Area:

The study area is Nsukka agricultural zone in Enugu State, Nigeria. Enugu state is one of the five states in South East Nigeria. South East Nigeria is a region often associated with high population density and agro-forestry intensification occasioned by increased land scarcity.

Nsukka agricultural zone comprise communities where indicative evidence of agro-forestry patterns and practices already exist (Eboh and Agu, 1994). The zone is located in the northern fringe of the state and shares boundary with some North Central states of Benue and Kogi. It lies in derived savanna zone with the soils that are slightly acidic. The zone comprises seven local government areas (LGAs) which are Nsukka, Igbo-Eze South, lgbo-Eze North, lgbo-Etiti, Isi-Uzo, Udenu and Uzo-Uwani. Though some of the *irvingia* species trees grow in the wild in the area, this study made use of only trees that were deliberately planted and incorporated in the village agro-forestry system where they grow along with other arable crops.

Data collection:

The data for this study were primary data collected from a cross-sectional survey of *irvingia* seed farmers. Four local government areas of Nsukka, lgbo-Eze North, lgbo-Eze South and Udenu were purposively selected for the study. This is on the basis of the preponderance of *Irvingia* species (*Irvingia wombolu* and *Irvingia gabonensis*) trees in most of the farm lands in the area. From each of the selected local government area, five communities were randomly selected through simple random technique. From each of the sampled community, ten *irvingia* seed farmers were randomly selected making a total sample size of 200 that were used for analysis. The field survey was carried out in two successive phases; on the spot observations and interview schedule through the administration of questionnaire. With the assistance of local enumerators, visits were made to farmers' homes and farm lands. The questionnaire sought information on various socioeconomic variables of *irvingia* seed farmers. Among these are age of farmers, gender, number of trees, labour use, access to credit, level of education and household size. Data were also gathered on the level of utilization of relevant production inputs and also farmers' socioeconomic variables.

Data analysis/Analytical procedure

Data were analyzed with the aid of descriptive statistics, which involved the use of mean, mode and percentages to describe the study variables; and stochastic frontier production function was used to analyze the determinants of farm level technical efficiency of irvingia seed farms.

The stochastic frontier production function was independently proposed by Aigner *et al* (1977), Battese and Corra (1977) and Meeusen and van den Broeck (1977). The modeling, estimation and application of stochastic frontier functions to economic analysis assumed prominence in econometric and applied economic analysis during the last four decades (Ike and Inoni, 2007). A number of international and local researchers have applied this technique in efficiency analysis (Battese 1992; Battese and Coelli, 1995; Ajibefun and Abdulkadri, 1999; Ajibefun *et al* 1996; lwala *et al*, 2006; Ike and Inoni, 2007; Akinleye, 2007; Bamire *et al*, 2007; Agbo and Ojo 2012).

A stochastic production function comprises a production function of the usual regression type with a composite disturbance term equal to the sum of two error components (Aigner et al 1977; Meeusen and Van den Broeck 1977). One error component - random error (Vi) represents the effect of statistical noise (e.g. weather, topography, distribution of supplies, measurement errors, etc). The other error component (Ui) captures systematic influences that are all explained by the production function and are attributed to the effect of technical inefficiency. This study uses a variant of the stochastic frontier production function proposed by Battese and Coelli (1995) which builds hypothesized efficiency determination into the inefficiency error component so that the focal points for action to bring efficiency to higher levels can be identified. The general form of the model is expressed as:

Yi = $\beta 0 = \beta i X i + (Vi - Ui)$ (1)

Where Yi is the output (or the logarithm of the output) of the ith firm: Xi is a KXi vector of (transformations) input quantities of the ith firm: β is a vector of unknown parameters. The Vi are random variables which are assumed to be independently identically and normally distributed iid $N{\sim}(O,\delta V^2)$ and independent of the Ui. The Ui measures the technical inefficiency relative to the frontier. Ui is assumed to have a non-negative distribution and are often assumed to be iid $N{\sim}(O\ \delta^2)$. It is further assumed that the average level of technical inefficiency measured by the mode of the truncated normal distribution (i.e. Ui) is a function of factors believed to affect technical inefficiency as shown in equation (2).

Ui = δo + δiZi (2)

Where Zi is a column vector of hypothesized efficiency determinants and δo are unknown parameters to be estimated. It is clear that if Ui does not exist in equation (1) or Ui = δo = 0, the stochastic frontier production function reduces to a traditional production function. In that case, the observed units are equally efficient and residual output is solely explained by unsystematic influences. The distribution parameters, Ui and δu^2 are hence the inefficiency indicators of the farmer, indicating the average level of technical inefficiency and the latter the dispersion of inefficiency level across observational units. Given functional and distributional assumptions, the values of unknown coefficients in equations (1), and (2), i.e. βs, δs, δu^2 and δv^2 will be jointly estimated by the method of maximum likelihood estimation (MLE) using the computer program FRONTIER version 4.1 developed by Coelli (1994). An estimated value of technical efficiency for each observation can be calculated as in equation (3).

TEI = exp (-Ui) (3)

The unobservable value of Vit may be obtained from its conditional expectation given the observable value of (Vi-Ui) (Battese and Coelli, 1995).

This study employed a production function as in equation (1). Thus;

$\ln Yi = \beta o + \Sigma\beta_1 \ln Xi + ½ \Sigma \Sigma\beta ij \ln Xj + (Vi – Ui)\ U \geq 0$ (4)

Where YI = value of irvingia seed (Ogbono) output (kg),

Journal of Agriculture and Food Sciences
Volume 11 Number 1, April 2013 pp. 19-31. **P. C. Ike and E.O. Emaziye**

X_1 = number of trees,
X_2 = Organic fertilizer (dummy variable 1 if there was a deliberate effort to apply organic
manure to enhance the growth of the tree; 0 otherwise),
X_3 = Labour (Mandays),
X_4 = Age of the trees which serve as a proxy to capture the decline in output over the years. Thus; the *a priori* expectation is that the older the tree the less the output;
Vi = random error or statistical disturbance term,
Ui = farmer specific characteristics related to production efficiency (technical inefficiency effects). It is assumed that the technical inefficiency measured by the mode of truncated normal distribution (i.e. Ui) is a function of socioeconomic factors (Yao and Liu, 1998). Thus;

$$Uij = \delta_0 + \delta_1 Z_1ij + \delta_2 Z_2ij + \delta_3 Z_3ij + \delta_4 Z_4ij + \delta_5 Z_5ij \quad (5)$$

Where

Uij = technical inefficiency of the ith farmer and jth observation of the farmer, Z_1 age of
farmers (years),
Z_2 = frequency of extension visits per year,
Z_3 = years of formal education,
Z_4 = years of farming experience,
Z_5 = Access to credit,
Z_6 = Gender (Dummy variable, 1 for male, 0 otherwise), and
Z_7 = household size.

A negative sign of the parameter in the inefficiency function means that the associated variables reduce the level of technical inefficiency in production, while a positive sign indicates the reverse.

RESULTS AND DISCUSSION

Socioeconomic variables of *Irvingia* seed Farmers

The values of the socioeconomic factors of *irvingia* seed farmers are as presented in Table 1. The result shows that about 90% of the farmers had between one and ten *irvingia* trees on their farms while only four percent had more than 18 trees. The trees are scattered in the various fragments of land where the farmers lay claim to ownership. Some of the trees were also inherited along with the land in the traditional tenure inheritance. Over 60% of the farmers however accepted having made concerted effort to plant new *irvingia* trees to add to the inherited stands. In all, the number of trees owned by farmers of *irvingia* seeds in the area is dismally low. This calls for a concerted effort on the part of the forestry department through the extension agents to sensitize the farmers on how to develop a proper village agro-forestry system that will incorporate the planting of more *irvingia* specie trees.

Journal of Agriculture and Food Sciences
Volume 11 Number 1, April 2013 pp. 19-31 .

More than 70% of the farmers are aged between 45 and 64 years. The dominance of older farmers in ownership of *irvingia* trees is explained to be as a result of the time it takes the trees to reach maturity. In particular *irvingia wombolu* species according to the respondents take upwards of 10-15 years or more before producing fruits and this is why most of the farmer-owners are of older generation except those who acquired theirs through inheritance. The dominant ownership of trees by male farmers (87%) is a reflection of traditional ownership of economic trees in Africa which favours the man over the woman. These trees are part of the traditional inheritance of the male as against the female who does not have the same opportunity. Also, the study shows that about 74% of the farmers have been in *irvingia* seeds production for over a decade. This could be attested to by the fact that most of the farmers inherited these trees from generations before them.

About 10% of the farmers did not go through any formal education process while 70% of the farmers made use of both family and hired labour in *irvingia* seed production. Labour is employed in picking of the fruits which fall after ripening in various fragments of farms under current cultivation in the cropping season or in bushes for those farm lands that are under fallow. The fruits are picked and carried to homes where they are broken with knives and the seeds extracted and dried under the sun. Alternatively, over ripened fruits are allowed to dry and the kernels broken with stones or harmer which could be wooden or metal and the seeds extracted. It is worthy of note that despite the employment of labour in *irvingia* seed production, only about seven percent of the farmers accessed financial credit for *irvingia* seed collection and processing. This has greatly limited the level of output of *irvingia* seeds as some fruits are either abandoned in the farms and/or bushes during the peak periods or resort to share cropping processes with hired labourers. The implications of inadequacy or unavailability of credit facilities to small scale farmers in developing countries are well documented in literature (Ike and Chidebelu, 2003; Pischke, 1991).

TECHNICAL EFFICIENCY ESTIMATES OF *IRVINGIA* SEED FARMS

The maximum likelihood estimates of the stochastic frontier production function for *irvingia* seed production in Nsukka agricultural zone are presented in Table 2. The frontier estimates indicate a good fit as shown by the likelihood function, the gamma and sigma-squared coefficients. The estimated gamma parameter (γ) of 0.725 indicates that over 72% of the variations in output of *irvingia* seeds among the farmers were due to differences in their technical inefficiencies. In the same vein, the statistical significance of the variance parameter (δu^2) reveals that inefficiency effects abound and influence the productivity of *irvingia* seed farms in the area, implying that variations in *irvingia* seed productivity are mainly due to factors within the control of the farmers rather than on natural forces. (e.g. weather or environment factors) that may be beyond their control.

Farm size, fertilizer and labour were positively signed and statistically influenced *irvingia* seed productivity, while expenditure on other agro-chemical inputs had negative sign and was not statistically significant. Thus, when farm size holdings increased by one unit, *irvingia* seed productivity increased by 0.09 units, while a unit increase in quantity of fertilizer applied increased productivity by 0.06 units. These imply that planting more *irvingia* trees and increasing the use of fertilizer (both organic and inorganic) will enhance increased *irvingia* seed production in the area. This supports the findings of Ajibefun *et al* (1999) and Bamire *et al* (2007) who variously reported similar trend in farms studied. In the same vein, a unit increase in labour (mandays) increased *irvingia* productivity by 0.24 units. This implies that more labour is needed for *irvingia* seed production in the area particularly during the peak period of production. This period is normally between the months of May and July which coincides with the time of planting as well as harvesting of some arable crops. Such farm operations as land clearing cultivation weeding etc at this time of the year greatly competes for the farmers time used for collection and breaking of *irvingia* fruits.

The results of factors influencing technical inefficiency in *irvingia* farms are presented in Table 3. The estimated coefficients of education, farming experience and access to credit are statistically significant and negatively signed. This implies that these variables reduce production inefficiencies in *irvingia* seed farms. For every unit increase in the level of education, production inefficiency reduced by 0.2 units and as the farmers gain an additional unit of experience or access credit for farming activities, inefficiency will reduce by 0.5 and 0.6 units respectively. This suggests that educating farmers on appropriate agro-forestry practices through effective extension services, as well as introducing appropriate rural based microfinance services are good policy strategies to promoting *irvingia* seed productivity in the survey location.

This finding of the positive contribution of education, farming experience and access to credit in reducing inefficiency in *irvingia* seed production supports an earlier finding made by Bamire *et al* 2007 but is at variance with the findings of Iwala *et al* 2006 who found that rather than reduce inefficiency in palm oil production, education and farming experience aggravates inefficiency. The positive contribution of age of farmers to technical inefficiency is understandable because older farmers would not only possess lesser vigour for farming activities but also very few of them believed in the importance of adopting new or improved technologies particularly for *irvingia* trees which may be viewed as traditional tree crops.

The predicted farm specific technical efficiencies (TE) of the *irvingia* farms in the study area showed the existence of variations ranging from 26.3% to 99.9% with a mean efficiency level of 67 8% (Table 4).

The average level of technical efficiency indicates that the average *irvingia* seed farm falls short of maximum production level by about 32%. This implies that there is still room to improve the efficiency and productivity of *irvingia* farms in the area by adopting the production technologies being utilized by the best technology-friendly *irvingia* seed farmer in the area.

CONCLUSION

On the basis of findings made in this work, it could be concluded that it is possible to improve upon the productivity of *irvingia* species in the study area using the current production systems without introducing new technologies such as improved variety among others. In other words, farmers can maximize their returns through effective use of available resources. However, to achieve this policy and/or developmental strategies aimed at promoting *irvingia* seed production in the area, there is the need to consider the significant socioeconomic factors in the study findings. Thus, introducing appropriate policy to enhance adult literacy among the rural farmers will expand *irvingia* seed production in the area. Also making credit available to farmers for the purchase of relevant agro-chemicals and payment for labour at appropriate time are issues which require immediate implementation so as to improve farm level productivity.

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Journal of Agriculture and Food Sciences
Volume 11 Number 1, April 2013 pp. 19-31. **P. C. Ike and E.O. Emaziye**

APPENDIX

Table 1: Socioeconomic Characteristics of *Irvingia* Seed farmers in Nsukka Agricultural Zone, Enugu State

Variables	No of Respondents	Percentage
Farm size (No of trees)		
1 – 5	110	55
6 – 10	70	35
11 – 15	16	8
Above 15	4	2
Labour use		
Family labour only	60	30
Family plus hired labour	120	60
Hired labour only	20	10
Age (years)		
25 – 34	12	6
35 – 44	32	16
45 – 54	50	25
55 – 64	90	45
Above 64	19	8
Gender		
Male	174	87
Female	26	13
Farming experience (in years)		
1 – 5	24	12
6 – 10	28	14
11 – 15	36	18
16 – 20	62	31
Above 20	50	25
Access to Credit		
Yes	14	7
No	186	93
Educational Level		
No formal education	20	10
Primary education	116	58
Secondary education	44	22
Tertiary education	20	10
Household size		
1 – 5	80	40
6 – 10	112	56
Above 10	8	4

Journal of Agriculture and Food Sciences
Volume 11 Number 1, April 2013 pp. 19-31. **P. C. Ike and E.O. Emaziye**

Table 2: Stochastic Frontier Production Estimates of Technical Efficiencies in Irvingia Seed Farms

Variable	Maximum Likelihood Estimate of the Production Function	
	Coefficient	**t-value**
Constant	0.1139	0.0134
Farm size (X_1)	0.092**	13.06
Fertilizer (X_2)	0.059*	2.73
Labour (X_3)	0.241**	5.98
Expenditure on other agro-chemicals (X_4)	-0.021	-0.61
Y	0.725*	0.323
δv^2	0.187	
δu^2	0.0088*	
Log likelihood function	127.5	
Number observation	200	

**Significant at 0.01 level, *Significant at 0.05 level

Table 2: Socioeconomic Variables Influencing Inefficiency in *Irvingia* seed farms.

Variable	Technical inefficiency estimate	
	Coefficient	**t-value**
Constant	3.459**	4.668
Age (Z_1)	0.172	0.216
Extension visits (Z_2)	-0.286	-1.221
Education (Z_3)	-0.284*	-2.25
Farming experience (Z_4)	-0.482*	-2.783
Access to credit (Z_5)	-0.649**	-11.544
Gender (Z_6)	0.082	0.111
Household size (Z_7)	-0.168	-0.093

**Significant at 0.01 level *Significant at 0.05 level

Table 4: Distribution of Technical Efficiency in *Irvingia* Farms

Technical inefficiency (%)	Frequency	Percentage (%)
≤ 20	2	1
21 – 40	10	5
41 – 60	74	37
61 – 80	64	32
Total	200	25
Mean	67.8	100
Minimum	26.3	
Maximum	99.9	