

# **INTERNATIONAL JOURNAL OF AGRICULTURE, MANAGEMENT AND TECHNOLOGY**



**Vol 8(1) 2024**

**Published by**  
**Federal College of Agriculture,**  
**Ishiagu Ebonyi State**

## **Productivity and Technical Efficiency of Smallholder Arable Crop farmers in Agricultural Research Adopted Villages in Abia and Rivers States, Nigeria.**

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### **ABSTRACT**

Achieving increased production and income through innovation adoption is possible with efficient use of limited resources among the farmers. The study investigated Productivity and the Technical efficiency of smallholder arable crop farmers in Agricultural Research Adopted Villages in Abia and Rivers States. Multistage sampling technique was used to collect data from 119 participants and 69 non participants in the project using well structured questionnaires. Descriptive and Cobb Douglas stochastic production function frontier were used for data analysis. The results showed that farm size, family labour, hired labour, planting materials, quantity of chemical fertilizer, organic fertilizer and capital input were significant in determining the output of participants while hired labour, organic fertilizer and capital input significantly determined the output level of the non participants. The mean technical efficiency of the participants was 0.89 while that of the non participants was 0.78. Z-test statistics showed that the participants were more technically efficient than the non participant. Gender, household size, level of education, farming experience, credit and membership of farmers' organization influenced the technical efficiency of participants while gender, household size, farming experience and credit were the factors that influenced the technical efficiency of the non participants. The study concludes that though farmers in the adopted villages were not fully efficient, the participants were more technically efficient than the non participants and recommends that teachings on efficient management of resources be included in the project for more impact among the farmers.

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**Keywords: Technical efficiency, adopted villages, participants, non participants, smallholder, arable crop farmers**

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### **1. INTRODUCTION**

Although Nigerian Agricultural sector is dominated by smallholder farmers who produce the bulk of the food requirements of the country, the sector still remains the most viable sector among the oil and non-oil sectors because it still employs the larger percentage of the population; it is multifunctional in nature and has a multiplier effect to the nation's economic development (Simonyan, Amusa and Akpan 2018). Production of arable crops for food and income is very common among the smallholder across the globe. Oluwatosin, Ajiboye, Osundare, Adekunmi, Toluwase and Akokoh (2020) noted that arable crops are grown by almost all households in Nigeria and it serves as a major source of income especially for the increasing rural dwellers. Increase in productivity and income of these smallholder farmers are achievable through adoption of improved technologies. Researchers have shown that adoption of technologies has been low among farmers, majorly due to weak research-extension – farmer linkage. Consequently, agricultural research institutes were saddled with the responsibility of adopting villages by the federal government, to transfer improved technologies to the farmers directly. This is to encourage large scale adoption of technologies among

farmers, especially the smallholders. According to Akinola, Ene and Baiyegunh (2013), the adopted village model is a model aimed at selecting villages within the locality of the institutions to transfer improved technologies directly to the farmers in order to empower the resource poor farmers economically, increase their productivity, farm income and ensure food security. Considering the fact that smallholder farmers are resource poor implying that the resources with which they produce are limited and the land area dedicated to arable crop production is dwindling, efficiency in resource combination as well as increasing productivity per unit area are very vital in achieving success. Oladimeji, Offokansi and Egwuma (2021) stated that food security in Nigeria, among the smallholder farmers is achievable if the farmers move closer to efficiency frontier implying that they produce determined output from a given combination of inputs or use the lowest possible levels of inputs for a given level of output to meet the rapid population growth and competing land use in Nigeria.

Studies have shown that the smallholder farmers are hardly technically efficient and majority of them increase production through increased land area under cultivation, therefore updated knowledge of the technical efficiency of the farmers in the adopted

villages will help the government and stakeholders in policy making. Previous studies in the adopted villages centered on adoption rate of improved technologies, output and income level of beneficiaries. Akinola *et al.* (2013) investigated the extent to which the National Agricultural Extension Research and Liaison Services (NAERLS) adopted village project has improved the livelihood status of beneficiaries in Kaduna State while Oduhie (2015) studied the impact of National Agricultural Extension and Research Liaison Services (NAERLS) of Ahmadu Bello University Adopted Village Project on participants' crop output and income in Abia and Oyo States. Yusuf, Salau and Girei (2019) analyzed the determinants of adoption rate of rice production technologies introduced by Agricultural Research Outreach Centres in Nigeria. The study specifically evaluated some socioeconomic characteristics influencing the farmers' output, investigated the total factor productivity and the technical efficiency of participant and non participants in the adopted villages, compared their technical efficiency, if there is significant difference between them and evaluated the factors influencing the technical efficiency of both groups.

## 2. METHODOLOGY

The study was conducted in Abia and Rivers States, Nigeria. These two states were the only states with functional research adopted villages in the South east and South-shout zones of Nigeria respectively. Michael Okpara University of Agriculture, Umudike and National Agricultural Extension Research Liason Services respectively, were the agricultural research institutions that adopted the villages in Abia and Rivers States used in the study.

Multistage sampling technique was used to select one hundred and eighty-eight(118) respondents from fifteen (15) research adopted villages.. Firstly, purposive selection of Abia and Rivers States was done because of the location of functional adopted villages in these States while the second stage also involved purposive selection of five local government areas from Abia State and three Local Government Areas from Rivers State implying that a total of eight Local Government Areas were sampled. The third stage involved purposive selection of fifteen research adopted villages, twelve from Abia State and three from Rivers State while the fourth stage involved random selection of one hundred and nineteen participants and sixty-nine non participant smallholder arable crop farmers. Data were collected en route cost on farmers' socioeconomic characteristics, input and output levels of the farmers through the use of well structure questionnaires Descriptive and inferential statistics were used in analyzing the data collected. The technical efficiency, productivity and sources of inefficiency were analyzed using Cobb Douglas stochastic production

function frontier in which the stochastic frontier specification incorporates models for technical inefficiency effects and estimates all the parameters simultaneously. According to Eze, 2004 and Ogundari *et al.*, 2006, in Simonyan et., 2012, the stochastic frontier production technique is preferred for accessing efficiency in agriculture because of the inherent stochasticity. It makes it possible to find out whether the deviation in technical efficiencies from the frontier output is due to farm specific factors or due to external random factors,

Following the Stochastic Frontier Production Function developed by Aigner Lovell and Broeck 1977, the model is specified as follows:

$$Y_i = f(X_i, \beta) \exp(V_i - U_i), i = 1, 2 \dots$$

(1)

where:  $Y_i$  = output of the farm,  $X_i$  = vector of input quantities,  $\beta_i$  = vector of the parameter estimated,  $v_i - u_i$  = composite error term  $v_i$  = random error outside farmer's controlled,  $u_i$  = is a non negative random variable representing technical inefficiency effects in production relative to the stochastic frontier.

Maximum likelihood method was used to estimate the parameters of the stochastic frontier production function.

Specifically, the production technology (technical efficiency) of arable crop farmers in the adopted villages was estimated by the Cobb Douglas stochastic production function frontier following Simonyan et., 2012 as follows:

$$\ln Y_i = \beta_0 + \beta_1 \ln k_1 + \beta_2 \ln k_2 + \beta_3 \ln k_3 + \beta_4 \ln k_4 + \beta_5 \ln k_5 + \beta_6 \ln k_6 + \beta_7 \ln k_7 + \beta_8 \ln k_8 + (V_i - U_i) \dots 2$$

Where,  $\ln$  = natural logarithm,  $Y_i$  = output of  $i$ th measured in grain equivalent,  $k_1$  = farm size (ha),  $k_2$  = family labour used in mandays,  $k_3$  = hired labour used (mandays),  $k_4$  = quantity of chemical fertilizer used (kg),  $k_5$  = quantity of organic fertilizer used (kg),  $k_6$  = quantity of planting material used (naira),  $k_7$  = quantity of agro- chemical used),  $k_8$  = capital inputs and  $\varepsilon = V_i - U_i$ ,  $\varepsilon$  = error term,  $V_i$  = random error and  $U_i$  = technical inefficiency, assumed in this study to follow a half normal distribution.  $\beta_0 - \beta_8$  = parameters estimated.

The technical efficiency of farmer  $i$  in the contest of the stochastic production function as indicated in equation 1 as:

$$TE = Y_i / Y^* \dots 3$$

$$= f(X_i; B) \exp(V_i - U_i) / f(X_i; B) \exp(V_i) \dots 4 = \exp(-U_i) \dots 5$$

Where;

$Y_i$  = observed output;  $Y^*$  = frontier output;  $TE$  = technical efficiency

The determinants of technical efficiency of farmers was determined using the error due to inefficiency as dependent variable and estimated jointly with stochastic frontier model in a single stage maximum likelihood estimation procedure using the computer software Frontier Version 4.1C

Exp(-  
 $U_i = \Omega_0 + \Omega_1 Z_1 + \Omega_2 Z_2 + \Omega_3 Z_3 + \Omega_4 Z_4 + \Omega_5 Z_5 + \Omega_6 Z_6 + \Omega_7 Z_7 + \Omega_8 Z_8 + e$  ...6  
 Where  $U_i$  = inefficiency effects,  $Z_1$  = age of farmer in years;  $Z_2$  = gender of farmer (dummy; 1= male, 0 = female);  $Z_3$  = household size (measured numerically);  $Z_4$  = educational level of farmer in years;  $Z_5$  = Farming experience (years);  $Z_6$  = amount of credit (in naira);  $Z_7$  = extension contact (number of visits);  $Z_8$  =

membership of cooperative society (1 for membership and 0 otherwise) and  $\Omega_0 - \Omega_8$  = parameters estimated

**3. RESULTS AND DISCUSSIONS**  
**SOCIOECONOMIC CHARACTERISTICS FARMERS IN THE ADOPTED VILLAGES**  
 Socio-economic characteristics of participants and non - participants in the research adopted villages were analyzed using mean, standard deviation as presented in Table 1.

Table 1: Socio-Economic Characteristics of the Respondents in Research Adopted Villages

Participants (n = 119)			Non-participants (n = 69)	
Variables	$\bar{X}$	SD	$\bar{X}$	SD
Age of Farmers	48.33	11.68	49.24	12.96
Household Size	6.21	3.06	6.27	3.11
Education	11.21	5.63	10.63	5.27
Experience	16.89	11.16	19.46	13.83
Farm Size	0.68	0.18	0.60	0.08

Source: field Survey, 2021

The average age of participants in the research adopted villages were 48.33 while that of non-participants were 49.24 implying that the respondents are capable of high productivity. The result is similar to that of Nwahia and Edwin (2021) who found an average age of 47 and 46 for Fadama III participants and non-participants respectively in Abia State. Table 1 also showed that the average household size of participants and non participants were six persons respectively, the educational level of participants and non participants were 11.21 and 10.63 years respectively indicating that the farmers in the adopted villages had at least secondary education. The mean years of farming experience were 16.89 and 19.46 respectively for both categories of farmers indicating that they were well experienced in farming. Formal education and having experience in farming is expected to enhance the capacity of farmers in the adopted villages to manage their resources better. This is similar to the results of Ume, Ebe, Ochiaka and Ochiaka (2017) who found that yam farmers in Abia State were educated and experienced in farming. The

farm sizes of participants and non-participants were 0.68 and 0.60 respectively conforming with the fact that most of the farmers were smallholders.

#### Productivity of Different Output of Arable Crops for Participants and Non Participants

The output of different arable crops cultivated by majority of the respondents was presented in table 2. The table shows the output of cassava, maize and melon produced by participants and non participants. The mean output produced per participant was 5623.111kg while that of the non participant was 4326.301kg for cassava, 2623.535kg and 1492.350kg respectively for maize and 1521.113kg and 1021.104kg respectively in case of melon. This showed high production of cassava, maize and melon by both participants and non participants for each crop in the adopted villages. The participants having higher mean output for each crop could be as a result of adoption of improved technologies presented to them by the researchers.

Table 2: Mean Output of Different Crops of Participants and non Participants

Crops	participants	Mean output(kg)	Std deviation	Non participants	Mean output(kg)	Std deviation
cassava	119	5623.111	300.6291	69	4326.301	80.5472
maize	119	2623.535	105.3421	63	1492.350	69.4759
Melon	119	1521.113	89.4123	57	1021.104	88.7435

Source: field Survey, 2021

#### Estimated Production Function of the participating and non- participating smallholder arable crop farmers in the Agricultural Research Adopted Villages.

The results of the Cobb-Douglas stochastic frontier production function of participating and non-participating smallholder arable crop farmers were

presented in Table 3. As in indicated in the Table, the estimated variance ( $\sigma^2$ ) was significant at 1% level for both participating and non-participating farmers indicating goodness of fit and correctness of specified distribution as assumption of composite error terms. The gamma ( $\gamma$ ) was estimated at 0.844 and 0.769 for the participating and non-participating farmers

respectively and were significant at 1% for both respondents. This implied that 84% and 77% variations in the output of the respondents is attributed to technical inefficiency. This is similar to Haruna and Damisa (2017) who compared the technical efficiency

of participants and non-participants in Kogi accelerated rice programme and found that 84% variations in output of respondents were due technical inefficiency.

**Table 3: Maximum Likelihood Estimates (MLE) of the Stochastic Frontier Production Function for participating and non-participating smallholder arable farmers**

Variables	Parameters	Participating Farmers		Non-participating Farmers	
		Coefficient	t-ratio	Coefficient	t-ratio
Constant	$\beta_0$	3.922	10.626***	6.329	7.787***
Farm size	$\beta_1$	0.126	3.634***	0.883	0.104
Family labour	$\beta_2$	-0.164	-2.414**	-0.184	-0.139
Hired labour	$\beta_3$	0.145	6.084***	-0.861	-2.784***
Planting materials	$\beta_4$	0.261	5.104***	0.432	2.862***
Chemical fertilizer	$\beta_5$	0.167	3.622***	-0.577	0.828
Organic fertilizer	$\beta_6$	0.551	3.121***	0.214	2.951***
Quantity of agro chemicals	$\beta_7$	-0.173	-0.108	-0.131	0.233
Capital inputs	$\beta_8$	-0.332	-2.696**	-0.221	-1.674*
<b>Variance Parameters</b>					
Sigma squared	$\sigma^2$	4.726	6.028***	4.261	2.851***
Gamma	$\gamma$	0.844	4.323***	0.769	3.297***
L-R test		15.912		12.390	
Log-likelihood function		150.928		74.183	

Source: field Survey, 2021. \*\*, \*\*\* represents 5% and 1% level of significance respectively

The coefficient of farm size was positive and highly significant at 1% for the participating farmers. The implication is that as farm size increases, the output of the participating farmers increased by 0.13%. The result is in akin with Oluwatosin *et al.*(2020) who analyzed technical efficiency of arable crop farmers in Nigeria and found direct relationship with the output of the sampled arable crop farmers.

The coefficient of family labour is negative and significant at 5% for participating smallholder farmers. This result is suggestive of the fact that as family labour increases by one man day, output of the participating farmers decreases by 0.16%. This is similar to Ambali (2012) whose study compared the production efficiencies of beneficiaries and non beneficiaries of bank of agriculture loan and reported that the result showed that labour was over used. Hired labour was positive for participating but negative for non-participating farmers and significant at 0.01 alpha level.

Table 3 also showed that planting materials was positive and significant at 1% for both groups of smallholder arable farmers. This is as expected and agrees with Simonyan,Umoren and Okoye (2012) who compared the technical efficiency of male and female maize farmers in Nigeria. Quantity of chemical fertilizer used was significant and positive for the participating farmers. The result of findings supports an earlier finding by Ume *et al.* (2017) who analysed technical efficiencies of yam farmers in Abia State but deviates from results of efficiencies of farmers in Iraq obtained by Dehibi, Telleria, Aw-Hassan, Mohammed, Ziadat and Wu(2013). Organic fertilizer was significant and positive for both groups of farmers

implying that increasing organic fertilizer use increases the output of participating and non-participating farmers. Capital input was negative and significant at 5% and 10% respectively for the participating and non-participating smallholder arable crop farmers. This varies from Obianefo, Nwigwe, Meludu and Anyasie (2020) whose result showed otherwise for rice farmers in Anambra State, Nigeria.

#### **Determinants of Technical Efficiency among Participating and non-participating Farmers**

The factors that determined technical efficiency of the participating and non-participating smallholder arable crop farmers is presented in Table 4. From the results, the coefficient of gender was found to be negative and significant for the participating smallholder arable crop farmers at 1% implying that having more female farmers in arable crop production increased technical inefficiency by 0.029 for participants. This could be due to the fact that most female farmers are always concerned with production for family consumption and not really concerned about efficiency. The result is similar to Simonyan *et al.*(2011) who reported that male maize farmers in Akwa Ibom State were more technically efficient than their female counterpart. The result of the study varies from Nwaru, Okoye and Ndukwu(2011) who found female farmers among smallholder sweet potato farmers in Imo State to be more technically efficient than the male farmers. The Table also showed that household size was negatively related to technical efficiency of the participating farmers and was significant at 1% level. This signifies that the larger the household members the lower the technical inefficiency of the participating farmers.

**Table 4: Determinants of Technical Efficiency for Participating and Non-Participating farmers**

Variables	Parameters	Participating Coefficient	t-ratio	Non-participating Coefficient	t-ratio
Constant	$\Omega_0$	0.012	3.051***	0.218	1.692*
Age of farmer	$\Omega_1$	-0.013	0.106	-0.026	-1.242
Gender of farmer	$\Omega_2$	-0.029	-3.417***	-0.107	-1.282
Household size	$\Omega_3$	-0.054	-8.140***	-0.010	-1.849*
Level of education	$\Omega_4$	-0.021	-1.802*	0.001	0.112
Farming experience	$\Omega_5$	-0.012	-2.285**	-0.017	-1.737*
Credit	$\Omega_6$	-0.124	-1.909*	0.191	3.127***
Extension contact	$\Omega_7$	-0.014	-0.910	0.004	1.438
Membership of coop	$\Omega_8$	-0.730	-6.002***	-0.625	-0.442

Source: Survey analysis, 2021 computed from Frontier 4.1 version

The result is in line with *a priori* expectation and also concur with the findings of Chakwera (2015) among maize farmers that large household size guarantees the availability of family labour for farm operations to be accomplished on time, thus leading to increased productivity and income. Table 4 also indicated that the level of education was negative and statistically significant at 10% level for the participating farmers. This implies that as the number of years spent in school increased, technical inefficiency of the participating farmers decreased. This is in line with *a priori* expectation and supports the result of findings of Kamua (2019) among maize and rice farmers in East Africa but varies from Simonyan *et al.*(2011) who found technical inefficiency to increase as education of female maize farmers increased and attributed that to the strong competing effect of diverting skills to other off farm activities by these farmers.

Farming experience was negative and significant for the two groups of farmers. This signifies that increased number of years spent in farming decreased technical inefficiency for participants and non participants. The implication is that increased practice and experience in the use of resources avails the farmers opportunity for better performance in resource allocation. This is in congruent with the *a priori* expectation and similar to an earlier finding by Ume *et al.*(2017)who found that increased years of experience in yam cultivation reduces technical inefficiency of yam farmers in Abia State. The coefficient of credit was found to be negative and significant at 0.10 probability level for participating farmers but positive and significant at 0.01 probability level for the non-participating farmers. This indicates that access to credit, reduced technical inefficiency among participating farmers but increased technical inefficiency of non-participating farmers. Availability of credit may have helped the participants to acquire

extra trainings that helped them improved on their technical efficiency. This is in line with Nwaru *et al.*(2011) who asserted that credit availability helps potato farmers in Imo State to take risk, adopt innovations and reduce technical inefficiency. The result is contrary to the *a priori* expectation in the case of non- participants and could be as a result of diversion of credit facilities to non- farm businesses. The coefficient of membership of cooperative society is negatively related to technical efficiency and significant at 10% level for participating farmers at 1% level. This implies that membership of cooperative organization reduced technical inefficiency of the participating farmers in the study. This is in akin with *a priori* expectation and supports Onyenweaku and Nwaru (2005) who reasoned that members who participated in cooperatives were expected to have more access to input and output market information, have the capacity to adopt innovation and bear more risk.

#### **Distribution of technical efficiency of participants and non-participants**

The results of the frequency distribution of technical efficiency for the participating and non – participating farmers are presented in Table 5. The result indicated that the participating farmers' technical efficiency indices ranged between 22% and 99% with a mean of 89%, while, the non- participating farmers' technical efficiency indices ranged between 1% and 98% with a mean of 78%. The implication is that it would take the average and the least efficient non-participating farmer about 22 percent  $[(1 - 0.78/0.98)100]$  and 92 percent  $[(1 - 0.10/0.98)100]$  cost-saving respectively to become the most efficient farmer. Similarly, for the average and the least technically efficient participating farmers to attain the efficiency level of their most efficient counterparts, they would need cost saving of about 11 percent  $[(1 - 0.89/0.99)100]$  and 79 percent  $[(1 - 0.22/0.99)100]$  respectively

**Table 5: Frequency distribution of the range of technical efficiency**

Range	Participant		Non participant	
	Number	%	Number	%
0.01-0.20	0	0.00	9	13.04
0.21-0.40	2	1.68	11	15.94
0.41-0.60	12	10.08	8	11.59
0.61-0.80	50	42.01	21	30.43
0.81-1.00	55	46.23	20	30.43
Total	119	100.00	69	28.99
Mean	0.89		0.78	99.99
Minimum	0.22		0.01	
Maximum	0.99		0.98	

Source: Survey analysis, 2021

#### TEST OF DIFFERENCES IN MEAN TECHNICAL EFFICIENCY OF PARTICIPANTS AND NON-PARTICIPANTS

The test of differences in mean technical efficiency of participating and non-participating farmers was presented in Table 6.

**Table 6: Z-test differences in mean technical efficiency of participating and non-participating farmers**

Technical Efficiency	Category	Mean	Number	Std. Dev.	Std. E. Mean	Z-cal
	participants	0.89	119	0.17	106.012	13.920**
	Non participants	0.78	69	0.15	54.074	
	Differences	0.11	50	0.02		

Source: Survey analysis, 2021

A test of difference for means carried out at 5% between the technical efficiency indices for participating and non-participating farmers show that the Z-test statistic value calculated is 19.18 while the tabulated is 13.920. The implication of the result is that the mean technical efficiency of participating farmers is significantly higher than those of the non-participating farmers indicating that the participating farmers were more technically efficient than the non-participant. This could be attributed to the trainings received by the participants from the researchers.

#### 4. CONCLUSIONS AND RECOMMENDATIONS

The study concludes that both participants and non-participants in the adopted villages were productive but not fully technically efficient. The participants were more productive and technically efficient compared to the non-participants. Technical efficiency of participants and non-participants were influenced by gender, household size, farming experience and credit. Level of education and membership of cooperative organization influenced the technical efficiency of participants without having any impact on the technical efficiency of the non-participants. The study recommends that teachings on efficiency be included in the adopted village project. Policies that will encourage formal education such as adult education, micro credit facility and organizing farmers into groups will help achieve better results in the adopted villages, hence increasing the food security of the rural households.

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