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Farm Size and Determinant of Productive Efficiency among Smallholder Rice Farmers in Abia State, Nigeria

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Abstract

This study examined farm size and the determinant of productive efficiency among smallholder rice farmers in Abia State, Nigeria. The specific objectives were determine the effect farm size on productivity of smallholder rice farmers, estimate the profit function of the respondents, and to ascertain the determinants of productive efficiency among smallholder rice farmers in Abia State, Nigeria. Multi-stage sampling technique was adopted in selecting the respondents for the study. Data collection was by using structured questionnaire which were administered to the respondents. The collected data were analyzed using descriptive statistics such as frequency counts, percentages, means etc. and regression analysis. The ordinary least squares (OLS) model and the stochastic frontier profit model were analyzed. The result showed that farm size is a significant determinant of productivity. The significant factors influencing profit were price of seed (P = 0.01), price of labour (P = 0.05), price of fertilizer (P = 0.10), farm size (P = 0.05), and capital (P = 0.05). On the determinants of efficiency of the rice farmers, all the variables except years of educational attainment were significant. The frequency distributions of the efficiency of the rice farmers showed that the individual efficiency indices range from 42.57 – 100% for farmers with a mean of 87.95%. It was recommended that farmers should be granted access to more farm lands by removing obstacles that hinder land acquisition as cultivation of larger farm lands would lead to increased productivity and efficiency.

1. Introduction

Rice is one of the major staple food crop grown in Nigeria and it is ranked first as the most important cereal crop in sub-Saharan Africa [10]. It provides food for more than 1.2 billion people in addition to other uses. Nigeria with an annual production of close to 8 million metric tons in 2013 is the largest producer in Africa. Rice is the third most widely grown crop in Nigeria, following sorghum and maize. It is highly productive, cheap, less rigorous to produce and adapts to wide range of agro ecological zones [3, 6]. Rice is not only an important cereal crop produced in Nigeria on the basis of output but also on the basis of number of farmers that produced it, as well as for its economic value [30]. An estimated 4.2 million hectares were harvested in 2013 with an average yield of 2 metric tonnes per hectare [15].

Rice is an important food crop in Nigeria and its consumption is growing, particularly among urban dwellers in Abia state. Rice contributes 90% of the food requirements of the country. The importance of rice in the Nigerian economy is also seen in its contribution to agricultural GDP and employment. Therefore as Nigeria struggles to achieve accelerated growth in food production, increasing the output of rice has become an important goal. The strategic nature of rice has long drawn the attention of policy makers who view promoting domestic rice production as a means of reducing dependency on imports, lowering the pressure on foreign currency reserves, ensuring stable and low-priced sources of food for people, and generating employment and income for rice growers [30].

Unfortunately, the domestic production of rice has not met the demand, leading to food shortage problems. [7] projected annual growth in rice consumption for Nigeria as 4.5% beyond 2000. In a bid to address the demand/supply gap for rice, the government at various times had come up with policies and programmes such as rice importation to supplement the local production which no doubt continues to drain the country's hard earned foreign exchange earnings. [7] estimated that Nigerian rice import increases from 2630 tonnes in 1980 to 1876 million tonnes in 2002. The total import also stood at 1.9 million tonnes in 2003 [4].

The continued fluctuation in rice production in the country is an indication of limited capacity of the Nigeria rice economy to match the domestic demand which can be attributed to the inability of the rice farmers to obtain maximum output from the resources committed to the enterprise [17]. For instance, an average yield of rice in Nigeria is 1.8 tonnes per hectare compared to 3.0 tonnes / hectare from a country like Cote d'Ivoire and Senegal [33]. The existing level of production in rice in the country reflects low level of production efficiency of rice farmers in the country as this is a serious problem in achieving food security in the country and poor management of farm size. Also, the ability of rice farmers in Nigeria to adopt new agricultural technologies is affected by farmer's farm size and farm characteristics. Examples of such characteristics include age and household size of rice farmers, total number of years of farming, total land area used for rice production, and farmer's managerial ability or experience in rice farming. Others are extension visits and benefit of credit facility

Land is the major source of wealth and livelihood for rural inhabitants, whose are predominantly small scale farmers. [26] noted that small scale farmers have consistently remained the major producers of rice in Nigeria, producing over 80 percent of the total rice output. There is an emerging consensus that technical efficiency and overall performance of farms are influenced by farm size so that larger and more diversified farms are more productive or efficient than small farms [16]; hence, positive size–productivity relationships [34].

According to [9], the concept of efficiency is concerned with the relative performance of the processes used in transforming given inputs into output. The analysis of efficiency is generally associated with the possibility of farms producing a certain optimal level of output from a given bundle of resources at least cost. Efficiency is achieved either by maximizing output from given resources or by minimizing the resources required for producing a given output [32]. Production efficiency is the product of technical and allocative efficiencies. Technical efficiency is the ability of a farm to maximize output for a given set of resource inputs while allocative efficiency refers to the choice of optimum combination of inputs consistent with the relative factor prices [21, 9].

This study therefore, investigated the farm size and determinant of productive efficiency among smallholder rice farmers in Abia State, Nigeria. The specific objectives were to determine the effect farm size on productivity of smallholder rice farmers, estimate the profit function of the respondents, and to ascertain the determinants of productive efficiency among smallholder rice farmers in Abia State, Nigeria.

2. Research Methodology

The study was conducted in Abia State, Nigeria. Abia State is located in the South East geopolitical zone of Nigeria. It is bounded by Imo State on the West, Ebonyi and Enugu State on the North; Cross Rivers and Akwa Ibom State on the East and by River State on the South. The state has a population of about 2,833,999 persons and a population density is about 364 person per square kilometer [19]. Geographically, the State lies within between longitude 040 451 and 060171 North of the equator and latitude 07'00' and 08^0 10^1 East of the Greenwich Meridian. Abia State has 17 Local Government Areas (LGAs), grouped into three Agricultural Zones, namely – Ohafia, Umuahia and Aba Agricultural Zones. Agriculture is the major occupation of especially the rural dwellers; and subsistence farming is prevalent and about 70 percent of the population is engaged in it [12]. The major crops cultivated includes yam, cassava, rice, maize, cocoyam, melon, garden egg, fruit and vegetables.

Multi-stage sampling technique was adopted in selecting the respondents for the study. Firstly, Ohafia Agricultural Zone was purposively selected, being the major area of rice production in the State. The second stage involved the purposive selection 2 LGAs out of the 5 LGAs in the Zone. The LGAs were Bende and Arochukwu. From each of the selected LGA, 3 communities were selected randomly in the third stage. The fourth stage involved the random selection of 3 villages from each community. In the final stage, 6 rice farmers were randomly selected in each village giving a total of 108 respondents. However, of the 108 questionnaire distributed, 103 were retrieved and 98 were found useful and used for the analysis.

Data collection was by using structured questionnaire which were administered to the respondents. The collected data were analyzed using descriptive statistics such as

frequency counts, percentages, means etc. and regression analysis. The ordinary least squares (OLS) model and the stochastic frontier profit model were analyzed.

For the effect of farm size on productivity, the Cobb-Douglas function was analyzed and is specified as follows:

$$LnY = b_0 + b_1 LnX_1 + e \quad (1)$$

Where Y is productivity measured as the ratio of the value of output to the value of input; X_1 = farm size measured in hectares; b_0 = intercept, b_1 = coefficient to be estimated; and e = error term.

The theoretical model of the stochastic profit function is given as:

$$\prod_i = f(P_{ij}, Z_{kj}) \exp. (V_j - U_i) \quad (2)$$

Where $\prod_i$ is the normalized profit of the j-th farm defined as gross revenue less variable costs divided by farm specific output price; P_{ij} is the price of the i-th variable input faced by the j-th farm divided by the price of output; Z_{kj} is the level of the k-th fixed factor on the j-th farm; f is an appropriate function such as Cobb-Douglas, translog, etc; Vj is stochastic disturbance term representing the effect of random factors beyond the control of the farmer e.g. weather, diseases outbreaks, measurement errors, etc. V_i is assumed to be independently and identically distributed as N (O, δ_v^2) random variables independent of the U_is which is a non-negative random variable representing profit or economic efficiency. The U_is are assumed to be non-negative truncations of the N (O, δ_v^2) distribution (i.e. half normal distribution) or have exponential distribution. If $U_i = 0$, the farm lies on the profit frontier obtaining maximum profit given the prices it faces and levels of fixed factors. If $U_i > 0$, the farm is inefficient and losses profit because of inefficiency. The stochastic frontier model was independently proposed by [1, 18].

The economic efficiency of an individual farmer is defined in terms of the ratio of the observed profit to the corresponding frontier profit given the prices and levels of fixed factors of production of the farmer.

$$\text{Economic (profit) efficiency (EE)} = \prod/\prod^* = f(P_{ij}, Z_{kj}) \exp.(V_j - U_i)/ f(P_{ij}, Z_{kj}) \exp.(V_i) \quad (3)$$

$$= \exp (U_i)$$

Where $\prod$ is the observed profit and $\prod^*$ is the frontier profit and other parameters were as previously defined. The parameters of the stochastic frontier models are estimated using the maximum likelihood techniques [1]

The empirical model: The profit function of the rice farmers in the state is assumed to be represented by a Cobb-Douglas frontier profit function and is specified as follows:

$$\text{In } \prod p^* = \text{In } \alpha_o + \alpha_1 \text{ In } P^*_1 + \alpha_2 \text{ In } P^*_2 + \alpha_3 \text{ In } P^*_3 + \alpha_4 \text{ In FS} + \alpha_5 \text{ In CAP} + V_j - U_i \quad (4)$$

Where in equation (4), In = natural logarithm, α_0 = intercept, $\alpha_1 - \alpha_2$ = coefficients of the parameters, $\prod p^*$ = normalized profit in naira per rice farmer, P^*_1 = normalized price of seed in naira, P^*_2 = normalized price of labour in naira, P^*_3 = normalized price of fertilizer in naira, FS = farm size in hectares, CAP = capital (naira), and other variables were as previously defined.

In order to determine the factors contributing to economic efficiency, the following model was formulated and estimated jointly with the stochastic frontier profit model in a single stage maximum likelihood estimation procedure using the computer software frontier version 4.1 (Coelli, 1996):

$$EE_i = a_0 = a_1Z_1 + a_2Z_2 + a_3Z_3 + a_4Z_4 + a_5Z_5 + a_6Z_6 + a_7Z_7 + a_8Z_8 + a_9Z_9 \quad (5)$$

Where: EE_i is the economic efficiency of the i-th farmer, Z_1 is the age of the farmer (in years), Z_2 is household size, Z_3 is farmer's level of education in years, Z_4 is years of farming experience, Z_5 is number of extension contact made by the farmer in the cropping year, Z_6 is farm size (in hectares), Z_7 is membership of farmers association or cooperative society (a dummy which takes the value of unity for members and zero if otherwise), Z_8 is access to credit (a dummy which takes the value of unity for access and zero if otherwise), Z_9 use of improved rice variety (a dummy which takes the value of unity for use and zero if otherwise), and a1, a_2, a_3,..., a_9 are regression parameters to be estimated. It is expected *a priori* that a_1 and a_2 would be negative while the others would be positive.

3. Results and Discusssion

3.1. Effect of Farm Size on Productivity

The estimated Cobb-Douglas function of the effect of farm size on productivity is presented in Table 1. The coefficient of multiple determination was 0.7719 which implies that 77.19% of the variations in productivity was explained by farm size. The f ratio was significant at 1% level of significance indicating the goodness-of-fit of the model. The coefficient of farm size was significant at 1% and positively related to productivity. This implies that productivity increases with farm size. This conforms to the findings of [34, 27, 25, 2, and 31]. Large farms are more amenable to mechanization and application of superior technology leading to increased output per unit of input. Also larger farms enjoy economies of scale. This explains the positive relationship between productivity and farm size.

Table 1. *Estimated regression result of the effect of farm size on productivity.*

Variable	Coefficient	Standard error	t - ratio
Intercept	3.633	1.201	3.33***
Farm size	0.414	0.063	6.59***
R^2	0.7719		
R-^{2}	0.7243		
F - ratio	16.24***		

Source: Computed from survey data, 2016.

3.2. Stochastic Frontier Profit Function

The maximum likelihood estimates of the Cobb-Douglas stochastic profit function parameters of the rice farmers is

presented in Table 2. The coefficients of the prices of seed and fertilizer were negatively signed and significant at 1% and 10% respectively. This implies that the profit level increases with decrease in the prices of these variables. The coefficient of the price pf labour, farm size and capital were positively and significantly related to the profit at 5% level of significance. Hence, increase in the level of employment of these inputs, *a priori,* will lead to increase in the level of profit.

Table 2. *Cobb-Douglas stochastic profit function estimates of economic efficiency of the farmers.*

Production factor	Parameter	Coefficient	Standard error	t-ratio
Constant term	α_0	11.697	1.092	10.716***
Price of seed	α_1	-0.623	0.172	-3.624***
Price of labour	α_2	0.419	0.169	2.477**
Price of fertilizer	α_3	-0.329	0.204	-1.61*
Farm size	α_4	0.547	0.276	1.98**
Capital	α_5	0.639	0.283	2.257**
Diagnostic statistics				
Log likelihood function		-0.889E+02		
Total variance	δ^2	0.594	0.107	5.551***
Variance ratio	γ	0.735	0.112	6.563***
LR test		0.1653E+02		

Source: Computed from Frontier 4.1 MLE/ survey data, 2016

The estimated variance is statistically significant at 1 percent indicating goodness of fit and the correctness of the specified distribution assumptions of the composite error terms for both groups of farmers. However, the variance of the non-negative farm effects is a non-significant proportion of the total variance of farm profits. Gamma (γ, given by [λ^2 / 1 + λ^2]) is estimated at 0.735 indicating that 73.5% of the total variation in farm profit are due to economic inefficiency.

3.3. Sources of Economic Efficiency

The estimated determinants of economic (productive) efficiency of the smallholder rice farmers is presented in Table 3. Apart from the level of educational attainment, all the variables were statistically significant.

Table 3. *Determinants of economic efficiencies of the men and women rice farmers.*

Variable	Notation	Coefficient	Standard error	t-ratio
intercept	a_0	-1.601	0.261	-0.613
Age	a_1	-11.209	0.101	-11.147***
Household size	a_2	0.297	0043	6.879***
Years of education	a_3	0.004	0.019	0.219
Farming experience	a_4	0.330	0.103	3.320***
Extension contact	a_5	6.276	0.898	6.986***
Farm size	a_6	0.536	0.116	5.62***
Farmers association	a_7	2.583	0.269	9.642***
Access to credit	a_8	1.109	0.282	3.933***
Improved variety	a_9	0.032	0.019	1.636*

Source: Computed from Frontier 4.1 MLE/ survey data, 2016

The coefficient of age was significant at 1% level of significance and negatively related to economic efficiency. This implies that the economic efficiency of the rice farmers decreases as they farmers get older. This is consistent with *a priori* expectation. This result is consistent with [9, 13, 8] who stated that the older a farmer becomes, the more he is unable to combine his resources in an optimal manner given the available technology. [14, 9, 22] posited that the risk bearing abilities and innovativeness of a farmer, his mental capacity to cope with the daily challenges and demands of farm production activities and his ability to do manual work decrease with advancing age.

The coefficient of household size was significant at 1% level and positively related to economic efficiency of the rice farmers. This implies that the larger the household size, the higher the economic efficiency of the farmers. This could be as a result of the farmers sourcing labour for their farm operations from members of their households. Iheke (2010) reported large household size provide cheap source of labour for farm work as farmers rely more on members of their households for labour which more predictable than hired labour.

The coefficient of years of farming experience was significant at 1% level and positively related to economic efficiency. This result implies that the higher the experience of the farmer, the more economically efficient he/she becomes. It has been noted that farmers would count a lot more on their farming experience for increased productivity and efficiency [24, 21]. Thus the result has some positive implications for increased rice productivity because according to [22, 11], the number of years a farmer has spent in the farming business may give an indication of the practical knowledge he has acquired on how he can overcome certain inherent farm production problems and

challenges. This result conforms to the finding supports [28, 29,20,31] that farmers with more experience would be more efficient, have better knowledge of climatic conditions and market situation and are thus, expected to run a more efficient and profitable enterprise.

The coefficient of farm size was significant at 1% and positively related to efficiency. This implies that larger farms are more economically efficient than smaller farms. This conforms to the result of farm size and productivity.

The coefficient of extension contact was significant at 1% level of significance and positively related to economic efficiency. This implies that increased extension contact increases economic efficiency. Extension services provide informal training that helps to unlock the natural talents and inherent enterprising qualities of the farmer, enhancing his ability to understand and evaluate new production techniques leading to increased farm productivity and incomes with concomitant increase in the welfare of the farmer (Nwaru *et al.,* 2011). Iheke (2010) stated that farmers' interactions with extension agents would help them to receive and synthesize new information on economic activities in his locality and beyond.

The coefficient of cooperative membership was significant at 1% level of significant at positively related to the economic efficiency of the rice farmers. This implies that farmers who belong to cooperatives/farmers association has higher efficiency than non-members. [11] noted that cooperative societies/ farmers' associations are sources of good quality inputs, labour, credit, information and organized marketing of products. According to [35], members of cooperative societies have enhanced ability to adopt innovations than non-members.

The coefficient of access to credit was significant at 1% level and positively related to economic efficiency. This means that access to credit increases efficiency of the farmers. Access to credit make it possible for the farmers to acquire improved farm inputs and labour saving technologies, leading to increased efficiency.

3.4. Distribution of Economic Efficiency

The frequency distributions of the economic efficiency of the rice farmers were presented in Table 4.

Table 4. *Distribution of economic efficiency of the rice farmers.*

Economic efficiency range (%)	Frequency	Percentage
41-50	5	6.25
51-60	9	11.25
61-70	13	16.25
71-80	15	18.75
81-90	27	33.75
91-100	11	13.78
Total	80	100
Maximum economic efficiency	100.00%	
Minimum economic efficiency	42.57%	
Mean economic efficiency	87.95%	

Source: Computed from Frontier 4.1 MLE/ survey data, 2016

The individual economic efficiency indices range from 42.57 – 100% for farmers with a mean of 87.95%. Majority (82.5%) of the rice farmers had an efficiency index of above 60 percent. The level of economic efficiency obtained in this study still suggest that ample opportunities exist for both groups of farmers to increase their productivity and income through increased efficiency in resource utilization in their farm operations.

4. Conclusion

It could be concluded from this study that the size of farm cultivated is a major determinant of productivity and efficiency, given that large farms are more amenable to mechanization and application of superior technology leading to increased output per unit of input and also large farms enjoy economies of scale. Again, the farmers were relatively economically efficient as shown by the mean efficiency of 87.95%. However the efficiency index suggest that there exist potential for the farmers to increase their productivity and income through increased efficiency in resource utilization. It was recommended that farmers should be granted access to more farm lands by removing obstacles that hinder land acquisition as cultivation of larger farm lands would lead to increased productivity and efficiency.

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