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Research Article

Efficiency in Rice Production in Nigeria

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Abstract

The study examined the efficiency in rice production of peasants in North Central zone of Nigeria using Benue and Nasarawa States as case studies. Purposive and snowball sampling approach were used to select across LGAs in the states using structured questionnaire for data collection with the aid of computer assisted personal interview (CAPI). A total of 408 rice farmers was drawn the mentioned state. Descriptive statistics was used to project socioeconomic characteristics of the rice farmers and their farms, while stochastic production frontier was used to determine input-output relationship of rice farmers, identify and estimate determinants of technical efficiency of the farmers. Given the specification of Cobb Douglas frontier model, the input-output relationship result shows that there was a positive and significant relationship ($P < 0.01$) between rice output and quantity of rice seed planted. There was a positive and significant relationship ($P < 0.01$) between farm size and rice output. Quantity of fertilizer applied was positively and significant related ($P < 0.10$) to rice output and quantity of Hired labour correlated significantly ($P < 0.01$) with high rice output, increased use of hired labour increased significantly the rice frontier outputs. There was a return to scale value of 0.68 indicating a decreasing return to scale. The implication of decreasing-returns-scale in this study means farmers can still increase the level of output at the current level of resources at their disposal as the farmers are not using their resources efficiently. The estimated value of gamma (γ) was 54% and was significantly different from zero ($P < 0.01$), thereby, establishing the fact that inefficiencies exists among these farmers. In other words, 54% of the difference between the observed output and the potential production output was due to technical inefficiency. Inefficiency existed among farms and that technical inefficiency was generally reduced by the use of tractor ($P < 0.10$) and the farmer with large family size ($P < 0.10$), thereby affording family labour esily. Variables that increased inefficiency included age of farmers ($P < 0.05$), meaning that efficiency will be reduced with younger farmers engaging in rice production than the older ones and intercropping cropping system by farmers ($P < 0.05$); showing that mono-cropping will help reduce inefficiency than practicing intercropping. The mean technical efficiency for small scale rice farmers was 61%. This suggests that technical efficiency could be increased by 39% given the current level of technology if the available resources are efficiently utilized. The study suggests the use of service provider that can make inputs available to farmers, monitor and supervise such farmers for better yield and improved efficiency in production.

Keywords: Cobb Douglas Frontier Model; Mono-Cropping; Return To Scale; Efficiency

Introduction

It has been estimated that about ninety per cent of the farmed land in Nigeria is rain-fed while the most important rice production system is in the rainfed lowlands [1] as it accounts for about half of the total rice production in the country [2.3]. Local production of rice in Nigeria is estimated at three million tonnes which has not been able to keep pace with national demand of about five million tonnes [4-6]. This deficit in national rice supply has attracted attention from several successive Nigerian governments leading to various interventions in the rice subsector of the economy [7,8]. These interventions include the establishment of the River Basin Development Authority (RBDA) in 1976 to harness the country's water resources and optimize the country's agricultural resources for food self-sufficiency [9]. The river basins were expected to contribute positively to the nation's search for food security by reducing the country's dependence on rain-fed agriculture and increase the proportion of irrigated agriculture that would make possible two, and sometimes three cropping seasons in one year [9,10]. The Green Revolution launched in 1980 aimed at increasing food production and raw materials in order to ensure food security and self-sufficiency in basic staples which included rice. The National Special Programme on Food Security (NSPFS) was launched in 2002 with objectives which included assisting farmers to increase their output, productivity and their capacity for effective utilization of resources for self-sufficiency. The Agriculture Transformation Action Plan (ATAP) which was launched in 2011 focuses on developing the value chain of specific commodities which include rice, cocoa, cotton, cassava and sorghum. In spite of all these interventions, the smallholder rainfed rice farmer in Nigeria produces 4.6 tonnes of paddy per year from an annual crop area of 3.3 hectares [11,12]. The average national yield of rice in 2012 was 1.8 tonnes of paddy per hectare [13], which is quite low when compared with the national average potential of 3.0 t ha-1 for upland system and 5.0 t ha-1 for lowland [14]. The consequence of this is that local rice production has not been able to meet up with the domestic demand and as a result, the importation of rice has become necessary to bridge the demand-supply gap [15,16].

However, despite numerous efforts and policies to increase rice farming, there has not been any significant improvement [17]. The difficulties in improving the yield could be attributed to the inefficient farm management despite intensive use of inputs. Thus, in this context, the measurement of the vacant farm's efficiency is much more useful as it can help solicit for information relating to the gap of efficiency in production among the farms and the potential for improvement [18]. Moreover, the analysis of technical efficiency in the agricultural sector has been widely used in both developed and developing countries due to the importance of productivity growth to improve the economic development. Therefore, the core objective of this research was to estimate the possibilities of technical gains from enhancing the efficiency of rice farmers.

Idiong [12] estimated the farm-level technical efficiency in small-scale swamp rice production in the Cross River State of Nigeria using the stochastic frontier approach and found an average technical efficiency score of 77 percent, implying better scope of enhancing the resource-use efficiency. Bamiro and Janet [19] employed the stochastic frontier approach to analyze the technical efficiency of swamp rice and upland rice production in Osun Sate, Nigeria, and estimated an average technical efficiency of 56% and 91%, respectively, which showed that efficiency improvement was possible in the swamp rice production. Kadiri., *et al*. [20] revealed that paddy rice production was technically inefficient in the Niger Delta Region of Nigeria. Efficiency is measured as the ratio of output produced with given inputs relative to the maximum feasible output. A proper understanding of the performance of the rice sector and the factors affecting such performance is vital to improving its output.

In addition, there are service providers with extension sevice outfit, that can assist farmers to improved on their efficiency of production; example of such is AgroMall Extension and Discovery Limited (AgroMall). AgroMall is a service provider that helps smallholder farmers to improve their yield and quality by supporting them with agronomy, extension and financial services. It also facilitates the interactions between farmers and other participants in the agricultural value chains. AgroMall aims to increase the quantity and quality of information available in Africa's agriculture for improved agricultural production, processing, and marketing. AgroMall is interested in those factors that influence farmers' productivity, so as to know how to approach their needs.

Methodology

Study area

The survey was conducted in two of thirty six states of Nigeria - Nasarawa and Benue states of Nigeria.

Nasarawa state

The state is centrally located in the Middle Belt region of Nigeria. Its capital is Lafia. The state lies between latitude 7° 45' and 9° 25' N of the equator and between longitude 7° and 9° 37' E of the Greenwich meridian. It has a maximum and minimum temperature of 81.7° F and 16.7° F respectively. Rainfall varies from 131cm to 145 cm. The state is really endowed with rich fertile soils, from the loosed soil materials of alluvial deposit in most of the southern part of the state to the well-structured and developed oxisols and ferrisols in the northern part of the state and the undeveloped soils on hill slopes and entrenched river valleys. Agriculture is the main economic activity in Nasarawa State with bulk of crop production undertaken by small scale farmers. Crops grown include grains such as rice, wheat, soybeans, beans, maize and millet and tuber crops such as yam and cassava.

Benue state

It is one of the 36 states of Nigeria located in the North-Central part of Nigeria. The State has 23 Local Government Areas, and its Headquarters is Makurdi. Located between Longitudes 60 35'E and 100 E and between Latitudes 60 30'N and 80 10'N. The State has abundant land estimated to be 5.09 million hectares. This represents 5.4 percent of the national land mass. Arable land in the State is estimated to be 3.8 million hectares. This State is predominantly rural with an estimated 75 percent of the population engaged in rain-fed subsistence agriculture. The state is made up of 413,159 farm families and a population of 4,219,244 people. These farm families are mainly rural. Farming is the major occupation of Benue State indigenes. Popularly known as the "Food Basket" of the Nation, the State has a lot of land resources. For example, cereal crops like rice, sorghum and millet are produced in abundance. Roots and tubers produced include yams, cassava, cocoyam and sweet potato. Oil seed crops include pigeon pea, soybeans and groundnuts, while tree crops include citrus, mango, oil palm, guava, cashew, cocoa and *Avengia* spp. [21].

Sampling techniques and methods

These states were purposefully selected based on the fact that they are among rice producing states in the North Central zone of Nigeria. In Nasarawa, 172 rice farmers were purposively and snowballing sampled from across 12 local government areas (LGAs) while in Benue, 236 rice farmers from across 20 LGAs were contacted and interviewed between late in the year 2017 and early 2018 on their rice production practices. In the exercise, a total of 408 rice farmers were contacted and interviewed with questionnaire administered through Computer Assisted Personal Interview software (CAPI). Extension agents from Benue and Nasarawa states were trained in the use of CAPI before the survey dates; these agents were the enumerators for the field survey. The questionnaire contains questions on farming activities of farmers and specifically to rice production. The main objective of this study is to analyze technical efficiency of small scale rice farmers using stochastic frontier model approach. The specific objectives are to determine input-output relationship of small scale rice farmers in the study area; identify and estimate determinants of technical efficiency of small scale rice farmers in the study area. Based on the specific objectives the following hypotheses were tested: 'there is no significant relationship between input use and output obtained in small scale rice production in the study area' and that 'socio-economic factors have no significant influence on technical inefficiency of small scale rice farmers in the study area'.

Analytical techniques

Data analysis was done using descriptive analysis and stochastic frontier using Frontier 4.1 from http://www.uq.edu.au/economics/cepa [22].

LGA	Farmers' number	LGA	Farmers' number
Benue		Nasarawa	
Ado	6	Akwanga	6
Agatu	22	Doma	21
Apa	22	Karu	19
Buruku	11	Keana	5
Gboko	6	Keffi	6
Gwer east	11	Kokona	19
Gwer west	14	Lafia	22
Kastina-ala	8	N/eggon	22
Konshisha	11	Nassarawa	17
Kwande	12	Obi	11
Makurdi	12	Toto	12
Obi	37	Wamba	12
Ogbadibo	1	-	-
Oju	7	-	-
Okpokwu	1	-	-
Tarka	11	-	-
Ukum	11	-	-
Ushongo	23	-	-
Vandeikya	8	-	-
Okpokwu	2	-	-
Total	236		172
Overall Total	408		

Table 1: Sample list of LGAs with farmers in Nasarawa and Benue states.

Stochastic production frontier model (SPF)

This study uses the stochastic frontier production function as one of its analytical tools. The model has the advantage in that it allows simultaneous estimation of individual technical efficiency of the respondent farmers as well as determinants of technical efficiency [23]. The model that is employed for the stochastic production function analyses individual rice household farm technical efficiency in the study in the form of the Coelli and Battese [24] inefficiency model (in form of Cobb-Douglas frontier production function). The estimated production function is of the form:

$$\mathrm{Ln}(Y_i) = \sum \beta_i \,\mathrm{Ln}(X_j) + \varepsilon_i (V_i - U_i) \qquad (1)$$

Where:

Subscript 'i' refers to the ith farm household, Ln is the natural logarithm and Y_i is the total value of output of i^{th} farmer in Kg, X_s are input variables. The β coefficients in equation (1) are unknown parameters to be estimated. ε_i is the error term, equals $V_i - U_i$. the term U_i is a non-negative variable representing inefficiency in production relative to the stochastic frontier. The term V_i is a symmetric error, which accounts for random variations in output due to factors beyond the control of farmers like weather, and it is assumed to be independently and identically distributed as N(0, σV^2). The distribution of U_i is also assumed to be independently and identical as N (0, σU^2) which could be half-normal at zero mean, truncated half-normal (at mean M). The technical efficiency of farmer is defined as the ratio of the observed output to the frontier output that could be observed by a farmer operating at 100% efficiency, in which the inefficiency is zero. The technically efficient farms are those that operate at the production frontier and the level by which a farm lies below its production frontier is regarded as the measure of technical inefficiency.

Empirical model

The dependent or endogenous variable is the rice produce (Output). The explanatory variables included farmer, farm and institutional factors postulated to influence rice output; the variables are shown and describe in Table 2. The rationale for inclusion of these factors was based on previous agricultural production literature and the analysis of these systems.

The stochastic production frontier model (SPF)

The Stochastic Production Frontier model was used to achieve objective six of the study. The model that was employed for the analysis of individual cassava household farm technical efficiency in the study; it is in the form of the Coelli and Battese [24] inefficiency model (in form of Cobb-Douglas frontier production function); it is of the form:

$$Ln(Y_i) = \sum \beta_i \, Ln(X_j) + \varepsilon_i (V_i - U_i) \qquad (2)$$

For this study the Cobb-Douglas frontier production function [25] is specified as:

$$LnY = \beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \beta_4 LnX_4 + \beta_n LnX_n + V_i - U_i \quad (3)$$

Where:

L_n = natural logarithm

Y = the total quantity of rice harvested by the i^{th} household measured in kilogram (Kg)

$X_s = X_1 - X_n$ is a vector of explanatory variables

$\beta_s = \beta_0 - \beta_n$ coefficient to be estimated

V_i = normal random error (with zero mean and unknown variance)

U_i = technical inefficiency effects (independent of V_i s such that U_i s is the non-negative truncation (at zero) of normal distribution with mean, u_i and variance σ^2; u_i is defined as,

$$u_i = *0 + *1Z_{1i} + *2Z_{2i} + *3Z_{3i} + *4Z_{4i} ..... + *nZ_{ni} \quad (4)$$

Xs and Zs are defined below

Dependent variable: Rice output in kg.

Variables Used for SPF Analysis		Description	Apriori	Mean (SD)	%Yes
Output	Y	Dependent variable, rice output		1550.50 (2773)	-
Seed	X_1	Rice seed planted in Kg	+	68.6 (124)	-
FarmSize	X_2	Farm size for rice production in hectare (Ha)	+	2.1 (4.2)	-
Fertilizer	X_3	Quantity of fertilizer use in kg	+	120 (399)	-
Hired labour	X_4	Hired labour in mandays	+	22.2 (46)	-
Family labour	X_5	Family labour in mandays	+	16.5 (27)	-
Age	Z_1	Age of the farmer in year	±	45.2 (14.3)	-
Education Years	Z_5	Education of the farmer in years	+	8.0 (5.5)	-
FamilySize	Z_6	Family size of the farmer	±	10.3 (3.2)	-
Salary Earner	Z_7	Farmer earning off farm salary=1, Otherwise=0		-	16
Livestock Owner	Z_8	Farm family owning livestock=1, Otherwise=0		-	65
Herbicide Usage	Z_9	Herbicide used on rice farm=1, Otherwise=0		-	78.9
Insecticide Usage	Z_{10}	Insecticide used on rice farm=1, Otherwise=0		-	26.5
Tractor Usage	Z_{11}	Tractor used on rice farm=1, Otherwise=0		-	10.5
Farm Occupation	Z_{12}	Farming is the only occupation=1, Otherwise=0		-	
Improved Variety	Z_{13}	Farmer cropped improved rice variety=1, Otherwise=0		-	43
Intercropping	Z_{14}	Farmer intercropped with rice=1, Otherwise=0		-	5
Agric Association	Z_{15}	Farmer belongs to an agric. association=1, Otherwise=0		-	31.9
Credit Association	Z_{16}	Farmer belongs to a credit association=1, Otherwise=0		-	7.6
Trader Association	Z_{18}	Farmer belongs to a trade association=1, Otherwise=0		-	24.5

Table 2: Description of variables used for SPF Analysis.

Results and Discussions

Socioeconomic description of farmers

Data on 408 farmers from Benue and Nasarawa states are analyzed. Considering the socioeconomic features of the farmer respondents, the result in Table 3 shows that 94% of the farmers were male-headed farmers and that 93% of them were married with responsibilities that will make them sit up to their farming responsibilities., thus 86% of them were full time farmers. More than 50% of the farmers were educated; education is hypothesized to influence farmer's production positively because as farmers acquire more education, their ability to obtain, process, and use new information improves and enhance their production ability and efficiency. In several studies, positive relationships have been found between education and improved agricultural productivity [26]. The average household size was 10; family size is defined here as all the number of people living under the same roof and eating from the same pot and it has been identified to have either a positive or a negative influence on farm productivity [19]. Larger family size is generally associated with a larger labor force available for the timely operation of farm activities. However, the negative relationship of this variable in relation to productivity has been linked to the increased consumption pressure associable with a large family. Therefore, it was difficult to predict the impact of this variable a priori in this study. Average age of the farmers was 45 years and was within economic active working life. The effect of age (Age) on the farm productivity could be negative or positive irrespective of intensification gradients and manners of redistribution, thus for many past studies, there is no agreement on the sign of this variable as the direction of the effect is location- or technology-specific [27]. Previous studies show that the age of individuals affect their mental attitude to new ideas and influences adoption and production in several ways [26,27]; Younger farmers have been found to be more knowledgeable about new practices and may be more willing to bear risk and adopt innovation because of their longer planning horizons. The older the farmers, the less likely they are to adopt new practices as he gains confidence in his old ways and methods. On the other hand, older farmers may have more experience, resources, or authority that may give them more possibilities for trying a new technology that will lead to improved productivity.

Average farm size of farmers was 2.1 ha; farmers with larger farm size resource can easily adopt new technologies that will improve his farm productivity; such farmers need not to manage land as such can practice mono-cropping system instead of managing land with mixed cropping system.

Worthy of note is the rice output/hectare; on Table 2, average rice yield was 1550.50kg/ha with a standard deviation of 2773. This is in line with past work, Ajah and Ajah [28], stated that on average rice farms cultivated was 1.84ha of land with mean output per farmer of 1349.5kg and mean output per hectare of 730.4kh/ha. Report by Okeleye., *et al.* [29] shows that the grain yield in most developing countries is as low as 0.5tons/ha. It also agrees with the report of Ekelene., *et al.* [30]; which indicated that the average rice

Variables	Score
Household head %	
Male headed households	93.86
Female headed households	6.14
Marital status %	
Single	1.97
Married	93.35
Widowed	4.68
Literacy %	
Yes	65.36
No	34.64
Farming as main occupation %	
Yes	86.03
No	13.97
Age(year) Average	45.2
Education(year) Average	8.0
Family size (Number) Average	10.3
Farm size (Ha) Average	2.1

Table 3: Socioeconomic characteristics of farmers (N=408).

Source: Field survey, 2017/18

Awareness of improved seeds	% Yes
Yes	57.3
Use hired labour	
Yes	81.19
Use family labour	
Yes	89.89
Use communal labour	
Yes	26.8
Use insecticides	
Yes	26.5
Use herbicides	
Yes	78.9
Apply fertilizer	
Yes	70.05
Practice irrigation	
Yes	0.5
Livestock production	
Yes	65.11
Belong to credit association	
Yes	7.6
Belong to farmer association	
Yes	31.86
Belong to trading association	
Yes	24.51
Rice intercrop with other crop(s)	
Yes	4.94
Incurred losses after harvest	
Yes	13.39

Table 4: Farm specific characteristics

Source: Field survey, 2017/18

yield in Nigeria is low and ranges within 1-2.5 ton/ha. The rice output per hectare reported at 2010 and 2011 by NAERLS and NPFS [31] were 1.78 and 1.77ton/ha respectively. FAO [32] stated that Nigeria recorded less yield per hectare compared to countries like Thailand, Malaysia, China and Indonesia. Part of the aim of AgroMall is to work on rice farmers so as to improve on their productivity and farm efficiency.

Table 4 shows that 57% of the farmers were aware of improved rice seeds while 43% of them adopted it. Most of the farmers had needed inputs such as family (90%) and hired labour (81%), fertilizer (70%), herbicides (79%) and insecticides (26.5%). The rice farmers in the study areas preferred mono-cropping to intercropping as only 4.9% of them intercropped their rice with other crops. Most of the farmers were involved in livestock production (65%). There are many association platforms including credit (8%), farmers (32%) and trading (25%) associations that farmers joined to derive one benefit or the other. AgroMall, a service provider, can take advantage of these association to link up with farmers in area of service provision in term of giving loan and inputs in kinds and managing through monitoring their agronomic practices as to ensure improved efficiency management of input and agronomic resources.

The stochastic frontier production model

The model that was employed for the stochastic production function analysis of individual rice household farm technical efficiency in the study is in form of Coelli and Battese [24] inefficiency model; for this study the Cobb-Douglas frontier production function is specified (see equations 2 and 3).

Technical efficiency analysis

Stochastic (Cobb-Douglas) frontier production function was specified on the survey data to determine input-output relationship in rice production. Averages of inputs used on per hectare basis to achieve this are shown in Table 1.

Productivity of farm inputs in rice production

Technical efficiencies was estimated and the values of the likelihood ratio (LR=-563.5), sigma square (σ^2 = 1.5) and chi-square (P>0.000) in Table 5 indicated that the model had a good fit and that inefficiency effects of a stochastic nature existed in the study areas. Given the specification of Cobb Douglas frontier model, the results show that there was a positive and significant relationship ($P < 0.01$) between rice output and quantity of rice seed planted. There was a positive and significant relationship ($P < 0.01$) between farm size and rice output. Quantity of fertilizer applied was positively and significant related ($P < 0.10$) to rice output and quantity of Hired labour correlated significantly ($P < 0.01$) with high rice output, increased use of hired labour increased significantly the rice frontier outputs. However, the use of family labour reduced quantity of rice output, meaning that the farmers were operating at the third stages of production function, when marginal output becomes zero and total output starts to fall, however, this is not significant.

Inefficiency effects

Table 5 also reports the results of testing the hypothesis that the efficiency effects jointly estimated with the production frontier function are not simply random errors. The key parameter is γ (gama), and is bounded between 0 and 1, where if γ=0, inefficient is not present, and if γ=1, there is no random noise (Battese and Coelli, 1995). The estimated value of γ is 54% and is significantly different from zero ($P < 0.01$), thereby, establishing the fact that inefficiencies exists among these farmers. In other words, 54% of the difference between the observed output and the potential production output was due to technical inefficiency. Inefficiency existed among farms and that technical inefficiency is generally reduced by the use of tractor ($P < 0.10$) and farm household with large family size ($P < 0.10$). Variables that increased inefficiency included age of farmers ($P < 0.05$), meaning that efficiency will be reduced with younger farmers engaging in rice production than the older ones and intercropping cropping system by farmers ($P < 0.05$); showing that mono-cropping will help reduce inefficiency than practicing intercropping.

Elasticity estimates

The elasticity of the mean value of rice farm output was estimated to be an increasing function of the quantity of rice seed planted in kg (0.33), area of land cultivated in hectares (0.30), quantity of fertilizer used in kg (0.01), and quantity of hired labour applied in mandays (0.04); and were all significant. The positive coefficients for these variables show that an increase in any or in all of these variables would enhance the level of technical efficiency. However,

Variable	Coefficient	Stand-error	t-ratio
Seed	0.3255***	0.0512	6.3522
Farm Size	0.2743***	0.0515	5.3249
Fertilizer	0.0135*	0.0076	1.7733
Hired labour	0.0361***	0.0099	3.6606
Family labour	-0.0021	0.0130	-0.1606
Constant	5.9060	0.2215	26.6672
Inefficiency			
Age	0.0242**	0.0104	2.3271
Education Years	-0.0217	0.0260	-0.8338
Family Size	-0.0803*	0.0484	-1.6579
Salary Earner (Dummy=1)	-0.3534	0.4811	-0.7344
Livestock Owner (Dummy=1)	0.5329	0.3254	1.6379
Herbicide Usage (Dummy=1)	0.5303	0.3830	1.3845
Insecticide Usage (Dummy=1)	0.3836	0.2941	1.3041
Tractor Usage (Dummy=1)	-5.8860*	3.2957	-1.7860
Farm Occupation (Dummy=1)	-0.2957	0.4040	-0.7320
Improved Variety (Dummy=1)	-0.2082	0.2395	-0.8693
Intercropping (Dummy=1)	1.1973**	0.5115	2.3409
Agric Association (Dummy=1)	0.3298	0.2669	1.2355
Credit Association (Dummy=1)	-0.2162	0.7537	-0.2868
Trader Association (Dummy=1)	-0.4467	0.3192	-1.3994
Sigma Squared (σ^2)	1.5274	0.3323	4.5968
Gamma (γ)	0.5396	0.1294	4.1707
Log likelihood function	-563.48		
Chi^2	102.5		
Prob > Chi^2	0.000		

Table 5: Production efficiency of rice production.

NB: ***, **, * significant at 1%, 5%, and 10% respectively

Source: Field survey, 2017/2018

family labour was not significant and showed a decreasing function tendency as its elasticity was −0.002. The elasticity of the mean values of output with respect to the inputs was estimated at the value of the mean of resources and is shown in Table 6. The return to scale value of 0.68 indicates a decreasing return to scale. The return to scale parameter indicates what happens when all production resources are varied in the long run by the same proportion. The implication of decreasing-returns-scale in this study means farmers can still increase the level of output at the current level of resources at their disposal as the farmers are not using their resources efficiently.

Technical efficiency estimates

Given the specification of the Cobb-Douglas stochastic frontier model in equations 2 and 3, estimates of predicted technical efficiency showed a wide variation among and within sampled populations (looking at the minimum, maximum and mean values) of rice in Table 6. The wide variation in technical efficiency estimate is an indication that most farmers are still using their resources inefficiently in the production process and there still exists opportunities for improving on their current level of technical efficiency. The mean technical efficiency for small scale rice farmers is 61%. This suggests that technical efficiency could be increased by 39%

Variable	Pooled
Elasticity estimates	
Rice seed	0.33
Area	0.30
Fertilizer	0.01
Hired labour	0.04
Family labour	-0.002
Return to scale	0.68
Technical Efficiency (TE)	Pooled
1 to 20	6(1)
21 to 40	36(9)
41 to 60	151(37)
61 to 80	168(41)
81 to 100	47(12)
Minimum efficiency	2
Maximum efficiency	93
Mean efficiency	61

Table 6: Elasticity estimates, returns to scale and the technical efficiency estimates for cassava production.

Source: Field survey, 2017/18; figures in bracket are the % of the total.

given the current level of technology if the available resources are efficiently utilized. Thorough extension service from service providers can ensure this if it is engaged.

Conclusion and Recommendations

This study was undertaken to analyze technical efficiency of small scale rice farmers in the North central zone of Nigeria (Nasarawa and Benue states) using stochastic frontier model approach. The results revealed that quantity of seed used, farm size and hired labour have significant effects on the output of rice at % level of probability implying that increases in the quantity of seed, farm size and hired labour use lead to increases in rice output. While quantity of fertilizer use has significant positive relationship with rice output at 10% probability level; increase in the quantity of fertilizer will increase rice output significantly. The results revealed that the use of tractor in the farms decreases technical inefficiency; same with larger family size, which probably provides required family labour. In contrast, being an aged farmer increases technical inefficiency of small scale rice farmers; meaning that younger farmer engagement in rice production will reduce inefficiency in rice production. Cropping system that encourages intercropping increases inefficiency in rice production. It is advisable for farm family to adopt mono-cropping cropping system for better efficiency and productivity. The mean technical efficiency for small scale rice farmers is 61%. This suggests that technical efficiency could be increased by 39% given the current level of technology if the available resources are efficiently utilized. It is therefore recommended that: -Training aimed at cropping system, fertilizer application, tractorization, and sensitization on engagement of youth in rice production and right usage of family workforce on the farm by small scale farmers should be frequently organized in the studied area.

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