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Resource Use Efficiency and Rice Production in Guma Local Government Area of Benue State: An Application of Stochastic Frontier Production Function

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Abstract

This study assesses resource use efficiency and Rice Production in Guma Local Government Area of Benue state. To achieve this Primary data were used. The analytical tools include gross margin and stochastic frontier production function applied on a cross-sectional data of 620 sampled randomly from rice farmers during 2011 farming season. The results indicate that both yield and profit of small and medium scale farmers remained small, when compared with large scale farmers. Also the results from Maximum Likelihood Estimation shows that all estimated coefficients among various farm operation indicates positive sign which implies that increase in quantities of these inputs would result in increase output of rice. The results obtained from the Inefficiency model, indicates the resource use in rice production in the study area was not fully utilized in all the categories of farms examined, although farmers were generally relatively efficient, they still have room to increase the efficiency of their farming activities to 65%, 53% and 46% for small, medium and large scale farm respectively to close the efficiency gap from the optimum (100%). The technical returns to scales measured by the sum of the elasticity of all significant factors showed that small and large scale exhibited increasing return to scale while medium scale farms demonstrated decreasing return to scale, but for pooled observation it depict constant return to scale. The study recommended that farm inputs should be made available to farmers at highly subsidized rates and makes them available timely, through adequate supply and efficient distribution.

Keywords: Efficiency of Resource-use, Food Crisis, Elasticity of Production, Maximum Likelihood Estimates, Return to Scale, Stochastic Frontier Production Function.

Introduction

Nigeria's socio-economic history and development has been very closely tied to its agricultural sector (Egbuna, 2008). The country is blessed with varied climatic zones, enormous resources, and has the potential of producing, processing, marketing and exporting different agricultural commodities.

In Nigeria, before and immediately after independence, agriculture was the mainstay of the economy. However, its contribution to the economy have been declining since the oil boom of 1970's.The contribution of agriculture to Gross Domestic Product (GDP) which was 65% on the average in the 60's dropped to 22.4% between 1976 and 1980 even though it rose to about 39.2% in the year 2005 (CBN, 2006). This trend of agricultural contribution to GDP is not consistent with the expected role of agriculture as the economy develops. Thus Guma Local Government Area of Benue State which is naturally endowed with both material and human resources has a great potential to produce and export various agricultural products, rice inclusive. It is therefore unfortunate that the opportunities available in the agricultural sector remain untapped because most available land is uncultivated and all year farming have not been carried out which shows that agricultural activities can all be carried out during the raining season.

Rice is widely consumed and there is hardly any country in the world where it is not utilized in one form or the other. In Nigeria, rice is one of the few food items whose consumption has no cultural, religious, ethnic or geographical boundary (Udoh, 2003). But unfortunately, the cultivation and production of this highly prized and very important food crop is dwindling. One way these resource-poor farmers, who contribute more than 90% of agricultural output in Nigeria (FMA and WR, 2008), can achieve sustainability in agricultural production within the limit of existing resource base will be a more efficient usage of resources. Thus, the main objective of this study is to identify any gaps that may exist in the current level of resources employed by rice farmers through the use of the Stochastic Frontier Production Function (SFPF) in the estimation of the efficiency of resource-use and production elasticities among rice farmers in the study area. These gaps would serve as intervention points that would assist in enhancing the productivity and profitability of the farmers, as well as encouraging them to beef up their current level of output so as to bridge the current shortfalls in rice production.

To cope with the predominant menace of poverty and unemployment in Guma LGA, resources use efficient is a prerequisite for optimum farm production since inefficiency in resource use, can distort food availability and security. For these reasons, the pertinent questions concerning rice farming therefore becomes; are these resources used productively? How statistically significant are these resources (inputs) to rice output? And if these inputs are available, are they technically efficient in their use in Guma Local Government Area where majority of the farmers are resource-poor?

Theoretical Framework and Literature Review

Three types of efficiency are identified in the literature. These are technical efficiency, allocative efficiency and overall or economic efficiency (Farrell, 1957; Olayide and Heady, 1982). Technical efficiency is the ability of a farm to produce a given level of output with minimum quantity of inputs under a given technology. Allocative efficiency is a measure of the degree of success in achieving the best combination of different inputs in producing a specific level of output considering the relative prices of these inputs. Economic efficiency is a product of technical and allocative efficiency (Olayide and Heady, 1982). In one sense, the efficiency of a farm is its success in producing as large an amount of output as possible from given sets of inputs. In Farrell (1957) frame work, economic efficiency (EE) is an overall performance measure and is equal to the product of TE and AE (that is EE= TE * AE). From his analysis, a farm that is technically efficient in resource use operates on a production frontier, while a technically inefficient farm in resources use operates below the production frontier. Hence, the position of individual farm relative to the frontier could be influenced by factors ranging from climatic, socio-economic and marketing etc. Mathematically, Farrell's production frontier function begins by considering a stochastic production function with a multiplicative disturbance term of the farm:

$Y = f(X_{a,;} \beta \square) e^{E}$ ……………………………………………..(1)

Where Y = output; X = vector of input, $\square$ β = vector of parameter, e = error term; E is stochastic disturbance term consisting two independent element "V" and "U".

Hence, E = U + V ………………………………………….. (2)

The symmetric element V account for random variation in output quantity attributed to factors outside the farmer's control (such as disease, weather). A one – sided component U < O reflects technical inefficiency relative to the stochastic frontier. Thus U = O for farm output that lie on the frontier (i.e. 100% technical efficiency in resource use) and U < O for farm output below the frontier as N ~ (o, $\square_u^2$ v). Thus equation (1) becomes:

$Y = f(X_{a},; \beta \square) e^{u+v}$ …………….. ……………………………. (3)

Several empirical applications have followed the stochastic frontier specification. The first application of the frontier model to farm level data was by Battese and Coelli (1995) who estimated deterministic and stochastic Cobb-Douglas production frontier for the economics of scale in sheep production in Australia. The variance of the farm effects was found to be in a highly significant proportion of the value of sheep production in Australia. Their study did not, however, directly address the technical efficiency of farms. Similarly, Bagi (2004) employed the stochastic frontier Cobb-Douglas production function model to investigate differences in technical efficiencies of sole and mixed enterprise farm in West Tennessee. The study found that the variability of farm effects was highly significant. The mean technical efficiency of mixed enterprise farms was found to be smaller (0.76) than for sole crop farms (0.85). The study show that, mixed enterprise farms were inefficient as compare to the sole crop farms as demonstrated by their various efficiency ratios.

The use of the stochastic frontier analysis in the study of agriculture in Nigeria is a recent development. Such studies include that of Udoh (2003), Okike (2006) and Amaza (2000). Udoh (2003) used the Maximum Likelihood Estimation of the stochastic production function to examine the land management and resource use efficiency in South–Eastern Nigeria. The study found a mean output –oriented technical efficiency of 77% for the farmers, this indicates that farmers can still expand production by 23%. The 0.98 indicates 98% for the most efficient farmers and 0.11 indicating 11% for the least efficient farmers. Okike (2006) investigated crop –livestock interaction and economic efficiency of farmers in the Savanna Zones of Nigeria. The study found average economic efficiency of farmers are higher in the low-population –low Market domain; Northern Guinea Sudan Savanna ecological zones; and crop –based Mixed Farmers farming system. Also Amaza (2000) work on small scale farm size and resource use efficiency in Kwara state, opined that, one of the means of proper utilization of farm inputs for greater efficiency is through farm size adjustment. The result was collaborated by the mean cost efficiency of 1.161 obtained from the data analysis which shows that an average farm in the sample area is about 16% above the frontier cost, indicating that they are relatively efficient in allocating their scarce resources.

Methodology

This study was conducted in fives communities of Guma Local Government Area of Benue state, Nigeria. The communities are purposively selected because of the prevalence of rice production in the study area. The communities include Mbabum, Gbayange, Mbayer, Mbakijime and Mbapupuu. The second stage involved a simple random selection of 124 farmers from each of the five communities, in each of the communities fifty questionnaires are distributed to small and medium scale farmers while 24 questionnaires are distributed to large scale farmers, thus making 620 respondents. The differences in questionnaires distributed between small, medium and large scale farms, is as a result of large number of existing small and medium scale farms which involves no stringent conditions for entry, while the large scale farms requires stringent conditions, this result to limited number of operators. For this study, farmer with 0.1 to less than 2.0 hectares of farm land was considered as small scale farmers while those with farmland of 2 to less than 5.0 hectares and 5 hectares and above, was considered as medium and large scale farmers respectively. Primary data were collected with the use of a structural questionnaire to collect input-output data of the farmers defined within economies of scale. Data were collected through the use of a structured questionnaire administered to rice farmers in the study areas. The questionnaires were given to educated farmers to fill while uneducated ones were interviewed orally.

Techniques of Analysis

Two methods were used to analyze the data collected. The first method used was gross margin analysis which involves the profitability of an individual rice farm, so that comparison can be made between farms and different plans. The purpose of this analysis is to identify the cost, returns and profitability of the farmers. It is given as:

GM = TR - TVC.

Where

GM = Gross Margin (₦/ha)
TR = Total Revenue (₦/ha)
TVC = Total Variable Cost (₦/ha) i.e. the cost incurred in the used of variable inputs.

Secondly, the stochastic frontier production function was used to estimate the resource use efficiency in various scale of rice production. It is given by:

$$\ln Y_i = \ln \beta_0 + \sum Bj \ln Xij + Vi - Ui \text{...} 4$$

Empirical formulation of equation 4 requires functional specification process in the presence of inefficiency. Base on the theoretical underpinnings, Cobb- Douglas production functional form is therefore used. Hence the empirical model is as follow:

$$\text{Ln } Y = \beta_o + \beta_1 \text{ In}(x_1) + \beta_2 \text{ In }(x_2) + \beta_3 \text{ In}(x_3) + \beta_4 \text{ In}(x_4) + \beta_5 \text{ In}(x_5) + Vi - Ui \text{…………….} 5$$

Where, Yi = farm output from family; Xi = vector of farm inputs used; X_1 = labour (in man days); X_2 = farm size; X_3 = fertilization (dummy: 1 = use fertilizer, 0 = not use fertilizer); X_4 = planting materials (in kg); X_5 = pesticide; V = random variability in the production that cannot be influenced by the farmer; μ = deviation from maximum potential output attributable to technical inefficiency. β_0 = intercept; β_i = Vector of production function parameters to be estimated; i = 1, 2, 3, n farmers; j = 1, 2, 3, m farmers inputs.

The inefficiency model is: $\mu_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + + \delta_4 Z_4$ …………………………..6

Where, δ_1 = technical inefficiency effect of the i^{th} farm; Z_1= educational level of farmers in years of formal education completed; Z_2 = household size; Z_3 = farm experience. Z_4 = age of farmer in years; δ = Parameters to be estimated. The parameters of the models will be obtained by the Maximum Likelihood Estimation method using the computer programme, FRONTIER VERSION 4.1 (Coelli, 1994). The *a priori* expectation is that the estimated coefficients of the inefficiency function provide some explanation for the relative efficiency levels among individual farms. Since the dependent variable of the efficiency function represents the mode of the inefficiency, a positive sign of an estimated parameter implies that the associated variable has a negative effect on efficiency and a negative sign indicate the reverse. Also the estimated coefficient for inputs implies that the associated variable has positive effect on efficiency and a negative sign indicates the reverse.

Results and Discussion

Gross Margin Analysis

Table 1: Average Costs and Returns per Hectares of Rice Production

Variable description	Small scale	Medium scale	Large scale
(A) Total Variable Cost	₦56,566.51	₦50, 056.620	₦41, 545.351
(B) Labour Cost	₦40,915.66	₦32, 825	₦19, 172.188
(C) Average Yield Per Rice/ha	2,433kg	2,601kg	2,640.6kg
(D)Gross Margin (C) - (A)	₦13, 382.6	₦24, 722,148	₦34, 371.899
Return on Gross Margin(D/A)	0.24	0.49	0.83

Source: Field Survey, 2011

The gross margin associated with rice production was estimated. Thus for this study, only variable costs such as cost of seeds, fertilizer, pesticides, bags and labour were used. Other costs such as marketing and fixed costs were not considered. On the other hand, returns were calculated based on average price that farmers received per kg of rice. The average cost of producing one hectare of rice was calculated for all the categories of farms as represented in table 1.

Table1 shows that Average Total Variable Cost of small, medium and large scale rice farmers was ₦56,566.51, ₦50, 056.620 and ₦41, 545.351 per hectare cost of rice production for the scale category were: Labour cost accounted for ₦40,915.66, ₦32, 825 and ₦19, 172.188 of the total variable cost, large scale farmers spent less money on labour compared with farmers in small and medium scale farms. This suggests that large scale farmers employed the use of machine (tractor) to compliment labour in the process of production.

The results show that, on the average, small and medium scale farmers produced 2,433kg and 2,601kg of rice. While large scale farmers produced 2,640.6kg of rice/ha, a figure greater than that of small and medium scale rice farmers. The gross margin obtained for small, medium and large was ₦13, 382.6; ₦24, 722,148 and ₦34, 371.899. The return on gross margin, which is a measure of financial success or failure for small, medium and large scale, was 0.24, 0.49 and 0.83 indicating that, on the average a gross margin of 24 kobo, 49 kobo and 83 kobo. However, comparing these figures with other categories of farm sizes examined, the results indicates that both yield and profit of small and medium scale farmers remained small. This could be as a result of the fact that majority of the farmers in these categories (small and medium scale) used seeds from previous harvest and the continuous usage of the same seeds, year in year out will definitely affects the viability of the seed especially if it is not treated.

Stochastic Frontier and the Inefficiency Model Analysis

The stochastic frontier and the inefficiency model are presented in the summary form in table 2. The variance parameters for δ^2 and γ are 0.2237, 0.2913, 0.3902 and 0.5209, 0.5999, 0.6634 for small, medium and large scale farms. They are significant at 1% level. The sigma squared, δ^2 indicate the goodness of fit and correctness of the distributional form assumed for the composite error term while the gamma γ indicates that the systematic influences that are un- explained by the production function are dominant sources of random errors. This means that the inefficiency effects make significant contribution to the technical inefficiencies of rice farmers, thus, the hypothesis that the coefficient of δ = o is rejected. The result shows that inefficiency effects were present and significant.

Maximum Likelihood Estimates of the Stochastic Frontier Function and Technical Inefficiency

Parameter		Coefficient			SE			T-statistic		
		SM	MD	LG	SM	MD	LG	SM	MD	LG
Constant	(β_o)	0.1219**	0.6444*	0.9877*	0.1005	0.1027	0.1099	0.3219	0.8544	0.6877
LB	(βx_1)	0.8406*	0.8999*	0.9999*	0.1077	0.1051	0.1035	0.6006	0.4499	0.2299
FS	(βx_2)	0.5485**	0.5499**	1.2222**	0.1079	0.1077	0.1079	0.4585	0.2289	0.6022
Fert	(βx_3)	0.1796**	0.6665**	0.8099**	0.1081	0.1045	0.1033	0.6296	0.3265	0.8199
PM	(βx_4)	0.5209**	0.7780**	0.8406**	0.1087	0.1016	0.1073	0.5209	0.7780	0.8406
Pest	(βx_5)	0.1219**	0.6444**	0.9877**	0.1005	0.1001	0.1002	0.4532	0.4310	0.8664
Inefficiency Model										
Constant	(δ_O)	0.2237	0.5733	0.6104	0.1011	0.1421	0.1143	0.1015	0.1211	0.5504
ED	(δz_1)	0.4558	-0.7011	- 0.7741	0.1225	0.1811	0.1021	0.1110	0.1821	0.4241
HS	(δz_2)	-0.2990	-0.8493	0.5279	0.1312	0.1031	0.1043	0.1302	0.1113	0.2179
AGE	(δz_3)	-0.6667	-0.7009	-0.8380	0.1621	0.1011	0.1059	0.1171	0.1421	0.6280
FE	(δz_4)	0.6912	-0.5987	-0.9373	0.1011	0.1231	0.1056	0.1003	0.1004	0.8973

Variance parameters of farms

	SM	MD	LG
Sigma Squared δ^2	0.2237	0.2913	0.3902
Gamma γ	0.5209	0.5999	0.6634
Mu (μ)	0.1235	0.1762	0.4571
Log Likelihood Function	-0.5331	- 0.6362	-0.6902
LR test	0.4569	0.4628	0.4970

Source: Author's computation. * = significant at 5% level, ** = significant at 1% level.

The results from table 2 shows that labour (β_1) appears to be the most important factor of production with an elasticity of 0.8406, 0.8999 and 0.9319 for small, medium and large scale farm sizes respectively, showing the labour intensive nature of farming in the study area. While Farm size (β_2) coefficient was found to be positive and significant at 1% level in all the farms operations (i.e. 0.5485, 0.5499 and 1.2222 for small, medium and large). Statistically, the magnitude of the coefficient of the farm size shows that output is inelastic to small and medium scale farms. If the small and medium scale farm increased by 10%, output level will improve by less than proportionate margin of 5.485 and 5.499% for both small and medium scale respectively. While the large scale farms indicates that output is elastic. That is output level will be improved by more than proportionate margin of 12.22%.

The production elasticity of output with respect to quantity of fertilizer (β_3) is 0.1796, 0.6665 and 0.8099 for small, medium and large scale respectively. By increasing the quantity of fertilizer by 10%, output level will improve by a margin 1.796, 6.665 and 8.099 percent in small, medium and large scale farm sizes respectively. Planting materials (β_4) and pesticides (β_5) from all the farm sizes was positive and significantly different from zero. This implies that planting materials and pesticides are important in rice production in the study area. All estimated coefficients indicate positive significant signs which conform to our priori expectation. The positive coefficient of these variables implies that increase in quantities of these inputs would result in increase output.

The sources of inefficiency are examined by using the estimated δ coefficients in table 3. The contribution of farmers' personal characteristics-level of education, age, years of farming experience and household size to farm inefficiency was also studied. If the dependent variables of the inefficiency model have a negative sign on an estimated parameter, it implies that the associated variable has a positive effect on efficiency, and a positive sign indicate that the reverse is true. The (δ_1) coefficient of education variable in small scale farm is estimated to be negative, that is (-0.4558) and statistically significant at the 1- percent level. The implication is that farmers with more years of formal schooling tend to be more efficient in rice production. Presumably due to their enhanced ability to acquire technical knowledge, which makes them move close to the frontier output. This finding agrees with comparable findings by Seyoum, Battese and Fleming (2007).

Household size coefficients of the small scale farm indicates negative sign δ_2 (-0.2990) this implies that small scale farm household sizes are more technically efficient since small scale farmers do not make use of hired labour as such since they made use of family labour hence the cost of hiring labour is save, The positive coefficient for age δ_3 (0.6667) variable in small farm sizes implies that the older farmers are more technically inefficient than the younger ones. Older farmers tend to be more conservative and less receptive to modern and newly introduced agricultural technology. The (δ_4) coefficient of farming experience in small scale farms is estimated to be negative, that is (-0.6912) and statistically significant at the 1 percent level. The implication is that farmers with more years of farming experience tend to be more efficient in rice production. This conforms to the findings of Battese and Coelli (1995) who reported negative production elasticity with respect to farming experience for farmers in two villages in India. While the coefficients of education δ_1 (-0.7011), house hold size δ_2 (-0.8493), age δ_3 (-0.7009) and farm experience δ_4 (-0.9373) in medium farm sizes have negative sign. This implies that farmers' personal characteristics do not contribute to farm inefficiency. Since these variables were not significant, they do not deserve further discussion.

The large scale inefficiency coefficients indicate negative scores for education δ_1 (-0.7741), age δ_3 (-0.8380) and farm experience δ_4 (-0.9373), except household size which have positive sign δ_2 (0.5279), the positive coefficient for the house hold size implies that the large scale farm constitute small household sizes as such the farmers embark on hired labour. This implies that the farmers with small household sizes accommodates hired labour which respond to the use of improved technology, such as the application of fertilizers, use of pesticides and so on, thus producing closer to the frontier.

Table 3: Distribution of Technical Efficiency Ratings among Rice Production in Guma LGA

Class Interval of Efficiency Indices	**Frequency of Farms**			**Percentage of Farms**		
	SM	**MD**	**LG**	**SM**	**MD**	**LG**
0.10 - 0.19	7	-	-	2.8	-	-
0.20 - 0.29	7	-	-	2.8	-	-
0.30 - 0.39	84	25	-	33.6	10	-
0.40 - 0.49	70	89	38	28	35.6	31.7
0.50 - 0.59	82	74	45	32.8	29.6	37.5
0.60 - 0.69	-	62	30	-	24.8	25
0.70 - 0.79	-	-	7	-	-	5.8
0.80 - 0.89	-	-	-	-	-	-
0.90 - 1.00	-	-	-	-	-	-
Total	**250**	**250**	**120**	**100**	**100**	**100**

	Efficiency Rating		
Farm operations:	**Small**	**Medium**	**Large scale**
Mean Efficiency	0.35	0.47	0.54
Minimum Efficiency	0.11	0.39	0.49
Maximum Efficiency	0.59	0.69	0.79

Source: Field survey, 2011

Alongside with the parameters already presented and discussed above, the technical efficiency rating of farmers in the three categories of farm sizes was also estimated. This is presented in table 3. More that 50% of the respondents in small, medium and large scale farms were fund to be more than 32.8%, 54.4% and 68% technically efficiency, while 67.2%, 45.6% and 32% of the respondents in small medium and large scale farms were fund to be less than 50%. The most efficient farmer operated at 59%, 69% and 79% for the small, medium and large scale farms, while the least efficient farmer was fund to operate at 11%, 39% and 49% efficiency level for small, medium and large scale farms. Rice farmers performed at an average technical efficiency of 35%, 47% and 54% for small, medium and large scale farms respectively.

From the results obtained, although farmers were generally relatively efficient, they still have room to increase the efficiency of their farming activities to 65%, 53% and 46% for small, medium and large scale farm respectively to close the efficiency gap from the optimum (100%) which are yet to be attained by all farmers in various scales of operations in the study area. The technical returns to scales measured by the sum of the elasticity of all significant factors showed that small and large scale exhibited increasing return to scale while medium scale farms demonstrated decreasing return to scale, but for pooled observation it depict constant return to scale.

Conclusion and Recommendations

The study showed that the resource use in rice production in the study area was not fully utilized in all the categories of farms examined. However, the highest utilization of resource was recorded for large scale farms, and then followed by medium scale farms and lastly the small scale farms. The rice crisis creates serious problem to food security in Nigeria. However, the following suggestions are made to help solve the rice crisis in Nigeria. Farm inputs such as fertilizers, improved varieties of rice seeds, chemicals for weeding and curbing the activities of pest, rodents and diseases etc should be made available to farmers at highly subsidized rates and make them available timely, through adequate supply and efficient distribution. More so, the extension activities of the extension agents should be revived. So that farmers will make better technical decision and also help in allocating their production input effectively, this will make our local rice a good substitute for imported ones for better consumer patronage.

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