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FARM-LEVEL PRODUCTION EFFICIENCY OF SMALLHOLDER RICE FARMERS IN SOUTHWEST, NIGERIA

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Abstract

An efficient food production system is a panacea for better output among farming households. However, this is not the case for Nigerian farmers who lacked access to resources for optimum food production thereby their productivity potential were undermined. Based on this premise, this study aimed to investigate the production efficiency of rice farming households in Southwest Nigeria using secondary data from the ECOWAS-RAAF-PASANAO Project. The study extracted data from 278 rice farming households sampled across six states in southwestern, Nigeria from the master data set. Data were analyzed using descriptive statistics, stochastic frontier analysis (SFA) and Tobin regression model. The results revealed that the majority of the rice farmers were male in their active and productive age and with low educational level. 62.9% of them had access to extension service and 64.7% had no access to credit. The average land area cultivated and the rice output of the respondents were 1.65 ha and 3123.57 kg, respectively, indicating smallholder and low productivity farm households. The result of the stochastic frontier analysis revealed that farm size, labour, herbicide and fertilizer were the factors that significantly increased the rice output, while the prices of land, tractor, herbicide and rice input significantly increased the production cost. The mean technical, allocative and economic efficiency of rice farmers were 0.62, 0.638 and 0.47 respectively, suggesting a potential for increasing rice production using the current technology, prices and fixed level of resources. Rice farmers' production efficiency was significantly determined by gender, education, access to credit and extension contacts. The government policy intervention should address the efficiency challenges of the rice farmers in the study area.

Keywords: farm-level, production efficiency, rice, smallholder, southwest

INTRODUCTION

In recent times, rice has emerged as a primary food staple in Nigeria thus leading to a major demand for imports because its consumption surpasses domestic production (Gyimah-brempong, *et al.*, 2016). Since the middle of the 1970s, rice's contribution to Nigerian households' per capita calorie consumption has increased at a rate significantly faster than the country's production (Bamidele, *et al.*, 2010). Nigeria emerged as the continent's top rice importer in 2014, and more recently, became the second largest importer of rice after China globally. Improving the domestic production is imperative in order to reduce the dependence on importation (IFPRI, 2016). The Federal Ministry of Agriculture and Rural Development (FMARD) in its Agricultural Promotion Policy document (2016 – 2020) stated that Nigeria is currently unable to produce enough rice to meet the domestic food requirements because the input use efficiency remains low. Thus, the problem is one of farm productivity, primarily caused by the input system and the farming model that are hugely inefficient (FMARD, 2016). Because of the relatively large land mass, the rice production systems in Nigeria are highly diverse. Despite this diversity, the rice yields are relatively low across the different production systems in Nigeria with an average of 1.8 tons per hectare compared to other countries like China and Senegal with 6.5 and 2.3 tons per hectare respectively (IFPRI, 2016).

In order to reduce Nigeria's dependency on rice importation and give way for rice production to effectively contribute to poverty reduction and food security, it is imperative to optimize rice production systems by improving the productivity and efficiency of production factors. Rice production is susceptible to various uncontrollable factors such as unfavorable weather patterns, pest and disease outbreaks. In addition, there exist a possibility of measurement and observational errors that may occur during data collection. In order to capture the effects of these uncontrollable errors, this study used the stochastic frontier model. An improvement in the understanding of the source of inefficiency in production and its relationship to factors at both individual and farm-levels can greatly assist policy makers in formulating policies that could overcome the efficiency challenges in the rice agricultural sector. It is against this background that the farm-level production efficiency in rice production was studied by using a stochastic frontier analysis. Specifically, the study analyzed the technical, allocative and economic efficiency among rice farmers and determined the factors influencing the production efficiency.

MATERIALS AND METHODS

Study Area: The study was conducted in South-west Nigeria that is one of the six geopolitical zones of Nigeria. It consists of six states, which are Ogun, Oyo, Osun, Ondo, Ekiti and Lagos. The zone has a total land mass of 114, 271 square kilometers, which represents 12% of the total land mass of Nigeria, and it lies between latitude 6^{o}N and 4^{o}S and longitude 4^{o}W and 6^{o}E. The climate of south-west Nigeria is tropical and is characterized by two distinct seasons (the rainy and the dry season). The zone experiences double rainfall maxima, with an annual average rainfall of 1200mm to 1500mm, as well as annual mean atmospheric temperature of 27^{o}C. Agriculture is a major occupation for the people in the South-western part of Nigeria with the production of rice being a major area of interest for farmers in this area because of the different Government interventions.

Data Collection: The secondary data used for this study is a subset of the data collected for the ECOWAS-RAAF PASANO Project. The project was titled "Incentivising the Adoption of Climate Smart Practices in the Cereals Producing Areas in Nigeria: Sociocultural and Economic Diagnosis". The data were collected between February and April 2017 through the administration of a questionnaire designed to capture the responses on the socio-economic variables, demographic variables, production variables (input quantities and prices, and output quantities and prices) for the 2016/2017 production season. The obtained data had entries on the rice and maize production and the corresponding food consumption drawn from 1329 households in 179 farming communities selected through a multi-stage sampling across 16 states in Nigeria. However, for the purpose of the analysis, the data entries from 278 farming households in South-west Nigeria were drawn from the sourced data universe and used for this research because they contained valid information on the rice inputs used in the production process, and the outputs of the respective farm holdings.

Data Analysis: The data were analyzed using descriptive statistics, stochastic frontier analysis and Tobit regression model.

Stochastic Frontier Analysis

The stochastic frontier production model that incorporated the Cobb-Douglas function was used to estimate the production efficiency of rice farming households in the study area.

Model specification

The generalized stochastic frontier model can be expressed for the rice producers as follows:

$$Y = f(X_{i,} \beta) \exp(\varepsilon_i) \dots \dots \dots \dots\dots \dots \dots (1)$$

Applying the Cobb-Douglas production function

$$InY = \beta_0 + \beta_1 InX_1 + \beta_2 InX_2 + \beta_3 InX_3 + + \beta_4 InX_4 + \beta_5 InX_5 + \beta_6 X_6 + \varepsilon \dots\dots\dots (2)$$

Where:

Y_i: Quantity of rice produced in kg, X_1: Farm size (hectares), X_2: Seeds (kg), X_3: Tractor hour (hour), X_4: Labor (man-day), X_5: Herbicides (lt), X_6: Fertilizer (kg), β_0 = Intercept

βi = the coefficients to be estimated,

ε = error term.

According to Aigner, Lovell and Schmidt (1977), the error term is really a composite of two terms:

$$\varepsilon = V_i - U_i \quad i = 1 \dots, n \quad \dots \dots \dots \dots (3)$$

Where, (V_i) is the random variability in the production that cannot be influenced by the farmer. U_i is the deviation from the maximum potential output attributed to technical inefficiency.

The technical inefficient effects, U_i are defined as:

$$U_I = \gamma_0 + \gamma_1 Z_1 + \gamma_2 Z_2 + \gamma_3 Z_3 + \gamma_4 Z_4 + \gamma_5 Z_5 + + \gamma_6 Z_6 + \gamma_7 Z_7 + \gamma_8 Z_8 \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots(4)$$

Where U_i is the inefficiency effect,

Z_1 = Age of farmer (in years),

Z_2 = Sex of farm household's head (male headed = 1, 0 otherwise),

Z_3 = Education (in years.),

Z_4 = Household size (the number of persons),

Z_5= Extension contacts (the number of visits),

Z_6 = Access to credit (access =1, 0 otherwise),

Z_7 = Membership in a cooperative (Member =1, Non Member=0),

Z_8 = Land type (Upland 0, Lowland 1).

Using STATA 15, all of the parameters of the stochastic frontier production function and the technical inefficiency models were estimated simultaneously.

The stochastic frontier cost function estimation

The cost frontier of the Cobb-Douglass functional form was used as the basis of estimating the allocative efficiencies of the rice farming households in the study area. The implicit form of the Cobb-Douglas stochastic frontier cost function is specified as follows:

$$InC_I + \alpha_0 + \alpha_1 InP_1 + \alpha_2 InP_2 + \alpha_3 InP_3 + \alpha_4 InP_4 + + \alpha_5 InP_5 + \alpha_6 InP_6 + \alpha_7 InY_i + (V_i + U_i) \dots . (5)$$

Where:

C_1 = Total production cost (Naira),

P_1 =Price of land rent (Naira),

P_2 = Price of labor (Naira),

P_3 = Price of machine rent (Naira),

P_4 = Price of rice seed (Naira),

P_5 = Price of herbicides (Naira),

P_6 = Price of fertilizer (Naira),

Y= Output of rice produced in kg

α_0 = Intercept, αi= Parameters to be estimated,

V_i are random variables independent of U_i.

U_i are non-negative random variables and account for the cost inefficiency in production.

That is

$$AE = \frac{C_I^*}{C_I} = \exp(U_I) \quad \dots\dots\dots\dots\dots (6)$$

The allocative efficiency ranges between zero and one. STATA 15 was used to estimate the parameters of the stochastic frontier cost function and cost inefficiency.

The allocative inefficiency effects U_i are defined as:

$$U_I = \partial_0 + \partial_1 Z_1 + \partial_2 Z_2 + \partial_3 Z_3 + \partial_4 Z_4 + + \partial_5 Z_5 + \partial_6 Z_6 + \partial_7 Z_7 \quad \dots\dots\dots\dots\dots (7)$$

Where U_i is inefficiency effect,

Z_1 to Z_8, are the same as previously defined in the technical inefficiency model.

The ratio $\gamma^2 = \lambda u^2{}_2 / \lambda^2{}_2$ measures the total variation of cost from the frontier which can be attributed to cost inefficiency.

Economic Efficiency estimation

A measure of economic efficiency can be obtained by combining the measures of allocative and technical efficiencies.

$EE = AE * TE$ ……………............. (8)

Tobit regression model

The Tobit regression model was used to analyze the factors affecting the production efficiency of rice farmers in the study area. Following Tobin (1958) and Okello *et al.* (2019), the Tobit model is specified as:

$y_i = y_i^* = X_\beta + \varepsilon_I$ ……………….. (9)

$y_I = 0 \; if \; y^* \leq 0$ ……………… (10)

$y_i = y_i^* \; if \; y^* > 0$ …..………… (11)

i=1,2,3,4………..n

Where: y_i is the observable but censored variable measuring production efficiency; y_i^* is the latent variable indicating that production efficiency may or may not be directly observable. Thus, the production efficiency is observed if $y_i^* > 0$ and unobservable if $y_i^* \leq 0$; X_i are a set of explanatory variables in the inefficiency model; β are the parameters to be estimated; e_i is the error term.

Definition and measurement of variables influencing rice production efficiency

The rice production efficiency was hypothesized to be influenced by the variables described in Table 1 below:

Table 1. Description of variables influencing production efficiency

Variables	Description	Measurement	Sign
Age	Age of household head	Years	+/-
Sex	Sex of household head	Dummy (1= male, 0 female)	+
Education	Education level of household head	Years spent in school	+
Household size	Number of persons living together and eating from same pot	Adult equivalent	+
Extension contact	Contact with extension agents	Number of visits	+
Credit access	Access to credit facilities	Dummy (1= access, 0 otherwise)	+
Membership of society	Member of farmer's cooperatives societies	Dummy (1 = member, 0 otherwise)	+
Production type	Type of rice production	Dummy (1 = Upland, 0 otherwise)	+/-

Source: Author's literature review

RESULTS AND DISCUSSION

Table 2 presents the socio-economic characteristics of the respondents in the study area. The result shows that the majority (77.7%) of respondents was male and 22.3% were female. This implies that men were more actively involved in rice farming than women in the study area. This result corroborates the findings of Afolami *et al.* (2012), and Ambali *et al.* (2012) who found in their respective study that the majority of rice farmers in Nigeria were male because of the rigorous activities in rice farming. The respondents' mean age was 48, implying that the rice farmers in the study area were in their prime working years. This is consistent with the findings of Yekinni & Popoola (2013) and Oladele & Kemisola, (2016). 45.7% of farm household heads had at most primary school education, as compared to 21.6% with tertiary education. The requisite educational knowledge possessed implies that the sampled farmers would be more receptive to adopting technological innovations in rice production. This is consistent with Maina's (2015) findings which suggested that individual personality, attitude to life, and adoption of new and better practices are significantly influenced by the degree of formal education. Further, the results show that the majority (81.7%) of the households had more than 4 members, while the mean household size was 6 members. This finding agrees with Adebo & Falowo, (2015), Coster *et al*., (2020) that the household size could have great implications for labor supply in farming. About 54% of the farming households had a farm size of less than 2.0 hectares with an average farm size of 1.65 hectares. This indicates that the majority in our sample was smallholder rice farmers. The majority (76.6%) of the respondents did not have access to credit that could, otherwise, help boosting the production and expanding their farm income. This agrees with the findings of Agada, (2012), Ahmed *et al*., (2015). Inadequate credit availability is predicted to have a negative impact on the domestic food production and other agro-processing enterprises, leading to food insufficiency. The majority (61.2%) of the respondents were members of a cooperative group. As reported by Francesconi (2014) engaging in agricultural cooperatives improves the efficiency gains of farming households. The study further revealed that the majority (65.8%) of the rice farming households planted in upland areas while 34.2% planted on lowlands. This indicates that the upland rice cultivation was dominant in the study area. About 63% of the farmers had at least one extension visit per month within the last production season. The implies that information dissemination to most farmers in the study area may not really be an issue and this corroborates the findings of Ambali et al. (2012) and Yahaya & Ezihe, (2017) that the access to extension agents influences the level of farm output and the ability of households to earn income. About 58.6% of the respondents engaged in off-farm activities. This is in line with the findings of Shittu (2014), Oladele & Kemisola, (2016) who reported that off-farm activity is essential for both a considerable increase in the income of rural farm households and the mitigation of income risk. The results on the annual income of the rice farmers revealed that the majority (63.7%) of the respondents have an estimated income of below ₦400,000 ($1,084) per annum with an average household income of ₦374,211.30 ($1,014) per annum. Consequently, the households with greater incomes from a variety of sources may have easier access to the food they need than households with lower incomes. It was observed that 64.7% of the respondents were not active members of a farmers' association. This implies that in most cases, the farmers' decision-making is primarily dependent on their membership in a cooperative society.

Summary statistics of the variables used in the stochastic production frontier

The summary statistics of the variables used in the stochastic production frontier is presented in Table 3. The results show that the mean output of rice harvested was 3,123.38kg during the production year with an average yield of 1,892.72 kg/ha. The rice yield obtained is much lower than the average grain yield in Africa (2.1 kg/ha) and the world average yield (3.4 kg/ha) (FAO, 1999). The average farm size was 1.65 hectares with a standard deviation of 1.51 hectares. The variability in the farm size as shown by the standard deviation is due to changes in the hectares of rice cultivated and the availability of farmland during the production season. The average labor input was 224 man-days priced at ₦1,146.25 ($31.06) per man-day. This is an indication that rice production is labor intensive considering the large variability recorded. The average seed rate per hectare was 172.22kg which is higher than the standard seed rate for rice production of 50-60kg/ha (Dibbing), 75-80kg/ha (Drilling) and 80-100kg/ha (Broadcasting) (WARDA, 2014). This indicates that the rice farmers in the study area over-utilized seed in rice cultivation.

Table 2. Socioeconomic and farm characteristics of rice farmers (n=278)

Variables	Frequency	Percentage	Mean	SD
Gender				
Male	216	77.7		
Female	62	22.3		
Age (years)			48	19
<30	15	5.8		
31-40	56	20.1		
41-50	103	37.1		
51-60	71	25.5		
>60	33	11.9		
Educational level (years)				
No formal education	53	18.7		
Primary	75	22.4		
Secondary	91	32.7		
Tertiary	60	21.6		
Household size (number)			6	4.1
<3	51	18.3		
4-6	125	45.0		
7-9	54	19.4		
>10	48	17.3		
Farm size (hectare)			1.65	1.42
<1ha	93	33.4		
1.0 - 2.9	85	30.6		
3.0 - 3.9	46	16.5		
4.0 – 4.9	33	11.9		
>5.0	21	7.6		
Access to credit				
Yes	65	23.4		
No	213	76.6		
Membership of cooperatives				
Yes	170	61.2		
No	108	38.8		
Production type				
Upland	163	65.8		
Lowland	95	34.2		
Extension contacts				
No access	103	37.1		
Once	98	35.2		
Twice	77	27.7		
Off farm activity				
Yes	163	58.6		
No	115	41.9		
Annual income			374,212.5	272,975.2
<200,000	105	32.8		
201,000- 400,000	95	25.9		
401,000-600,000	45	12.2		
601,000- 800,000	21	14.8		
>1,000,000	26	9.4		

Source, Field survey, 2017

Table 3: Summary statistics of variables used in the stochastic frontier analysis

Farm resources	Mean	Price (₦)
Output (kg)	3123.38 (2297.19)	470.35 (232.34)
Farm size (ha)	1.65 (1.51)	15,450.00 (7298.52)
Labor (man-day)	224.25 (636.25)	1,146.25 (714.91)
Tractor use (hour)	5.34 (9.50)	12,340.96 (11023.69)
Seeds (kg)	172.23 (142.30)	289.74 (82.10)
Fertilizer (kg)	371.85 (813.55)	203.48 (203.77)
Herbicide (lt)	13.57 (29.91)	1,770.85 (781.66)

Source: Field survey, 2017

The average tractor hire-hour was 5.34 hours. The average fertilizer used per hectare was estimated at 125kg per hectare which is lower than the recommended usage of 200-400kg/ha application level for effective optimum growth and yield (CRI/MOFA, 2005). The price of farmland rent, daily wage, tractor hiring unit, seed price, fertilizer price, herbicide price and price of Paddy was ₦15,450.00 ($41.86) per hectare, ₦1,146.25 ($31.06) per man-day, ₦12,340.96 ($33.44) per hour, ₦289.74 ($0.79) per kg, ₦203.48 ($ 0.55) per kg, ₦1,770.85 ($4.80) per liter and ₦470.35 ($1.27) per kg respectively.

1US$ = ₦369 (2017 official exchange rate)

Maximum likelihood estimates of the stochastic frontier production function

The Maximum Likelihood Estimates (MLE) of the stochastic production frontier is presented in Table 4. The distribution assumption stated fits the data well, as evidenced by the sigma squared value of 0.642. The result suggests that a suitable representation of the data is provided by the Cobb-Douglas stochastic frontier production function. The variance of the ratio (Gamma), which measures how technical efficiency affects the variation in observed output, is 0.637, implying that technical inefficiency was responsible for 63.7% of the variation in rice farmers' output overall. This implies that random shocks beyond farmers' control, such as weather disasters during the rice-producing process, accounted for about 64% of the variation. The output of rice will be optimized if producers reduce their technical inefficiencies. The coefficient of farm size was positive and significant at 1%. This implies that as the farm size increases by a unit, the output of the rice produced increases by 28%. This is in line with other studies that concluded that the large farm size enhanced the productivity among rice farmers in the study area (Afolami & Farinola, 2011; Akinbode *et al*., 2011; Kadiri *et al*., 2014). The coefficient of labor (0.054 $p< 0.05$) was positive and significant, implying that an increase in the labor input (man-day), will lead to an increase in the rice output. The implication is that the labor used for rice production in the study area was underutilized and it has to be put to better use to become more technically efficient. This result is in line with the findings of Enwerem & Ohajianya (2013) who reported that the elasticity of labor use with respect to rice output has an increasing influence on the output of rice produced. The coefficient of herbicide was significant and it has a positive influence on rice production. This implies that the herbicides used in controlling weeds in competition with rice for space and soil nutrients during the production cycle have had a positive effect on rice output. This corroborates the findings of Akanbi *et al*., (2011), Kaka *et al*., (2016) who found that an incremental use of agrochemicals on rice farms increases rice output. Similarly, the coefficient of fertilizer (0.018 $p< 0.1$) was found to have a positive and significant relationship with the rice output in the study area. This implies that an increase in the use of fertilizer by a unit increases rice output by 0.018 units. This is consistent with the findings of Dessale (2019), Coster *et al*., (2020) that fertilizer utilization increases crop output.

The return to scale was 0.40 which implies that, technically, the rice farming in the study is operating in decreasing the returns to scale. Additionally, this suggests that 1% increase in all inputs results in 0.40% increase in outputs, indicating that farmers should intensify efforts to increase the current scope of rice production in order to fully realize the potential for production.

Determinants of technical efficiency of rice farmers

A technical inefficiency model for rice production is shown in Table 4, and the coefficient of the variables plays a critical role in explaining the observed technical efficiency. A positive coefficient of the determinant of technical efficiency indicates the decrease in the level of technical efficiency with a unit increase in the explanatory variable, while a negative sign of the coefficient implies that the variable has the effect of reducing technical inefficiency, hence increasing farmers' technical efficiency in the study area.

The result shows that the age of farmers was positive and significant; this indicates that with an increase of age, their technical inefficiencies also increase. This result supports the findings of Ambali *et al.*, (2012) who found that younger farmers are better positioned in terms of knowledge and proper training in the rudiments of rice production compared to ageing farmers. However, the result is contrary to the findings of Akinbode *et al*., 2011; Kadiri *et al.*, 2014 and Dessale (2019) who found that older farmers are believed to have more farming experience than younger ones and are therefore more technically efficient.

Table 4: Maximum likelihood estimate of the stochastic production frontier

Variables	Coefficient	Standard error	p-value
Farm size	0.280***	0.059	4.746
Seed	0.021	0.063	0.334
Tractor	0.004	0.017	0.236
Labor	0.054**	0.028	1.927
Herbicide	0.023*	0.014	1.643
Fertilizer	0.018*	0.010	1.810
Constant	7.859***	0.327	24.033
Inefficiency model			
Age	0.025*	0.014	1.786
Sex	-0.310	0.378	0.821
Education	-0.035	0.029	1.206
Household size	0.054	0.212	0.255
Extension contacts	-0.064	0.317	0.201
Credit access	-0.667**	0.345	1.933
Membership of Cooperatives	-0.388	0.318	1.220
Land type	0.412	0.322	1.278
Log likelihood	-307.38		
$Sigma^2$	0.642	0.078	8.231
Lambda	1.325	0.115	11.521
Gamma	0.637	0.076	8.382

Source: Computed from field survey data, 2017

*** Significant at 1%; ** significant at 5%; * significant at 10%

The coefficient of access to credit is negative and significant (-0.667 $p< 0.10$). This implies that while a farmer has access to credit to further the expansion of scale of operation, there is the possibility of reducing inefficiencies. This indicates that the access to credit enhances farmers' technical efficiency. This result agrees with the findings of Biam *et. al.*, (2016) and Dessale (2019): farmers who have access to credit are more likely to innovate and have the capital to apply the best practices in rice production.

Maximum likelihood estimates of the stochastic frontier cost function for rice farming households in southwest, Nigeria

The allocative efficiency analysis of the rice farmers from the Maximum Likelihood Estimates (MLE) of the stochastic cost frontier is presented in Table 5. The value of sigma squared was 0.488 indicating a good fit and correctness of the distribution. The estimated gamma parameter (0.41) implies that about 41% of the variation in the total production cost among the sampled rice farmers was due to cost inefficiency in the pricing of inputs. The coefficient of rent paid on the land used for rice farming was found to be positive and significantly ($p<0.01$) contributed to the total cost of rice production. This implies that 1% increase in the price of land will increase the total cost of rice production by about 0.113%. The coefficient of the tractor rent (0.024 $p<0.01$) was positive and significantly influenced the total cost of rice production. Thus, 1% increase in the rent of tractor per hectare will increase the total cost of rice production by 0.024%, This result agrees with the findings of Girei *et al.*, (2013) and Solanke *et al.*, 2016) who found out that the tractor cost is an important factor that determines the minimization of production cost. The implication is that if combined well, the labor and tractor prices can help minimize rice production cost to get maximum output. The price of herbicide has a positive and significant relationship with the total cost of rice production. These results revealed that the rice farmers in the study area under-utilized the input resources, and so, were allocatively inefficient.

Determinants of allocative efficiency of rice farmers

The results of the allocative inefficiency model show that the coefficient of sex (-1.127 $p<0.05$) was negative and had significant impact on the allocative efficiency of farmers. This implies that the male farmers are more likely to be allocatively efficient than their female counterparts in rice production. The education coefficient was negative and significant (-0.083 $p<0.05$). This implies that with increased years of education, the level of allocative inefficiency is reduced. This may be attributed to the fact that farmers who are literate can easily understand the needs to adopt new innovations which could enhanced the rice production output and reduce production costs. This outcome confirms the findings of Mensah and Brummer (2016), who found that farmers with higher levels of education are better at obtaining up-to-date information on input and output prices and are more open to experimenting with new production technologies in an effort to enhance their farming practices. Access to extension agent was negative and significant (-0.688 $p<0.05$). This indicates that the access to extension services reduces inefficiency in resource allocation among rice producers. This is because of the role the extension agent plays in enlightening the farmers and introducing new and improved technology in rice production. This is consistent with the findings of Wongnaa & Awunyo-Vitor (2019), who found that extension agents help farmers learn about new production technologies and about the best way to combine production inputs.

Table 5: Maximum likelihood estimate of the stochastic cost function in rice production

Variables	Coefficient	Standard error	P-value
Rent on land	0.113**	0.054	2.092
Price of seed	0.086	0.156	0.551
Rent on tractor	0.024***	0.007	3.427
Price of labour	0.087	0.123	0.707
Price of herbicide	0.291**	0.141	2.063
Price of fertilizer	0.007	0.057	0.122
Output (kg)	0.175**	0.057	3.070
Constant	5.991***	1.681	3.563
In-efficiency model			
Age	-0.008	0.019	0.421
Sex	-1.127**	0.561	2.006
Years of schooling	-0.083**	0.036	2.305
Extension contacts	-0.688*	0.401	1.715
Access to credit	0.305	0.469	0.650
Membership of cooperatives	0.262	0.391	0.670
Production type	-0.645	0.445	1.449
Log likelihood	-306.07		
Sigma2	0.488	0.084	5.808
Gamma	0.410	0.119	3.444
Lanbda	0.834	0.127	6.556

Source: Computed from field survey data, 2017

*** Significant at 1%; ** significant at 5%; * significant at 10%

The estimation of technical, allocative and economic efficiency of rice farmers in the study area

Figure 1 shows the distribution of efficiencies scores for the technical, allocative and economic efficiency of the rice producers in the study area. The findings indicate that rice farmers' TE scores, on average, range from 5% to 88.5%. This suggests that the most efficient farmer operates at an efficiency level of 88.5%, while the least efficient farmer operates at an efficiency level of about 5.0%. The wide variation shows a possibility for improvement. The mean TE of 0.621 implies that the rice farmers were 62.1% efficient in using their technologies. By using their production resources more effectively, these farmers could increase their outputs by about 37.9%. According to the study's findings, the average farmer in the sample could increase output by 29.8% (1 – (62.1/88.5) if he were to reach the technical efficiency of his most efficient counterpart. About half (50.8%) of the rice farmers have their allocative efficiency between 60%-79% efficiency level. This suggests that using the cost-minimizing input ratio, the rice farmers in the study area are fairly efficient at producing rice at a given level of output. The sample's economic efficiency varies from 1.2% to 71.4%, and the mean EE was 41.2% suggesting that the average farmer in the sample could save 42.2% (i.e., 1 – (0.412/0.714) in costs if they were to reach the economic efficiency level of the majority of their efficient counterparts. Similarly, the most economically inefficient farmer should save costs of about 98% (i.e., 1 – (0.012/0.714)) to achieve the efficiency level of the most economically efficient rice farmer. These findings make it clear that there is room for significant improvement in economic efficiency and that allocative efficiency poses a greater threat than technical inefficiency.

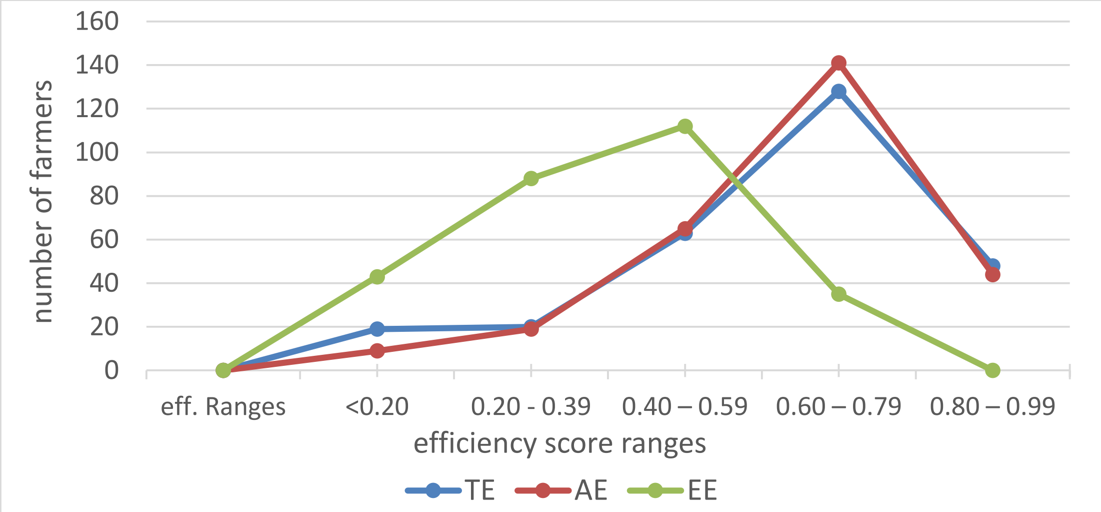

Fig. 1. Distribution of rice farmers' production efficiency level

Determinants of farm-level production efficiency

Table 6 presents the factors affecting the production efficiency of rice farmers. The sigma value of 0.058 indicates the goodness of the model at 1% probability level. The results show that the relevant and significant factors that influence production efficiency of rice farmers are age, sex, education, household size, extension contacts and credit access. The coefficient of age was negative and significant ($p<0.01$). This implies that as the farmer's age increases there is a decline in production efficiency by 0.042%. This implies that younger farmers are most likely to take risks, adopt new production technologies and utilize their resources optimally. This is in agreement with the findings of Ambali *et al.*, (2012) while it is contrary to Aboaba (2020), Dessale, (2019) who reported that old farmers are more efficient in resource allocation than younger farmer because of the accumulated years of experience in farming. Sex had a positive and significant coefficient ($p<0.05$). This suggests that male farmers are more productive and efficient in rice production than their female counterparts. Education of the household head was positively related to production efficiency and the relationship was significant at 1%. This implies that as the farmer's year of schooling increase, production efficiency also increases. The result agrees with the findings of Mensah & Brummer (2016), Iheke & Onyendi (2017), Okello *et al.*, (2019) who reported that educated farmers have responsive ability to adopt agricultural innovations that invariably increase their production efficiency. The coefficient of household size has a negative and significant ($p<0.05$) relationship with farmer's production efficiency. This implies that an increase in the household size by a unit would result in a decline in production efficiency of rice farmers by 0.286%. This is in consonants with the results reported by Aboaba (2020) and Okello *et al.*, (2019). The coefficient of extension contacts was positive and significant ($p<0.1$). This implies that access to extension delivery services requires updating farmers' skill and knowledge on new innovations. Improved production technologies have positive effects on production efficiency. The production efficiency of farmers is positively and significantly ($p<0.05$) correlated with their access to credit. This implies that farmers' cash constraints are lessened by the availability of credit, enabling them to pay for input purchases and meet the transaction costs of various farming activities when they are unable to do so by their own means. This supports the findings of Dessale (2019) and Biam *et al.* (2016) who reported a positive and significant relationship between credit and farmers' efficiency.

Table 6. Estimates of the factors influencing production efficiency using Tobit regression

Variables	Coefficient	Standard error	P-value
Age	-0.042***	0.011	3.818
Sex	0.428**	0.206	2.078
Education	0.040***	0.012	3.333
Household size	-0.286**	0.125	2.288
Extension contacts	0.234*	0.138	1.696
Access to credit	0.456**	0.189	2.413
Membership of cooperatives	0.511	0.486	1.051
Constant	1.554***	0.287	5.414
Sigma	0.058***	0.012	
Prob >chi2	0.000***		
Log likelihood	-347.02		

Source: Computed from field survey data, 2017

*** Significant at 1%; ** significant at 5%; * significant at 10%

CONCLUSION

The study revealed a wide variation in the technical, allocative, and economic efficiency of the rice farmers indicating the presence of inefficiency factors in rice production. The mean technical, allocative, and economic efficiency suggested that the rice farmers in the study area were operating below the frontier, indicating a potential for increasing rice production using the current technology, prices and fixed level of resources. Rice farmers' production efficiency was significantly influenced by age, sex, education, household size, extension contacts and credit access. The study recommends that policies to enhance availability and better use of production inputs should be implemented. The issues of improving farmers' knowledge through training and extension delivery services, strengthening the credit institutions for adequate support and offering encouragement to young people in active rice farming should be given adequate attention by the policy makers, as these will do a great deal of improving the farms' production efficiency.

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