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Analysis of Technical Efficiency of USAID-MARKETS II Project Participant and Non-Participant Rice Farming Households in Ebonyi State, Nigeria

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Abstract. Low level production efficiency of the Nigerian farmers have continued to be a major problem towards food security in Nigeria. The study examined the technical efficiency of USAID-MARKETS II project participant and non-participant rice farming households in Ebonyi State, Nigeria. A multi-stage sampling procedure was employed to select 491 rice farming households which comprise 239 participants, and 252 non-participants. Primary source of data were collected with the use of a structured interview questionnaire and field participation. Data were analyzed using mean, standard deviation, and percentage, Z statistic, and stochastic frontier Model. The result from the study, reveals that the USAID-MARKETS II project participants were 92% technical efficient while USAID-MARKETS II project non-participants were 91% technical efficient. The result further reveals that a significant difference exist between the participants' technical efficiency and that of non-participants of USAID-MARKETS II project. Household size and education were the vital factors that improved technical efficiency of the rice farmers. Therefore, Ebonyi rice farmers should be adequately trained on modern rice production techniques by the government agency, Agricultural Development Programme (ADP) and non-governmental agencies. Also, adequate extension services should be provided to the farmers by the ADP for proper information dissemination.

Keywords: comparative analysis, efficiency, rice production, stochastic frontier production function

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1. Introduction

The agro-ecological zones in Nigeria, favours the cultivation of rice. The climatic, vegetative and soil conditions in Nigeria are suitable for rice production. Despite this potential, Nigeria is still into rice importation [1]. Between 2001 and 2003, Nigeria imported 1.90 million tonnes of rice. In 2018, Nigeria imported 3.0 million tonnes of rice [1], [2] Rice production in Nigeria has traditionally been characterized by low yields, and slow growth [3]-[7]. Rice yield in Nigeria reached its peak in the mid-1980s, and has since been stagnant or even declining [5]. The land

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area that could be cultivated in rice is roughly 4.7 million hectares, but only 2.7 million hectares were put into rice production due to inability of the farmers to take up rice production as a serious business [8]-[9]. The current rice area in Nigeria is the largest within Sub-Sahara Africa (SSA), and almost twice as large as that of the second largest producer, Madagascar [9]. Progress has been made in increasing the hectares of land under rice production, but declines in rice productivity has been the problem [6], [9].

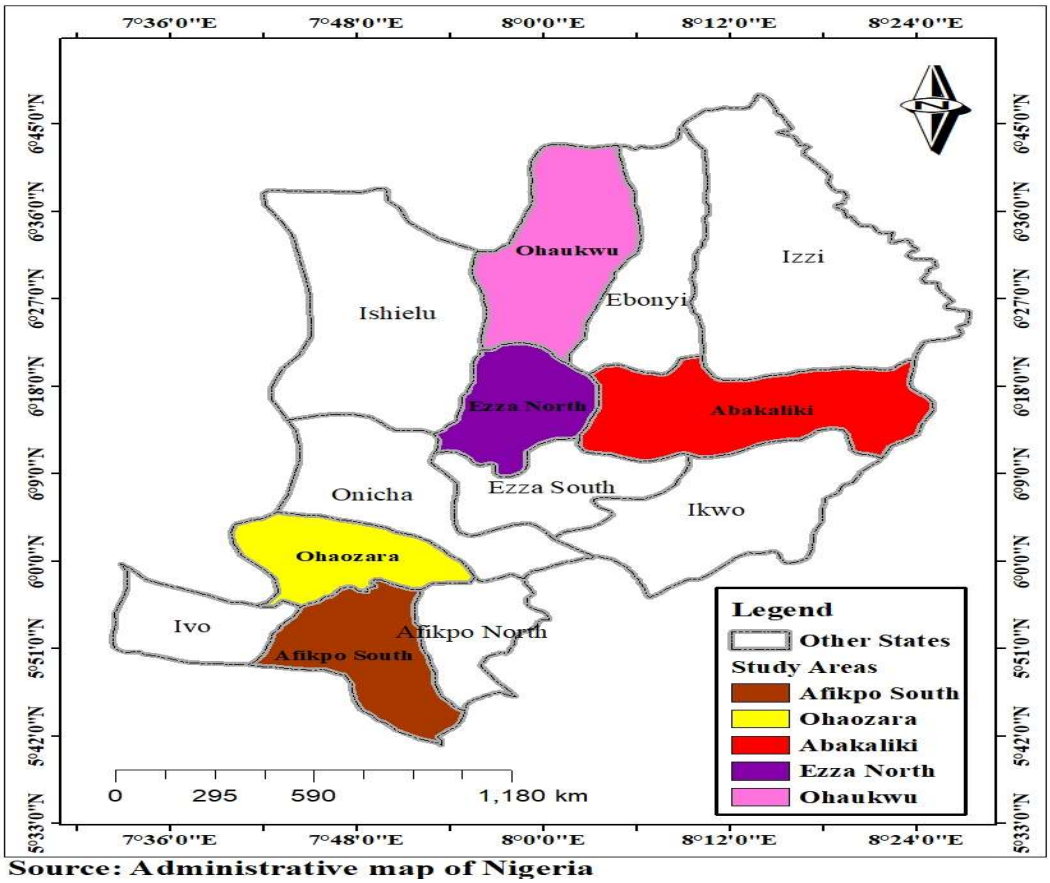
Low rice productivity have continued to be a major challenge facing rice producers in Nigeria [4], [6], [9]. The stagnation in agricultural productivity in Nigeria was as a result of loss of efficiency in agricultural production [9]. Changes in productivity are as a result of differences in the efficiency of the production process; differences in production technology, and differences in the environment in which production takes place [10]. Technical efficiency is considered as an important factor in productivity, if the inputs are not efficiently utilized, the resulting output will not be able to pay off all the factors of production [11]. Technical efficiency refers to the ability of a producing firm to obtain maximum or optimal output from the available inputs. Therefore, the level of technical efficiency is measured by the distance of farm production from the optimal production frontier.

In the quest to increase rice productivity and production, Nigerian government adopted many strategies and policies. USAID-MARKETS II is one of the strategies adopted by the Nigerian government to improve rice production and address low rice productivity. USAID is the United States Agency for International Development. They provides foreign aids to poor countries. The intervention of USAID in agricultural production is called Maximizing Agricultural Revenue and Key Enterprises in Targeted Sites (MARKETS). USAID MARKETS started operation in Nigeria in the year 2005. USAID MARKETS II project has the mandate of assisting rice producers with knowledge and skills in order to increase rice productivity, income, and better their well-being [12], [13].

Despite past interventions in the rice sector, the rice farmers in Nigerian are still technically inefficient. Literatures have proven that smallholder farmers in Nigeria are still inefficient in their resources utilization [7], [8], [14]-[17], and therefore are not maximizing their resources' potentials. Research works [18], [19] conducted on Ebonyi rice production, failed to look into the efficiency with which the participants of government rice projects utilizes the available/given resources. In order to address rice production problem in Nigeria, this research work tends to open a new dimension to the government, and policy makers on how rice producers who participated in any government rice projects increases rice production with the existing resource base, and available technology. Therefore, this research work aims at analyzing the technical efficiency of USAID-MARKETS II Project participant and non-participant rice farming households in Ebonyi State, Nigeria.

2. Methodology

The study was conducted in Ebonyi State. The major occupation in Ebonyi State is Agriculture. About 85% of Ebonyi people earns their living from agriculture. The total land area in Ebonyi State is 5,935 km^2 [20]. Among the agricultural potential are the production of Abakaliki rice, cultivated in an estimated land area of 311,208 hectares by over 140 thousand farmers [21], and contributing over 256,000 MT to the national quota [4], [22]. The Abakaliki rice is blessed with nutritional values which has made it to stand out among other local rice [21], [23]. Ebonyi State is within the Latitude 7^0 30E, and 8^0 30E, and Longitude 6^0 40N, and 6^0 45N and made up of 13 Local Government Areas (LGAs), with a total population of 3.1 million people.



Source: Administrative map of Nigeria

Figure 1. Map of Ebonyi State Showing Study Areas

2.1. Sampling Procedure

The study employed the use of multi-stage sampling procedures. The 1st stage involves random selection of four (4) Local Government Areas (LGAs) out of 12 that was involved in USAID-MARKETS II. The 2nd stage involves random selection of three (3) villages each from the 4 LGAs to give 12 villages in total. The 3 villages (selected on equal proportion basis) captured more than 10% of the total villages in each of the Local Government Areas. In the 3rd stage, 239 USAID-MARKETS participants were selected from their list. Lastly, [24] scientific formula for calculating sample size and adopted by [17]. The 12 sampled villages and the number of households selected include Onu-ebonyi = 24, Agelegu = 9, Ogbuchie = 10, Ufueseni = 17,

Ndikpo = 25, Owutu = 61, Agbaugo Okpo = 8, Enuogurugu = 18, Uchechi-Okposi = 11, Amoffia = 23, Umuakpu = 8, and Ngbo = 25.

[24] scientific formula is given as $n = \frac{N}{1+N(\propto^2)}$, 5% margin for error was given in the sample size selection. Where n = sample size, N = population size, and $\propto^2$ is the error margin (0.05). Six villages (>10%) were randomly selected from one LGA that was not involved in USAID-MARKETS II to serve as the control group. Also, from the list of non-participants, 252 of them were selected using the Yemen scientific formula. The six sampled villages which include Oriuzor = 52, Amuda = 34, Umuogharu = 54, Ogboji = 22, Umuezekaoha = 58, and Umuezeoka = 32. Therefore, a total sample size of 491 rice farming households was used for the study. Primary data was with the aid of structured interview questionnaire, and field participation. Data were analyzed using mean, frequency and percentage, Z statistic, and stochastic frontier model. Cost route survey approach was used in collecting the required data in three stages – after planting, during weeding, and after harvesting of rice for 2018 season.

2.2. Model Specification

Stochastic Frontier Production Function model was developed by [25]. The model is specified as

$$Y = f(Xi,\beta) + \varepsilon i \quad (1)$$

where: Yi = output of the farm, Xi = vector of inputs, β = vector of the parameter estimated, vi = random error outside farmer's controlled, ui = technical inefficiency effects.

Cobb Douglas production function is fitted into the stochastic frontier model, and the empirical stochastic frontier production model is specified thus:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + v_i - u_i \quad (2)$$

where: ln = logarithm to base e, Y_i = output of rice (kg), β_0 = constant, β_1 - β_5 = parameters estimated, X_1 = farm size (ha), X_2 = fertilizer (kg), X_3 = labour (man-days), X_4 = herbicide (litre), X_5 = rice seed (kg).

The inefficiency effect is non-negative with half normal distribution. It is assumed that it is truncated at zero and thus it is specified as;

$$U_i = \delta_0 + \delta_1 \ln Z_{1i} + \delta_2 \ln Z_{2i} + \delta_3 \ln Z_{3i} + \delta_4 \ln Z_{4i} + \delta_5 \ln Z_{5i} + \delta_6 \ln Z_{6i} \quad (3)$$

where U_i = technical inefficiency, δ_0 = constant, δ_1 - δ_6 = parameters estimated, Z_{1i} = age (years), Z_{2i} = education (years spent in formal education), Z_{3i} = household size (number), Z_{4i} = years spent in cooperative society (years), Z_{5i} = years in rice farming (years), Z_{6i} = extension visit (number of visit per rice farming period).

3. Results and Discussion

3.1. Socio-Economics and Demographic variables of the Respondents

The socio-economics and demographic characteristics results of the farming households as presented in Table 1 were analyzed using mean and standard deviation.

Table 1 shows that majority of USAID-MARKETS II project participant and non-participant households (70.94% and 70.25% respectively) were headed by males. This shows that male headed households participated in USAID-MARKETS II more than their female-headed counterpart. This is in line with [26] who discovered that males participated more in FADAMA II in Kogi State. The average age of USAID-MARKETS II participants were 47 while that of non-participants were 46. This implies that majority of both participants and non-participants are still within their productive stage. This is in line with [27] who found an average age of 42 and 45 for Fadama III participants and non-participants respectively in Abia State. Table 1 reveals that the average sizes of households of participants and non-participants in the study area were 7 and 6 respectively. Thus, rice farming households have a good source of family labour for their farm business. This agrees with [27] who found an average household size of 7 and 5 members for participants and non-participants respectively, of Fadama III in Abia State.

Table1. Socio-economics Characteristics of the Respondents

Variables	Participants Mean	Std Error	Non-participants Mean	Standard error
Sex (Male, Female)	(70.9%, 29.06%)	0.46	(70.25%, 29.75%)	0.48
Age (years)	47	10.49	46	10.04
Household size	7	2.83	6	2.47
Years in education	9	4.52	8	4.81
Extension visits	2	0.86	0.13	0.37
Years in rice farming	21	9.37	23.38	9.60
Rice farm size	1.28	0.83	1.12	0.61

It is believed that educational level of the household head affects his/her level of performance in farming. Table 1 reveals that the average years spent in formal education by participants and non-participants were 9 and 8 respectively. This shows that majority of the USAID-MARKETS II participants and non-participants had some level of formal education and therefore, can understand productive information that aid in effective farm management decision. This finding validates [28] who observed an average education of 8 and 9 years for Fadama III participants and non-participants respectively in North Central Nigeria. Extension visit is believed to increase adoption of improved technology. The study revealed that the average number of extension-visits to the participants were 2 times per farming period which is inadequate for the extension worker to guide them through the farming period. Extension visit was negligible for non-participants (0.13 almost non-existent for the entire production season), implying that adoption of an innovation will be quite difficult for them. The average years of rice farming experience of the participants and non-participants were 21 and 23.38 respectively, which is long enough for them

to improve their performance in rice operation. The average rice farm size of participants were 1.28 hectares while that of non-participants were 1.12 hectares. This shows that both participants and non-participants of USAID-MARKETS II project were mainly small-holder farmers.

3.2. Rice Production of USAID-MARKETS II Participants (UMP) and Non-participants of USAID-MARKETS II (NPUM)

The rice production of USAID-MARKETS II participants (UMP) and non-participants of USAID-MARKETS II (NPUM) are presented on Table 2. Table 2 shows that the sigma-squared (σ^2) estimate of 0. 66 and 0.79, gamma estimate of 80% and 69%, and the likelihood ratio of -115.6 and -130.7 respectively for UMP and NPUM were significantly different from zero at $P < 0.01$ level, which indicate a goodness of fit for the model. Table 2 reveals that the UMP estimated elasticity of output with respect to rice farm size were 0.77, and significantly positive at $P < 0.01$ level of probability. This shows that as the area cultivated with rice by the participants increases, output will increase as well, and vice versa. The result further reveals that holding other variables constant, 1% increase in the area cultivated with rice by the participants, will increase rice output by 0.77%. The fertilizer coefficient (0.05) was positive and significant at 0.05 level of probability, which implies that as the amount of fertilizer used in the rice production increases by 1%, rice output will increase by 0.05%. The estimated elasticity of output with respect to labour inputs were 0.12, and statistically significant at 10%. This means that a unit increase in labour (man-days) used in rice production by the participants, increases the output of rice by 0.12 unit. Using the coefficients of all the production variables, the returns-to-scale was 0.995. This shows decreasing returns to scale in the rice enterprise. This implies that the participants were at the stage 2 of the production function.

On the other hand, the result of non-participants in Table 2 shows that the estimated elasticities of the output with respect to rice farm land was 0.82 and significant at 5% level of probability. This shows that as the area cultivated with rice by the non-participants increases, output of rice increases as well, and vice versa. The result reveals that 1% increase in rice farm size by NPUM, will increase the output of rice by 0.82%. Likewise, the estimated elasticities of the output with respect to labour was 0.14, and statistically significant at $P < 0.1$. This means that as the man-days utilized in the rice production by NPUM increases, the output of rice increases as well, and vice versa. The result shows that a 1% increase in labour (man-days) used in rice production by the non-participants, will increase output of rice by 0.14%. Using the coefficients of all the production variables, the returns-to-scale was 0.917, showing decreasing returns to scale. This implies that non-participants of USAID-MARKETS II were also at the stage 2 of production function. This is the rational or economic production region where production is maximized. This is in line with [29].

3.3. Technical Inefficiency of USAID-MARKETS II Participants (UMP) and Non-Participants of USAID-MARKETS II (NPUM)

Socio-economic variables were considered, and estimated in the model, and the result are presented on Table 2. For the UMP, the result shows that the estimated coefficient for years of formal education was negative and significant at 1%. This reveals that participant farmers with more educated are technically efficient in rice production than those with less education. This could be due to their ability to read, write, and understand rice market and farming situation more than the less educated ones. Also, they may have undertaken self-training and other empowerment programmes that enrich their knowledge about the act of rice farming. This is in line with [30] who found that education increases technical efficiency. However, household size had a negative and significant influenced on inefficiency at $P < 0.1$ probability level. This reveals that households with more members are technically efficient in rice production than those with few members. This could be because large household size enhances labour availability as most of the members are directly involved in the farming business.

Table 2. Rice Production among UMP and NPUM

Variable	UMP coef	Std err	t value	NPUM coef	Std err	t value
Constant	7.516	0.380	19.77***	6.918	0.973	7.065***
Farm size	0.768	0.073	10.52***	0.818	0.146	5.614***
Fertilizer	0.052	0.025	2.10**	0.122	0.133	0.919
Labour	0.123	0.073	1.67*	0.140	0.076	1.860*
Herbicide	0.006	0.008	0.72	0.006	0.004	0.134
Rice Seed	0.047	0.039	1.22	-0.169	0.127	-1.329
Ineff. variables						
Constant	-6.571	2.124	-3.10***	-0.077	0.927	-0.083
Age	0.020	0.023	0.84	0.002	0.020	0.082
education	-0.282	0.094	-3.01***	-0.001	0.027	-0.038
Household size	-0.118	0.070	-1.68*	-0.103	0.022	-4.761***
cooperative	-0.130	0.056	-2.34**	0.101	0.023	4.437***
Years of rice farming	-0.099	0.026	-3.82***	0.004	0.014	0.319
Extension visit	-0.106	0.016	-0.65	-0.105	0.017	-1.015
Sigma-square	0.657	0.102	6.42***	0.789	0.076	10.415***
Gamma	0.798	0.040	19.9***	0.686	0.045	15.19***
Loglikelihood	-115.6			-130.7		

Note *** = P< 001, ** = P< 0.05, * = P< 0.1 respectively

Table 2 further shows that holding other variable constant, 1% increases in the household size of the participants, will decrease technical inefficiency by 0.12%. This is in line with the works of [7], [30]. Also, the coefficient of years in cooperative were found to be negative, and significant at $P < 0.05$ probability level. This means that UMP who spent more years in a cooperative, tends to be more technically efficient than others. This could be due to experience and knowledge being shared in such organization, and most times training are usually conducted for those who are in a cooperative society. This is in line with [28]. Lastly, the coefficient of rice farming experience were found to be negative, and significant at $P < 0.01$ probability level. This shows that those

with more experience, tends to be more technically efficient than others. This could be due to the fact that the more experience the rice farmers are, the better the ability of the farmer to obtain and process information relating to prices, and new technology.

For the NPUM, Table 2 shows that the coefficient for household size were negative, and significant at $P < 0.01$ probability level. This shows that non-participant household with larger members tends to be more technically efficient in rice production than those with fewer members. Also, coefficient of cooperative was positive and significant at $P < 0.01$ probability level, which is against the *a priori* expectation. This could be due to the fact that NPUM have not stayed in a cooperative society for long in order to get benefits of information/knowledge sharing from the cooperative.

3.4. Technical Efficiency of the USAID-MARKETS II Participants (UMP) and Non-Participants of USAID-MARKETS II (NPUM)

The technical efficiency levels for UMP and NPUM households in the study area are presented on Table 3. The result shows that the UMP mean technical efficiency were 0.92, which suggests that on average, UMP households were 8% less from the maximum possible level due to technical inefficiency. Likewise, the NPUM mean technical efficiency were 0.91, which suggests that on average, the observed output was 9% less than the optimum output. This implies that there are still room for improvement for both UMP and NPUM technical efficiencies in rice production. Thus, both UMP and NPUM are expected to be highly productive as a result of their high technical efficiencies. This is in line with [29] who revealed 0.89 technical efficiency.

Table 3. Technical Efficiency of UMP and NPUM

Ranges	UMP Technical Freq.	Efficiency %	NPUM Technical Freq.	Efficiency %
0.10 –0.24	0	0	0	0
0.25 -0.49	0	0	5	2.07
0.50 –0.74	2	0.9	14	5.78
0.75 -1.00	232	99.1	223	92.15
Total	234	100	242	100
Minimum	0.55			0.38
Maximum	0.99			0.99
Mean	0.92			0.91

3.5. Difference in Technical Efficiency of USAID-MARKETS II Participants (UMP) and Non-Participants (NPUM) in Rice Production

The result of the difference in technical efficiency of UMP and NPUM as presented on Table 4 shows that there were no significant difference between technical efficiency of USAID-MARKETS II participants (UMP) and non-participants (NPUM) in rice production.

Table 4. Difference in Technical Efficiency of UMP and NPUM

Variables	Technical Efficiency UMP	NPUM
Mean	0.924	0.911
Known variance	0.003	0.013
Number of Observation	234	242
Hypothesized Mean Difference	0	
z-statistic	0.856	
P(Z) one (1) tail	0.196	
Z-critical one (1) tail	1.645	
P(Z) two (2) tail	0.392	
Z-critical two (2) tail	1.960	

4. Conclusion and Recommendation

The study established that USAID-MARKETS II project participants were 92% technical efficient while USAID-MARKETS II project non-participants were 91% technical efficient. There was no significant difference between the technical efficiency of participants and non-participants, but there is a room for improvement. Household size and education were the vital factors that increases the technical efficiency of the rice farming households. Therefore, Ebonyi rice farmers should be adequately trained on modern rice production techniques by Ebonyi State Ministry of Agriculture, the Agricultural Development Programme (ADP) and non-governmental agencies. Also, extension services should be provided to Ebonyi rice farmers by ADP to ensure that the farmers fully utilize their resources.

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