

SHORT NOTE [NOTA CORTA]

**RELATIVE ECONOMIC EFFICIENCY OF FARMS IN RICE PRODUCTION:
A PROFIT FUNCTION APPROACH IN NORTH CENTRAL NIGERIA**

**[EFICIENCIA ECONÓMICA RELATIVA EN FINCAS PRODUCTORAS DE
ARROZ: UN ENFOQUE DE FUNCIÓN BENEFICIO EN LA REGIÓN
CENTRO NORTE DE NIGERIA]**

V.O. Okoruwa^{1*}, A.O. Akindeinde¹ and K.K. Salimonu²

¹ *Department Agricultural Economics, University of Ibadan, okoruwa@gmail.com*

² *Department of Agricultural Economics and Extension,
Ladoke Akintola University of Technology, Ogbomosho, Nigeria.*

**Corresponding author*

SUMMARY

The study examines the relative economic efficiency of small and large rice farms in central, Nigeria. Previous studies of such were based on production functions which have been criticized due to the associated simultaneous equation bias because the input levels are endogenous. However, the profit function approach avoids these problems. Data related to input and output prices, production factors and socio-economic characteristics were collected from 143 rice farmers in Niger state, Nigeria. Analytical tools included descriptive statistics and seemingly unrelated regression (SURE). A striking result is that no female was found among the large farmers. Coefficient of seed, fertilizer, capital and sex of respondent which were not significant in OLS, were found significant in the profit function. The use of modern rice varieties significantly increases profits. Significant difference in economic efficiency between small and large farms was also discovered. It is suggested that, to improve technical efficiency of rice farms, an accelerated program to provide modern rice varieties, fertilizer and land availability is needed. This paper provides support to eliminate bias distribution of production inputs to large rice farms.

Key words: Relative efficiency; farm sizes; rice; profit function; Niger State.

INTRODUCTION

In Nigeria, demand for rice had been increasing at a much faster rate than in any other African countries since mid 1970 (FAO, 2001). Nigeria consumes 50 percent of the total 10 million metric tones of rice for which only 3 million metric tones is produced in Africa (Oryza marked report – Nigeria, 2004). Furthermore, during the 1960s, Nigeria had the lowest per capita annual consumption of rice in the West Africa sub region with an annual average of 3kg. Since

RESUMEN

El trabajo examina la eficiencia económica relative de fincas productoras de arroz. Estudios previos han sido basados en funciones productivas las cuales han sido criticadas debido a los sesgos posibles en las ecuaciones. Sin embargo las funciones de beneficio no tienen este problema. Información relacionada con los insumos y precios de productos, factores de producción y características socio-económicas fueron recabadas en 143 fincas del estado de Niger, Nigeria. Un resultado sorprendente es que no se encontró mujeres empresarias para las fincas de tamaño grande. Los coeficientes para variables tales como: semilla, fertilizante, capital y sexo del encuestado no fueron significativos en regresión de mínimos cuadrados, pero si en la función de beneficio. El empleo de variedades modernas de arroz resulta en incremento en el beneficio. Se encontró diferencia en la eficiencia económica de las fincas pequeñas y grandes. Para mejorar al eficiencia técnica de la fincas de arroz es necesario un programa que provea de variedades modernas y disponibilidad de tierra. Los resultados proveen evidencia de apoyo para eliminar el sesgo generado por los insumos en las grandes fincas.

Palabras clave: Eficiencia relativa; tamaño de finca; arroz; beneficio; Niger.

then, Nigeria per capital consumption levels have grown significantly at 7.3 percent per annum (PCU, 2002). Consequently, per capital consumption during the 1980s average 18kg and reached 22kg in 1995 to 2000. In an apparent move to respond to the increase in per capita consumption of rice, local production increased at an average of 9.3 percent per annum. These increases have been traced to vast increase in rice area totalling an annual average of 7.9 percent and to a lesser extent through increase in rice yield of 1.4 percent per annum. In spite of this, the production

increase was not sufficient to match the consumption increase. In a bid to address the demand-supply gap, government, at various times, has come up with different policies and programmes. It is observed that those policies have not been consistent (Ogundele and Okoruwa, 2004). The erratic policies reflected the dilemma of securing cheap rice for consumers and a fair price for the producers.

Despite the various policy measures, domestic rice production has not increased sufficiently to meet the increased demand. Thus, these fluctuations in policy and limited capacity of the Nigeria rice sector to match the domestic demand have raised a number of pertinent questions both in policy circle and among researchers. For example, what are the factors explaining why domestic rice production lag behind the demand for the commodity in Nigeria? Central to this explanation is the issue of efficiency of the rice farmers in the use of resources. Average yield of upland and low land rain fed rice in Nigeria is 1.8 ton/ha, while that of the irrigation system is 3.0ton/ha (PCU, 2002). This is very low when compared with 3.0 ton/ha from upland and lowland systems and 7.0ton/ha from irrigation system in places like Cote d'Ivoire and Senegal (WARDA and NISER, 2001). Several studies have been carried out, featuring resource use efficiencies in rice production. Most adopted conventional Cobb-Douglas function and stochastic frontier production function with doubtful success in those approaches (Seyoum et al, 1998; Ajibefun et al, 1999 etc). However, Yotopoulos and Lau, (1971) emphasized the superiority of profit function approach over the production function approach especially in terms of overcoming estimation bias and providing a convenient analytical device for comparing technical efficiency and input prices among farmers. The use of shepherd's lemma in profit function approach enables us to obtain input-demand and product – supply with ease which was difficult using production function and this study adopt this methodology.

Production of rice in Nigeria is mainly in the hands of small scale farmers who are still using unimproved farming techniques. Actual yields of rice differ significantly from potential yields, and this has been attributed to low resource productivity (Federal Ministry of Agriculture, 2001). The implication is that there is a scope for additional increase in domestic output from existing hectares if efficiency of rice production is improved. Since increase output and productivity are directly related to production efficiency, the study become imperative, as it would identify factor that influence technical efficiency in rice based production system among rice farmers. The identification of those factors is significant for policy formulation. Thus, the main objective is to analyze efficiency relative to farm size in rice production in north central Nigeria. The main hypothesis of the

study is that there is no significant difference in technical efficiency among the group of farmers. The study focused on the production efficiencies of small and large scale rice farmers in Niger State in order to identify ways of improving the farmers' production efficiencies to the highest level possible.

MATERIAL AND METHODS

The study was conducted in Niger State of Nigeria. Niger State is particularly preferred because it has a lot of extensive flood plains of the River Niger which makes it to have one of the largest and most fertile agricultural lands in Nigeria. The state is also known to be largest producer of rice in Nigeria. Data were randomly collected from 143 rice farmers through the use of structured questionnaires administered in three local government areas (Gbako, Mokwa and Gurara) mostly known for rice production in the state. Data collected include quantities and values of variable inputs and output price level such as output of rice, farm size, family labour, hired labour, traction, and agrochemicals. Others are quantity of seed used for planting, quantity of fertilizer applied, age, sex, level of education, household size, farming experience, farmer's income and seed variety.

Analytical framework

Farell (1957) distinguished three types of efficiency as technical efficiency, price or allocative efficiency and economic efficiency which is the combination of the first two. Technical efficiency is an engineering concept referring to the input-output relationship. A firm is said to be efficient if it is operating on the production frontier (Ali and Byerlee, 1991). On the other hand, a firm is said to be technically inefficient when it fails to achieve the maximum output from the given inputs, or fails to operate on the production frontier. Mbowa (1996) in his study on the sugarcane industry in South Africa defined an efficient farm as that which utilizes fewer resources than other farms to generate a given quantity of output. Price or allocative efficiency has to do with the profit maximizing principle. Under competitive conditions, a firm is said to be allocatively efficient if it equates the marginal returns of factor inputs to the market price of output (Fan, 1999). Akinwumi and Djato (1996) in their study of relative efficiency of women farm managers in Cote d'Ivoire defined allocative efficiency as the extent to which farmers make efficient decisions by using inputs up to the level at which their marginal contribution to production value is equal to factor costs. Failure to equate revenue product of some or all factors to their marginal cost is at the very core of economic theory (Timmer, 1971). Economic efficiency is distinct from the other two even though it is the product of technical and allocative efficiency (Farell, 1957). A firm that is economically efficient should by definition be both

technically and allocatively efficient. However, this is not always the case as Akinwumi and Djato (1997) pointed out. It is possible for a firm to have either technical or allocative efficiency without having economic efficiency. The reason may be that the farmer, in this case, is unable to make efficient decisions as far as the use of inputs is concerned.

Normalized profit function is the modified form of the profit function. This modified form of the profit function has proved to be handier from the theoretical and econometric point of view. When an ordinary profit function is divided by the price of output, this implies normalizing the profit function. The outstanding feature of this function is that direct application of Hotelling's – Shephard's Lemmas to the Normalized profit function gives the corresponding factor demand and output supply equations. The negative of the first order partial derivative of the normalized profit function with respect to the normalized profit prices gives the factor demand function. The output supply function is obtained by differentiating the ordinary profit function with respect to price of the output. Shadow price (Marginal Productivity of fixed input) is obtained as the first order partial derivative of the normalized profit function with respect to the fixed input.

A number of functional forms exist in literature for estimating the profit function which includes the Cobb-Douglas (C-D) and flexible functional forms, such as normalized quadratic, normalized translog and generalized Leontif. The C-D functional form is popular and is frequently used to estimate farm efficiency despite its weaknesses (Saleem, 1988; Kaliranjan and Obwona, 1994. Dawson and Lingard, 1991; Yilma, 1996; Nsanzugwanko et al, 1996; Batesse and Saftaz, 1998). The translog model has its own weaknesses as well, but it has also been used widely (Ali and Flinn, 1989; Wang et al, 1996). The main drawbacks of the translog model are its susceptibility to multicollinearity and potential problems of insufficient degrees of freedom due to the presence of interaction terms. The interaction terms of the translog also do not have economic meaning (Abdulai and Huffman, 2000).

EMPIRICAL MODEL

The normalized profit function was used in this study to determine the relative efficiency of small and large rice farms. Using the output price as the numeraire, the normalized restricted profit function

$$\pi^*(q, z)$$

can be written in a generalized form as:

$$\pi^*(q, z) = f[X_j^*(q, z) \dots X_n^*(q, z)] - \sum_{j=1}^m q_j x_j(q, z) \quad (1)$$

Where:

q_j = Normalized factor prices

F = Production function

X^* = Vector of variable inputs used in production process

Z = Vector of variable inputs used in production process

With any well specified normalized restricted profit function, direct application of Hotelling's – Shephard's Lemmas to the function yields the corresponding factor demand and output supply equations.

$$\partial \pi^*(q, z) / \partial q_j = -X_j^* \quad j = 1, \dots, m \quad (2)$$

Multiplying both sides by q_j / π^* gives a series of m factor share equations.

$$\left[\partial \pi^*(q, z) / \partial q_j \right] = -X_j^* q_j / \pi^* = a^* j \quad j = 1, \dots, m \quad (3)$$

Equation (1) and (3) form the theoretical basis for the specifications of the empirical models. Following previous studies, Lau and Yotopoulos (1971), the specification of the systems of equations of the normalized restricted profit function and the factor share equations is given as:

$$\ln \pi^* = \ln A^* + \delta_1^* D_L + \sum_{i=1}^3 \alpha_i^* \ln w_i + \sum_{i=1}^3 \beta_i^* \ln Z_i + \varphi_1 \text{TRAC} + \varphi_2 \text{SEX} + \varphi_3 \text{MV} + \varphi_4 \text{PRDSYS} + \varepsilon \quad (4)$$

$$-\frac{w_i X_i}{\pi^*} = \alpha_i^{*L} D_L + \alpha_i^{*S} D_S + \mu_i \quad i = 1, 3 \quad (5)$$

Where:

π^* = Normalized profit (₦)

A^* = Intercept

X_i = Number of man-days of labour (family and hired labour)

w_1 = Normalized price of labour (₦)

w_2 = Normalised price of seed (₦)

w_3 = Normalized price of fertilizer (₦)

X_2 = Quantity of seed used (kg)

X_3 = Quantity of fertilizer used in (kg)

Z_1 = Value of farm fixed assets (N)

Z_2 = Size of land cultivated (ha)

D_L = Dummy variable for large farms

D_S = Dummy variable for small farms.

Other variables included in the profit function equation are whether farmers use tractor or not, gender whether male or female, whether farmer use improved seed

variety or not and the production system (upland and lowland). These variables were included because they were found to have positive effects on profits by the previous studies (Sidhu, 1974). Education was not included because majority of the respondents had formal education, minimum of six years of schooling. There was no substantial information on access to credit and extension services. They were therefore not included. Following previous studies, Zellner's seemingly unrelated regression method (SURE) was used to estimate the system of equations in order to obtain asymptotically efficient parameter estimates.

RESULTS AND DISCUSSION

Socio-economic characteristics and resource use

The characteristics of the small and large farmers are as shown in Table 1. Small farmers were relatively younger than the large farmers. A striking result is that no female was found among the large farmers which may be attributed to lack of access to productive resources as argued in past studies (Quisumbing, 1994 and Akinwumi and Djato, 1996). No significant difference existed in the educational status and the farming experience among the two farming categories. However, the extent of resource use differed significantly; 109 mandays were required for the large farmers compared to 79 in the case of small farmers. Though this is expected due to farm size difference but the same was observed in the choice of seed variety. This could be as a result of non-availability of improved seed to smaller farms and where available is usually costly. In practice, mean values and factor proportions are not appropriate measures of relative farm efficiency. The profit function provides a better measure of relative efficiency differences (Akinwumi and Djato, (1996).

Empirical result

Table 2 shows the estimation of ordinary least square (OLS) and the normalized profit function and factor share equations, using Zellner's seemingly unrelated regression method (SURE). The F-values are highly significant at 1% probability level. Most of the variables have the expected theoretical signs and were found to be significant at 1%, 5% and 10% levels respectively. In line with a priori, the coefficients of the prices for labour, seed and fertilizer are negatively signed as expected. Capital and land are highly significant in the profit function. However, the coefficient of seed, fertilizer, capital (fixed asset) and

sex of respondents were not significant at any level in the OLS estimate but were all found to be significant when the model was estimated using SURE method except for fertilizer that was only significant at six restriction.

Factor shares and hypothesis testing

The hypotheses tested and their results are shown in Table 3. All tests are evaluated at 1% level of significant. Hypothesis one (H_1) states that the economic efficiency (technical and price or allocative) of small and large farms are equal. This hypothesis is rejected. This means that there is significant difference in relative economic efficiency between small and large farms. Hence, it is concluded that small farms are relatively more economic-efficient than large farms. This finding is in agreement with Yotopoulos and Lau (1971 and 1973) where the test of relative economic efficiency is in favour of the small farms. Hypothesis two (H_2) states that the relative price or allocative efficiency of small and large farms is equal. This is also the equality of the elasticities of the variables inputs of small and large farms in the factor share equations. This hypothesis is rejected, suggesting that differences exist in the relative price efficiency between small and large farms. Hypothesis three (H_3) states that, there is equal technical and price efficiency jointly between small and large farms. This hypothesis is also rejected. This is anticipated given the test of H_1 and H_2 . Hypothesis four (H_4) states that large farms have absolute allocative or price efficiency, i.e. they maximize profits by equating the value of each factor's marginal product to the respective factor price. This hypothesis cannot be rejected for large farms, suggesting they are price efficient in their decision making. Hypothesis five (H_5) states that small farms are price efficient is also not rejected, implying that small farms have maximized profits. Hypothesis six (H_6) tests for absolute price efficiency for both small and large farms is rejected, indicating that as a group, there exist absolute price inefficiency among all rice farms in the sample. Hypothesis seven (H_7) states that there are constant returns to scale under the maintained hypothesis of absolute price efficiency for small and large farms (and thus equal relative price efficiency). The hypothesis is rejected. This is an evidence of decreasing returns to scale for the technology use on all the rice farms.

Table 1: Characteristics differences between small and large farmers in north central Nigeria

Characteristics	Small farmers (n=100)	Large farmers n=43
Age (Average years)	44	50
Gender (%): Male	59	100
Female	41	-
Educational Status (Average years)	7	8
Farming Experience (Average years)	23	27
Household Size (Average no. of members)	7	11
Labour Requirements (Average no. of Mandays)	79	109
Seed Variety (%): Improved	36	83.7
Non Improved	64	16.3

Table 2. Joint estimation of profit function and factor share equations for rice farmers in north central Nigeria.

Variable Profit Function	Parameter	Single Equation (OLS)	Zellner's Seemingly Unrelated Regression Estimation (SURE Method)		
			No Restriction	Three Restrictions	Six Restrictions
Constant	$\ln A^*$	4.64(1.89)**	3.73(2.73)*	3.76(2.13)**	9.14(17.15)*
Large Farm Dummy	δ_L^*	0.14(1.67)***	0.27(3.71)*	0.14(2.17)**	0.15(2.34)**
Labour	α_1^*	-0.28(-2.57)*	-0.35(-2.03)*	-0.25(-2.05)**	-0.37(-1.91)**
Seed	α_2^*	-2.03(-1.38)	-1.72(-2.00)**	-1.72(-2.15)**	-9.29(-12.59)*
Fertilizer	β_1	-0.35(-0.84)	-0.48(-1.44)	-0.48(-1.44)	-0.93(-3.99)*
Land	β_2	0.30E-01(2.06)**	0.29E-01(-2.52)*	0.29E-01(2.52)*	0.28E-01(-2.41)**
Capital (fixed assets)	β_3	0.18E-05(0.86)	0.67E-05(3.98)*	0.67E-05(3.98)*	0.75E-05(4.57)*
Traction	ϕ_1	-0.17(-2.63)*	-0.20(-3.96)*	-0.20(-3.96)*	-0.21(-4.07)*
Sex	ϕ_2	-0.20E-01(-0.33)	-0.14(-2.82)*	-0.14(-2.82)*	-0.14(-2.94)*
Seed Variety	ϕ_3	0.96E-01(1.90)**	0.31E-01(0.77)	0.31E-01(0.77)	0.15E-01(0.38)
Production System		-1.31(13.1)*	-1.30(-16.34)*	-1.30(-16.33)*	-1.28(-16.23)*
		$R^2 = 0.87$	$R^2 = 0.85$	$R^2 = 0.84$	$R^2 = 0.84$
		$\bar{R}^2 = 0.86$	$\bar{R}^2 = 0.84$	$\bar{R}^2 = 0.83$	$\bar{R}^2 = 0.83$
		$F[10,132] = 90.32^*$	$F[10,132] = 75.39^*$	$F[10,132] = 71.23^*$	$F[10,132] = 69.94^*$
Factor Share Equations					
Labour Demand Function					
Large farm		-19.71(-1.07)	-19.71(-2.13)**	-10.31(-2.10)**	-0.37(-1.91)**
Small farm		-6.26(-0.52)	-11.97(-1.91)**	-10.31(-2.10)**	-0.37(-1.91)**
Seed Demand Function					
Large farm	α_2^{*L}	-2.62(-0.87)	-2.62(-2.09)**	-8.47(-5.18)*	-9.29(-12.59)*
Small farm	α_2^{*S}	-10.97(-5.57)*	-10.99(-5.61)*	-8.47(-5.18)*	-9.29(-12.59)*
Fertilizer Demand Function					
Large Farm	α_3^{*L}	-173.24(2.63)*	-173.24(-2.65)*	-56.16(-1.57)	-0.93(-3.99)*
Small farm	α_3^{*S}	-5.81(0.14)	-5.81(-0.14)	-56.16(-1.57)	-0.93(-3.99)*

(a) Asterisks indicate significance at the following level; *** 10%, ** 5%, * 1%

(b) Values in parentheses are t-statistics (t-ratios).

Table 3. Tests of statistical hypothesis on efficiency differences between small and large rice farms.

Maintained hypothesis	Tested hypothesis	X ² value	Critical X ² value 0.01	P-value	
H ₁	$\delta_L^* = 0$	15.71	6.63	0.0001	
H ₂	$\alpha_1^{*L} = \alpha_1^{*S}$ $\alpha_2^{*L} = \alpha_2^{*S}$ $\alpha_3^{*L} = \alpha_3^{*S}$	29.81	11.34	0.0000	
H ₃	$\delta_1^* = 0$ $\alpha_1^{*L} = \alpha_1^{*S}$ $\alpha_2^{*L} = \alpha_2^{*S}$ $\alpha_3^{*L} = \alpha_3^{*S}$	24.75	13.30	0.0001	
H ₄	$\alpha_1^{*L} = \alpha_1^*$ $\alpha_2^{*L} = \alpha_2^*$ $\alpha_3^{*L} = \alpha_3^*$	7.64	11.30	0.0541	
H ₅	$\alpha_1^{*S} = \alpha_1^*$ $\alpha_2^{*S} = \alpha_2^*$ $\alpha_3^{*S} = \alpha_3^*$	6.98	11.30	0.0725	
H ₆	$\alpha_1^{*L} = \alpha_1^{*S}$ $\alpha_2^{*L} = \alpha_2^{*S}$ $\alpha_1^{*L} = \alpha_1^{*S}$	$\alpha_1^{*L} = \alpha_1^*$ $\alpha_2^{*L} = \alpha_2^*$ $\alpha_3^{*L} = \alpha_3^*$	36.30	14.40	0.0000
H ₇	$\alpha_2^{*L} = \alpha_2^{*S}$ $\alpha_1^{*L} = \alpha_1^{*S}$ $\alpha_2^{*L} = \alpha_2^{*S}$	$\beta_1^* + \beta_2^* = 1$	79.67	16.00	0.0000

Elasticity estimates

The main advantage of obtaining production elasticities indirectly from the profit function is one of statistical consistency. Estimate of these same elasticities obtained directly from the production function by the ordinary least squares method may, in general be inconsistent because of the existence of simultaneous equation bias. To determine the effects of individual production factors on rice farm output for the sample farmers, identities that linked the self-dual profit function with the primal production function were used. The indirect production elasticities are derived using the unrestricted parameter estimates. The results of the indirect elasticities for the production with respect to the variable factors and the fixed factors using the pooled sample of rice farmers (small and large) are present in Table 4. The estimates shows that the elasticity of paddy output is highest with respect to seeds (0.36), followed by fertilizer (0.20), labour (0.17), land (0.01) and capital is absolutely inelastic (0.00).

A 10% increase in seeds put to production purpose will increase paddy output by 3.6%. Similarly, a 10% increase in fertilizer, labour and land will lead to 2%,

1.7% and 0.1% increase in paddy output respectively, while a 10% increase in capital will yield zero output. The highly inelastic response of fixed factors (land and capital) may be due to lack of improved technologies which limits increase in rice productivity in the study area. On the other hand, the highly elastic response to seed, fertilizer and labour suggest that technologies that enhance the productivity of these factors are likely to achieve significant positive effects on rice production.

Table 4. Indirect elasticity estimates of production factors of rice farming in north central Nigeria

Production Factor	Indirect Elasticity Estimate
Variable factors	
Labour	0.17
Seed	0.36
Fertilizer	0.20
Fixed factors	
Land	0.01
Capital	0.00

CONCLUSION

The study concluded that small scale farmers dominate rice production in Niger State, most of which have attained their declining productive age. Low participation of women is an indication of limited access of women to inputs needed in rice production. High literacy level among respondents is expected to increase production by 7% and influence technology adoption and skill acquisition. Large farm operators have more years of farming experience thus expected to be more knowledgeable about the agronomic conditions of the area. Only the large farm operators plant improved seed variety because of easy accessibility. Results have shown that there is significant difference in economic efficiency between small and large farms. Also, indirect elasticity estimates have shown that every attempt to increase the availability of an improved seeds, fertilizer and labour will give a boost to paddy production. Hence, it is suggested that government policy should be geared towards the provision of and unbiased distribution of seeds to both small and large rice farms operators in Niger State. In the same vain, encourage the use of fertilizer and substitute labour by encouraging farm mechanization. Secondly, since older men dominate, policy should be directed towards encouraging active participation of women and injection of younger generation in rice production in the study area. The test of hypothesis showed that both group of farmers respond significantly to price changes. Hence, price policy instruments are likely to be quite efficient in increasing rice productivity. Lastly, there is need for more women participation in rice production. Strategies must therefore be put in place by the ministry of agriculture to get more women involved in its production. Extension services should be improved and intensified to impact technical and economic knowledge on farmers especially the female folks.

REFERENCES

- Abdulai, A. and Huffman, W. 2000. Structural adjustment and economic efficiency of Rice Farmers in Northern Ghana. *Economic Development and Cultural Change*, 48: 503-520.
- Ajibefun I.A. and Daramola, A.G. 1999. Measurement and Sources of Technical Inefficiency in Poultry Egg Production in Ondo State, Nigeria. *Journal of Rural Economics and Development*, 13(2): 85 – 94.
- Akinwumi, A., and Djato, K.K. 1996. Farm size, relative efficiency and agrarian policy in Cote d'Ivoire: Profit function analysis of rice farms. *Agricultural Economics*, 14: 93-102.
- Akinwumi, A., and Djato, K.K. 1997. Relative efficiency of women as farm managers: Profit function analysis in Cote d'Ivoire. *Agricultural Economics*, 16:47-53.
- Ali, M., and Byerlee, D. 1991. Economic efficiency of small farmers in a changing world: A survey of recent evidence. *Journal of International Development*. 13: 1-27.
- Ali, M., and Flinn, J. 1989. Profit efficiency among Basmati rice producers in Pakistan Punjab. *American Journal of Agricultural Economics* 71: 303-188.
- Battese, G.E. and Safraz, H. 1998. Technical efficiency of cotton farmers in Vehari District of Punjab Pakistan. Centre for Efficiency and Productivity (CEPA Working papers. No. 8/98). Department of Econometrics, University of New England, Armidale, Australia. (Working Papers No. 8/98). Armidale Centre for Efficiency and Productivity Analysis. (CEPA). <http://www.une.edu.au/econometrics/cepawp.htm>.
- Dawson, P.J., and Lingard, J. 1991. Approaches to measuring technical efficiency on Philippine rice farms, *Journal International Development*, 13: 211-292.
- Erenstein, O., Lacon, F., Akande, S.O., Titilola, S.O., Akpokodje, G. and Ogundele, O.O. 2003. Rice Production Systems in Nigeria: A Survey. *The Nigerian Rice Economy in a Competitive World, Constraints, Opportunities and Strategic Choices*. WARDA, Cote d'Ivoire.
- Fan, S. 1999. Technological change, technical and allocative efficiency in Chinese Agriculture: The case of rice production in Jiangsu. (EPTD Discussion Paper no 39, International Food Policy Research Institute IFPRI). Washington D.C.
- Farrell, M.J. 1957. The measurement of productivity efficiency. *Journal of Royal Statistics Society Series*. 120: 253-290.
- Federal Ministry of Agricultural and rural development, 2001. Crop, area and yield survey, 2001. Nigeria.

- Food and agriculture organization statistics (FAO) 2001: Rice Statistics, Rome, Italy.
- Kalirajan, K.P., and Obwona, M.B. 1994. A measurement of firm-specific and input-specific technical and allocative efficiencies. *Applied Economics*. 26: 393-398.
- Mbowa, S. 1996. Farm size and economic efficiency in sugar cane production in Kwazul-Natal. Unpublished doctoral dissertation, University of Natal, Durban.
- Nigeria – Online 2007. The Impact of Rice Policy in Nigeria” A Case study.
- Nsanzugwanko, M.D., Battese, G.E., and Fleming, E.M. 1996. The technical efficiency of small agricultural producers in Central Ethiopia. Centre for Efficiency and Productivity (CEPA Working Papers No 5/96). Department of Econometrics, University of New England, Armidale, Australia. <http://www.une.edu.au/econometrics/cepawp.htm>.
- Ogundele, F.O. and Okoruwa V.O. 2004. A comparative analysis of technical efficiency between traditional and improve rice variety farmers in Nigeria. *African Journal of Economic Policy*. 11: 90-94.
- Oryza Summary Report, 2004. Released by the United States Department of Agriculture attaché in Lagos.
- Project coordinating Unit (PCU), 2001 and 2002. Crop Area yield survey (CAY). Federal Ministry of Agriculture and Rural Development, Abuja.
- Quisumbing, A.R. 1994. Gender differences in agricultural productivity: A survey of empirical evidence. The World Bank: Washington D.C. (Paper Series No. 36) Education and Social Policy Department.
- Saleem, S.T. 1988. Relative efficiency of cotton farms in Sudanese irrigated agriculture *World Development*, 16: 975-984.
- Seyoum, E.T., Battese, G.E., and Fleming, E.M. 1998. Technical efficiency and productivity of maize producers in eastern Ethiopia: A study of farmers within and outside the Sasakawa-Global 2000 project. *Agricultural Economics*, 19: 341-348.
- Sidhu, S.S. 1974. Relative efficiency of wheat production in Indian Punjab. *American Economic Review*, 64: 742-751.
- Timmer, C.P. 1971. Using a probabilistic frontier production function to measure technical efficiency. *Journal of Political Economy*. 79: 776-94.
- Wang, J., Gramer, G.L., and Wailes, E.J. 1996a. A shadow-price frontier measurement of profit efficiency in Chinese Agriculture. *American Journal of Agricultural Economics*. 78: 146-156.
- West Africa rice development association and Nigerian institute of social and economic research, 2001. Report and Nigerian Institute of Social and Economic Research 2001. Report of the stakeholders workshop. November 8-9, 2001, Ibadan, Nigeria.
- Yilma, M. 1996. Measuring Smallholder efficiency: Uganda coffee and food crop production. Unpublished dissertation, Goteborgs. Universitet: Ekonomiska Studier Utgivna av Nationalekonomiska Institutionen Handelsh, Kompendiet-Goteborg. Sweden.
- Yotopolous P.A. and Lau, I.J. 1971. A test for a relative and application to Indian agriculture. *American Economic Review*. 61 94-109.
- Yotopolous, P.A., and Lau, L.J. 1973. A test for relative economic efficiency: Some further results. *American Economic Review*, 63: 214-223.

*Submitted April 26, 2008 – Accepted June 02, 2008
Revised received February 10, 2009*