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Profit Efficiency among Rain-Fed Rice Farmers in Northern Taraba State , Nigeria

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Abstract
The study analyzed the profit efficiency of rain-fed rice farmers in Northern zone of Taraba state by collecting data from 156 respondents in 2013. A measure of profit efficiency was provided using stochastic profit frontier and inefficiency model. The results showed that there were high levels of inefficiency in rice production. The mean level of profit efficiency was 59% indicating that 41% of the profit was lost due to a combination of both technical and allocative inefficiencies. The profit inefficiency model showed that age, education, farming experience, household size and access to credit facilities increased the profit efficiency of the respondents. It is therefore, recommended that learning opportunities, farm inputs and credit facilities should be made available to farmers in appropriate time.
Keywords: Efficiency, Profit-function, Rice, Taraba State.

1. Introduction

Rice has been an important food for most people in sub-Saharan Africa particularly West Africa where the consumption of cereals mainly sorghum and millet has decreased while that of rice has increased as a result of shift in consumers' preference, urbanization and increase in population. Rice is notably palatable and can digest easily. It is grown approximately on 3.7 million hectares of land in Nigeria, covering 10.6% of the 35 million hectares of land under cultivation, out of a total arable land area of 70 million hectares. Where 77% of the farmed area of rice is rain-fed, of which 47% is lowland and 30 percent upland (Cadoni and Angelucci, 2013). The range of grown varieties is diverse and includes both local (such as Dias, Santana, Ashawa, Yarsawaba, and Yarkuwa) and enhanced varieties of traditional African rice (such as NERICA) (Bayou 2009).

Despite recorded increase in rice production over the years, the demand for the commodity in Nigeria outstripped it supply. For example, Paddy rice production had increased between 2001 and 2006 from 2.75 million to 4.0 million tonnes, followed by a decline in 2007 to 3.5 million tonnes and a positive peak in 2008 was witnessed in which the output was estimated at 4.3 million tonnes. From 2008 to 2010 production statistics showed a decreasing trend in production from 4.3 to 3.5 million tonnes (FAOSTAT, 2012). On the other hand, the consumption pattern keep increasing from 3.05 million in 2001 to 5.95 million tonnes in 2012 (IRRI, 2013). This shows a wide gap between production and consumption of the commodity.

This phenomenon led various governments to come up with policies and programmes that would ensure efficient bridging of the gap. However, the policies were erratic and so unable to achieve the designed goals and objectives of increasing rice production in particular, and achieving agricultural growth and equity in general. Existing low level of productivity in food grain production reflect low level of technical, allocative and economic efficiencies. Therefore, increasing agricultural growth is an indication of appreciable growth in agricultural production process that is linked to farm profit (Ogundari, 2006).

Studies have shown that rice production in Nigeria is primarily done by small-scale producers, who do not measure their efficiency and elasticity of production, neither do they measure the yields produced from other rice farmers (Akighir and Shabu, 2011). Efficiency measurements that show the scope for improved performance may be useful in the formulation and analysis of agricultural policy (Russel and Young, 1983). Most of the studies of efficiency carried out in Taraba State were mainly on technical efficiency, using traditional frontier production function. Example of such studies include Ahmadu and Erhabor (2012), Jonathan and Barau (2012) and Taphee and Jongur (2014). There is, however, limited application of profit frontier function in the study of efficiency in the state. Some researchers (e.g., Ali and Flinn, 1989; Kumbhakar and Bhattacharya, 1992; Ali, et al., 1994; Wang, et al., 1996) argue that a production function approach to measure efficiency may not be appropriate when farmers face different prices and have different factor endowment. They alternatively used stochastic profit function model to estimate farm specific efficiency directly. Ogundari (2006) opined that physical productivity considerations (Technical efficiency) are important improvement in production efficiency, but profit efficiency will lead to greater benefits to agricultural producer in the country. It is on this backdrop that the paper investigated the profit efficiency of Rain-fed Rice farmers in Northern zone of Taraba State, using a stochastic profit frontier approach.

2. Methodology

2.1 Study Area

The study was conducted in Northern zone of Taraba State, Nigeria. Taraba State is located in the north eastern part of Nigeria. The state lies between latitude 6^0 30′ and 9^0 36′ north of the equator and longitude 9^0 10′ and 11^0 50′ east of the Greenwich meridian (Taraba State Ministry of Information, Youth, Sports and Culture [TSMIYSC], 1999).

The state has a land area of 59, 400 km^2 with a population of 2,294,800 people (Federal Republic of Nigeria Official Gazette, 2009). It shares common boundary with Bauchi state in the north and Gombe State in the north east, Adamawa State in the east and Plateau state in the North West. The state is further bounded to the West by both Nasarawa and Benue states, while it shares an international boundary with the republic of Cameroun to the south and south east (TSMIYSC, 1999). The state has a tropical climate marked by rainy and dry seasons. The rainy season starts in April and ends in October. The wettest months are August and September. Mean annual rainfall ranges from 800mm in the north to over 1800mm in the south. The dry season, on the other hand, starts in November and ends in April. The mean daily temperature ranges between 14.8^{o}C and 34.4^{o}C.

The state is predominantly agrarian in nature, with about 80% of its inhabitants depending on subsistence agriculture practices mainly in food production. The climate, soil and hydrology of the area provide good atmosphere for the cultivation of most staple food crops, grazing of animals, fresh water fishing and forestry. The rich alluvian tract of the soil found in most part of the state makes it conducive for growing various foods and cash crops.

2.2 Sampling Techniques

The study used a multi-stage sampling technique. The first stage involved selection of Local Government Areas (LGAs). Northern zone of Taraba State comprises six LGAs, namely: Ardo-Kola, Jalingo, Yorro, Zing, Lau and Karim-Lamido. Three of the LGAs (Lau, Karim-Lamido and Ardo-Kola) have a significant portion of their land situated along coastal areas of the River Benue and as such, the LGAs are notable in rice production in the state. Therefore, the three LGAs were purposefully selected in the first stage of the sampling.

The second stage involved purposive selection of three wards from each LGA selected in the first stage. These are: Lau, Mayo-Lope and Kunini from Lau LGA; Yelwa, Tau, and Mayo-Ranewo from Ardo-Kola LGA; and Usumanu, Sabon-Layi and Didago from karim-Lamido LGA.

In the last stage, a list of rice farmers from each ward was obtained from the Taraba State Ministry of Agriculture and 173 respondents were randomly selected from the list. The selection was done in proportion to the number of farmers in each ward.

2.3 Data Collection

Primary data were mainly used in the analysis. This include socio-economic data such as age, educational level, household size, access to credit and farm level data which include farm size, level of output, input and output prices and soon. The data were collected using structured questionnaires administered to 173 respondents sampled above. The total questionnaires used in the analysis were 156 only while the remaining 17 were either not retrieved or discarded as a result of some anomalies.

2.4 Analytical techniques

Following Rahman (2003) who utilized Battesse and Coelli (1995) model and postulated a profit function model which is assumed to behave in a manner consistent with the stochastic frontier concept, the stochastic profit function is defined as:

$$\Pi = f(p_i, Z_{ik}; \beta_i). \exp(e_i) \text{ --- } (1)$$

Where; Π= normalized profit calculated as Total Revenue (TR) less Total Variable Cost (TVC) divided by price of output, P_i = normalized price of variable inputs divided by output price, Z_{ik} = level of kth fixed factor on the farm, β_i = vectors of parameters, e_i = stochastic disturbance term, assumed to behave in a manner consistent with the frontier concept. i.e.,

$$e_i = v_i - u_i \text{ -- } (2)$$

Where: Vis are assumed to be independent and identically distributed random errors, having normal N (0, σ^2v) distribution, independent of the Uis. The Uis are profit inefficiency effects, which are assumed to be non-negative truncation of the half-normal distribution (|N(μ, σ^2u|).

The inefficiency effect is defined as:

$$U_i = \delta_0 + \Sigma\delta_d W_{di} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .(3)$$

Where: W_{di} is the dth explanatory variable associated with inefficiencies on farm i and δ_0 and δ_d are the unknown parameters. The variance of the random error, σ_v^2 and that of the profit inefficiency effect σ_u^2 and overall variance of the model σ^2 are related thus:

$$\sigma^2 = \sigma_v^2 + \sigma_u^2, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (4)$$

measures the total variation of profit from the frontier which can be attributed to profit inefficiency (Battese and Corra, 1977). Gamma (γ) is specified as:

$$\gamma = \frac{\sigma_u^2}{\sigma^2} = \frac{\sigma_u^2}{\sigma_v^2 + \sigma_u^2} \quad (5)$$

The parameter γ represents the share of inefficiency in the overall residual variance with values between 0 and 1. If γ = 1, profit inefficiency is the dominant source of error and there is no effect of random errors in the data. On the other hand, if γ = 0, it shows that the dominant source of error could be attributed to random factors alone and thus, no inefficiency effect.

All parameters of the stochastic frontier profit function and that of inefficiency model as well as sigma squared and the gamma were estimated using FRONTIER VERSION 4.1c (Coelli, 1996). In the final MLE, restricted and unrestricted models were estimated. The restricted model is the OLS model in which the inefficiency effects are not present (Ui=0). The unrestricted model is the general model where there is no restriction and thus γ= 0.The two models were compared for the presence of profit inefficiency effects using the generalized likelihood ratio test which is defined by χ^2 = -2In {H_0 / Ha}.Where χ^2 has a mixed Chi-square distribution with the degree of freedom equal to the number of parameters excluded in the unrestricted model. The null hypothesis was that there is no difference between restricted and unrestricted Cobb-Douglas profit frontier models.

2.5 Empirical Specification

A Cobb-Douglas stochastic profit function is as expressed below:

$$Ln\Pi_i = \beta_o + \beta_1 lnZ_{1i} + \beta_2 lnP_{2i} + \beta_3 lnP_{3i} + \beta_4 lnP_{4i} + \beta_5 lnP_{5i} + \beta_5 lnZ_{2i} + V_i - U_i \quad (6)$$

Where: Π_i represents normalized profit computed as total revenue less variable cost divided by farm specific rice price; Z_1 represents Farm size (ha); P_i represents average price per man day of labour ;P_2 represents average price per kg of fertilizer ;P_3 represents average price per kg of seed ;P_4 represents price per litre of agro chemical; Z_2 represents average price of farm tools.

The inefficiency model (u_i) is defined by:

$$Ui = \delta_0 + \delta_{1i}W_{1i} + \delta_{2i}W_{2i} + \delta_{3i}W_{3i} + \delta_{4i}W_{4i} + \delta_{5i}W_{5i} + \delta_{6i}W_{6i} \quad (7)$$

Where: W_1, W_2, W_3, W_4, W_5, and W_6 represent age, educational level, farming experience household size, access to credit and extension contact respectively. These socio-economic variables are included in the model to indicate their possible influence on the profit efficiencies of the rice farmers (determinant of profit efficiency).

3. Results and Discussions

3.1 Socio-Economic Characteristics of the Respondents

Table 1: Socio-economic characteristics of the respondents

Variable:	Frequency	Percentage
Gender:		
Male	123	79
Female	33	21
Age range:		
<20	10	6.41
21 – 30	60	38.46
31 – 40	50	32.05
41 – 50	18	11.54
51 – 60	12	7.69
>60	6	3.85
Marital status:		
Married	133	85.26
Single	11	7.05
Widow	12	7.69
Educational level:		
None	20	12.82
Arabic	36	23.08
Primary	48	30.77
Secondary	32	20.51
Tertiary	20	12.82
Farming experience (years):		
≤ 5	53	34.20
6 – 10	34	21.80
11 – 15	37	23.50
16 – 20	18	11.50
>20	14	9.0
Farm size (hectares):		
0.1 – 2.4	96	61.54
2.5 – 4.9	33	21.08
≥ 5.0	27	17.38

Source: field survey,2013

Table 1 shows the distribution of respondents based on their socio-economic characteristics. Majority

(79%) of the respondents were males. The reason could be attributed partly to socio-cultural and religious set up of the people in the area which encourages women to observe Purdue (house confinement), and partly to the fact that since mostly men have more physical strength than their female counterpart, they engage more in strenuous activities while the female take part mostly in marketing activities. Majority (82%) of the respondents were aged between 21-50 years old, this shows that they are predominantly youths and hence agile and economically productive. Also, majority (61%) are married with a mean family size of five members. Large family size could be viewed as added advantage in terms of family labour supply, and thus production may be enhanced. Furthermore, majority (87%) of the respondents had one form of education or the other; hence they will likely be early adopters of innovations. Similarly, 66% of them had more than five years experience and 83% were small scale farmers cultivating less than five hectares of land. This may not encourage mechanization system of farming and thus, production may continue to remain at subsistent level.

3.2 Hypothesis Testing

Table 2: Test of hypothesis

Null hypothesis	LR	χ^2 value 0.99	Decision rule
H_0:γ = 0	59.9	16.074	H_0 is Rejected

Source: Computer print-out (2014)

The value of the test statistics as contained in Table 2 is 59.9, while the critical value obtained from Table 1 of kodde and Palm (1986) for the mixed chi-square distribution with six degree of freedom at 1% is 16.074, smaller than the observed statistics. Therefore, null hypothesis is rejected in favour of the alternative hypothesis at 1% level. Implying that deviations from the production frontier were as a result of inefficiency, thereby justifying the specification of the stochastic frontier production function and that OLS estimate could not be an adequate representation of the data.

3.3 Estimate of the stochastic profit frontier function

The maximum likelihood estimates of the parameters of the stochastic profit frontier model are presented on Table 3. The diagnostics statistics showed that the estimated sigma-squared (δ^2) is significant at 10% level. This indicated a good fit and correctness of the specified distributional assumptions of the composite error term. This signifies that subjecting the data to Ordinary Least Square (OLS) could not give an adequate estimate. In addition, the estimated gamma (Υ) of 0.89 which is the ratio of the variance of farm specific profit efficiency to the total variance of the profit was significant at the 10% level of significance as indicted in Table 3, signifying that 89% of the variation in actual profit from maximum profit (profit frontier) among rain-fed rice farms was due mainly to differences in farmers' practices.

The result shows that the coefficient of farm size was 1.1321 and significant at 1% level. This indicates that increasing farm size by 10%, holding other variables constant, farm profit will increase by about 11%, i.e increasing return to scale. This result corroborates with the findings of Abdulai and Huffman (1998), Rahman (2003) and Nmadu and Salihu (2013) who independently found a positive relationship between farm size and profit efficiency in their studies.

The result further reveals that the coefficient of labour had the expected negative sign. This implies that increasing cost of labour by 10% will conversely decrease farm profit by about 4.4%. This is in line with the finding of Tsue, et al. (2012) who in their study of profit efficiency among catfish farmers in Benue State, Nigeria established an inverse relationship between hired labour and gross profit of their respondents. Similarly, the result shows that the coefficient of fertilizers was positive and significant at 5% level. However, decreasing return to scale was established since increasing the cost of fertilizers by 10% will result to an increase in farm profit by only 0.4%. The positive relationship between cost of fertilizers and farm profit can be explained to mean that farmers had resorted to using high quality fertilizers. Therefore, it follows that fertilizers when properly and timely applied will increase yield per area planted and subsequently increases farm profit, all other variables constant. This finding is consistent with that of Long and Yabe (2012) who reported positive relationship between high price of fertilizer and profit efficiency of rice production in Vietnam's Red River Delta.

Table 3: Maximum Likelihood Estimates of parameters of Cobb-Douglas stochastic frontier production function for rice farmers in Taraba State.

Variables	Parameter	Model 1			Model 2		
		Coefficient	SE	t.value	Coefficient	SE	t.value
Production factors							
Constant	β_0	1.88	0.5829	3.225	3.267***	0.3238	10.092
Farm size / ha (Z_1)	β_1	0.6706	0.3827	1.7525	1.132***	0.2103	5.3838
Price labour / per man day (X_1)	β_2	-0.5999	0.1976	-3.0366	-0.4359***	0.1085	-4.0162
Price of fertilizer /kg (X_2)	β_3	0.0148	0.0306	0.4843	0.0435**	0.0189	2.3081
Price of seed /kg (X_3)	β_4	0.1364	0.3750	0.3637	0.0127	0.1816	0.0697
Depreciation on farm tools (₦)(Z_2)	β_6	0.9402	0.2533	3.7119	0.4064***	0.1302	3.121
Inefficiency model							
Constant	δ_0				4.8883	4.0068	1.2199
Age	δ_1				-0.4258	1.0897	-0.3908
Educational level	δ_2				-6.1506*	4.4194	-1.3917
Farming experience	δ_3				-1.8761*	1.7568	-1.0679
Extension contact	δ_4				-2.9661*	2.0872	-1.4210
Access to credit	δ_5				1.2559*	0.8702	1.4432
Family size	δ_6				1.5443**	0.9783	1.5786
Variance parameters							
Sigma squared	σ^2				13.79	8.289	1.664
Gamma	γ				0.89	0.0031	287.09
Log likelihood function	LLF	-45.68			-85.09		
LR test of the one-sided error					59.9		

Source: Computer print-out (2014) ***Significant at 1% **Significant 5% *Significant at 10%

Variable related to price of seed has positive sign but insignificant. It follows that, though using high quality seed which is relatively expensive than local variety will increase farm profit but the effect is very minimal since it only contributes 0.1% when cost of seed increases by 10%. Therefore farmers should not rely solely on using high yielding seed without incorporating other vital cultural practices. The result also shows that the variable related to herbicide was positive but again insignificant. It can be inferred from this result that using herbicides will yield more profit to farmers than engaging the services of hired labour. However, this result is at variance with the findings of Rahman (2003) who in his study of profit efficiency among Bangladesh rice farmers established that cost of agro-chemicals reduces profit efficiency of the farmers.

3.4 Determinants of profit inefficiency

The parameter estimates for the determinant of profit inefficiency are also presented on the lower part of Table 3. The results of the analysis of inefficiency model show that age had negative coefficient and thus, reduces inefficiency. In other words, as farmers get older, the more allocatively efficient they become, because they might have accumulated experiences and opportunities to correct observed errors in the past. This result is in consonance with the findings of Ogundari (2006) and in contrast to the work of Abdulai and Huffman (1998) who suggested that, with life being finite, young farmers have more years to obtain benefits from making costly change and thus have higher adoption rates for profitable technologies than older farm operators.

Education plays a significant role in technology transfer and skill acquisition. It enhances technology adoption and the ability of farmers to plan and take risks. The results further reveals that the coefficient of education had negative sign as expected and significant at 10% level. This implies that farmers with high level of education earn higher profit than those with little or no education at all. This result corroborates with the findings of Kumbhakar and Bhattacharya (1992) and Abdulai and Huffman (1998) who found education to be having positive impact on profit efficiency of their respondents.

Farming involves a lot of risks and uncertainties, hence, to be competent enough to handle all the vagaries of farming a farmer must have stayed on the farm for quite some time. The result from the analysis reveals that farming experience had negative impact on profit inefficiency. This result is expected, because experience is gained through learning by doing which enables farmers to correct past mistakes and adopt better practices in the farm. This result is in line with that of Rahman (2003) who concluded that farmers in his study area with more than three year of experience in growing modern varieties earn significantly higher profit, incur less profit-loss and operate at significantly higher level of profit efficiency. Household size plays a significant role in subsistence farming in Nigeria where farmers rely on household members for the supply of about 80% of the farm labour requirement (Ogundele, 2003). The index of family size can be used as proxy to family labour availability. The coefficient of family size was negative and significant at 10% level (Table 3). This implies that a larger family may have sufficient family labour for farm production especially in such areas where farming is labour intensive and thus, reduces profit inefficiency in rice production. This result is similar with that of Ogundari (2006) who in his profit inefficiency analysis found that the coefficient of household size was negative. The result further revealed that the coefficient of access to credit was positive, implying that farmers lacking credit to purchase necessary inputs at appropriate time tend to experience higher profit inefficiency.

3.5 Efficiency indices of the respondents

Table 4: Frequency Distribution of Profit Efficiency of rice farmers

Range of Profit Efficiency	Frequency	Percentage
0.001 – 0.200	14	8.97
0.201 – 0.400	20	12.82
0.401 – 0.600	34	21.79
0.601 – 0.800	50	32.06
0.801 – 1.00	38	24.36
Min.	0.004	
Max.	0.93	
Mean	0.59	

Source: Computer print-out (2014)

Table 4 represents the distribution of profit efficiency of rain-fed rice farmers. The profit efficiency ranged between 0.004 and 0.93 for the worst and best farmer respectively and with mean efficiency of 0.59. This implies that the average rice farmer in the study area could increase profit by 41% by improving his/her technical and allocative efficiencies. This suggests that there is a wide chance for the farmers to increase their farm incomes and consequently reduce their poverty level. In a related study, Rahman (2003) reported mean profit efficiency level of 0.77 (range 0.125 to 0.925) for Bangladeshi rice farmers. Similarly, Ogundari (2006) recorded mean profit efficiency of 0.601 (range 0.201 to 0.932) for small scale rice farmers in Nigeria. It can be observed that even the best efficient farmer was not optimal in resource allocation and, therefore, need improvement to attain frontier profit. The improvement can be achieved if inefficiency determinants are minimized.

4. Conclusion and Recommendations

The study used stochastic profit function to analyse production efficiency of rain-fed rice farmers in Northern zone of Taraba state, Nigeria. Data from 156 farmers were obtained in 2013 and used to measure their profit efficiency. The result showed wide variation of profit efficiency among the farmers with mean level of 0.59, indicating that there remains considerable scope to increase profits by improving technical and allocative efficiency. The socio-economic characteristics used to explain inefficiencies indicate that those farmers with more years of experience, higher level of education, large number of household size and more access to credit tend to be more efficient.

It is therefore recommended that experienced farmers should be enrolled in the current SURE-P program so as to share their experiences with prospective entrants. This could go a long way to increase profit efficiency and alleviate poverty in the state. Since education was found to be a significant factor in increasing profit efficiency, there is need to extend better teaching and learning opportunities to the farmers. This could be in terms of opening adult literacy classes for the farmers, improving the existing public schools for farmer's children and encourage private schools for those that can afford them.

Production inputs should be made available to farmers at affordable prices and at appropriate time. Also, government land should be opened up to practicing farmers. This could be in terms of reducing cost of capital, relaxing credit conditions and reducing protocols associated with credit procurement procedures. Farmers at their end are encouraged to form saving associations and cooperatives.

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