Efficiency and productivity of farmers in Nigeria: a study of rice farmers in North Central Nigeria.

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INTRODUCTION

Nigeria's rice sector has witnessed some remarkable developments particularly in the last ten years. Both rice production and consumption in Nigeria have vastly increased during this period. The demand for rice in Nigeria is, however, growing faster than for any other major staples, with consumption broadening across all socio-economic classes, including the poor. Substitution of rice for coarse grains and traditional roots and tubers has fuelled growth in demand at an annual rate of 5.6 per cent between 1961 and 1992 (Osiname, 2002). FAO (2003) projected growth in rice consumption for Nigeria beyond year 2000 remained as high as 4.5 per cent per annum. In response to the growing demand for this staple, government at various periods actively interfered in the rice economy coming up with policies and programmes one of which is the enormous (rice) imports to supplement the local production which no doubts constitute an enormous drain on the country's had earn foreign earnings. Others had included oscillating import tariffs and import restrictions. Notwithstanding the various policy measures, domestic rice production has not increased sufficiently to meet the increased demand.

Rice is cultivated in virtually all the agro-ecological zones in Nigeria. Despite this, area cultivated to rice appears small. Estimate of locally produced rice for year 2002 was 2.9million tones (FAOSTAT, 2005). Also, only about 6.7 per cent of the 25 million hectares of land cultivated to various food crops was cultivated to rice between 2000 and 2002 (Osiname, 2002). Paddy rice production in Nigeria has not followed any clear-cut pattern but seems to oscillate with policies of various governments. The trend in production shows that a boom was first experienced in 1965-1970 periods when average output stood at 321 thousand tons. During this period, average area cultivated to rice stood at 234 thousand hectares while average national yield was 1.36 ton/ha. A significant improvement in rice production was recorded in the country between 1986-1990 when output increased to over 2 million tons while average area cultivated and yield rose to 1,069,200 hectares and 2.09 tons/ha respectively. Throughout the period, rice output and yield increased but in the 1991-1995 periods, while output increased, yield of rice declined. The increased output was traced to expansion in area cultivated. On geographical zone basis, the central zone is the largest producer of rice in Nigeria; accounting for 44 per cent of the total rice output in 2000. This was followed by the Northwest (29%) while the Southwest was the least (4%). These zones however, differ in terms of their competitive advantage in rice production. It is interesting to note that within a zone, there could be more than one rice ecologies or production systems (Singh et al., 1997). Thus, where two distinct ecologies exist, the zone may have a competitive advantage in the production of rice.

The limited capacity of the Nigerian rice economy to match the domestic demand raises a number of pertinent questions both in policy circle and amongst researchers. For instances, what factors explain why domestic rice production lag behind the demand for the commodity in Nigeria. Central to this explanation is the issue of efficiency of the rice farmers in the use of resources. Average yield of upland and lowland rainfed rice in Nigeria is 1.8ton/ha while that of the irrigation system is 3.0ton/ha (PCU, 2002). This is low when compared with 3.0ton/ha from upland and lowland systems and 7.0ton/ha from irrigation system in places like Cote d' Ivoire and Senegal (WARDA and NISER, 2001). It thus appears that rice farmers in Nigeria are not getting maximum return from the resources committed to their enterprise. This paper therefore examines the levels of efficiency of selected rice farmers for the two major rice ecologies in the country (upland and lowland rainfed ecologies) and explains those factors that determine their levels of efficiency.

ANALYTICAL FRAME WORK[1]

The estimation of a frontier function will be most heavily influenced by the best performing firms and so the frontier function represents a best practice technology against which the efficiency of firms within the industry can be measured (Coelli, 1995). Assuming that a farm frontier production function is of the form:

$Y = g\,(X_a; \beta)$……………………………………..(1)

Where Z is the agricultural output quantity, X_a is input quantities vector and β is a vector of production function parameters. For a given level of production ($\bar{Y}$), the technical efficient input vector X_t, is derived by solving Eq. (1) and the input ratios $X_1/X_i = ki$ ($i > 1$), where ki is the ratio of observed inputs X_1 and X_i at output $\bar{Y}$.

Given the assumption of Cobb-Douglas technology, the frontier production function is self-dual. Thus the corresponding cost frontier derived analytically from the stochastic frontier production function is given in the general form as:

$C = h\,(P, Y; \gamma)$……………………………………(2)

Where C is the minimum cost associated with the production of Z, P is input price vector and γ is the vector of parameters. Using the Shephard's Lemma we derive a system of minimum cost input demand equations written as:

$$\frac{\partial C}{\partial P_i} = X_i(P, Y; \Psi) \text{ ……………………………(3)}$$

Substituting a firm's input prices and output quantity into the demand system in Eq. (3) yields the economically efficient input vector X_e. Since the cost function is derived from the original frontier production function, X_e is said to be both allocatively and technically efficient. By combining the technically efficient, economically efficient and actual input

[1] The model presented in this section is an adaptation of Bravo-Ureta et al. (1991) Bravo_Ureta and Everson, 1994) model which is based on the stochastic efficiency decomposition methodology. The model is an extension of the model introduced by Kopp and Diewert (1982). See Coelli (1995) and Battese et al. (1996) for further review of frontier function approach.

vectors (X_t, X_e and $X_{a,}$) respectively with the input price vector P following Farrell, (1957) we obtain technical efficiency (TE), economic efficiency (EE) and allocative efficiency (AE) indexes given as follows:

$TE = (X'_t P)/(X'_a P)$..................................(4)

$EE = (X'_e P)/(X'_a P)$..................................(5)

and

$AE = (X'_e P)/(X'_a P)$..................................(6)

Where X'_t P and X'_e P are respectively the corresponding technically and economically efficient coats of production, while X'_a P is the actual cost of production for any particular firm's observed level of output. In all cases, efficient production is represented by an index value of 1.0, and a lower index value is an indication of less efficient production (i.e., a greater degree of inefficiency).

An empirical measure of efficiency can be done by employing the approach introduced by Jondrows et al., (1982) to separate the devotions from the frontier into random and an efficiency component. Showing how this separation is accomplished, we consider the stochastic production frontier of the form:

$Y = f(X_a; \beta) + \varepsilon$.......................................(7)

Where $\varepsilon = v - u$, is the composed error term (Aigner et al., 1977). The two components v and u are assumed to be independent of each other, where v is the two-sided, normally distributed random error ($v_i \sim N(0, \sigma_v^2)$), and u is one-sided efficiency component with a half-normal distribution ($u_i \sim N(0, \sigma_u^2|)$) (Dawson 1990, Sharma *et al* 1999). It follows that the maximum likelihood estimation of Eq. (1) yields estimates for β and λ, where β was defined earlier, $\lambda = \sigma_u / \sigma_v$, and $\sigma^2 = \sigma_v^2 + \sigma_u^2$. Battese and Corra (1977) defined $\gamma = \sigma_u^2/\sigma^2$, so that $0 \leq \gamma \geq 1$ and represent the total variation in output from the frontier attributable to technical efficiency. Jondrow *et al (*1982) quoted in (Bravo-Ureta and Evenson, 1994;

Zaibet and Dharmapala, 1999) have demonstrated that the farm specific measure of technical inefficiency can be determined from the conditional expectation of ui given εi as:

$$E[u_j \mid \varepsilon_j] = \frac{s_u s_v}{s} = s^* \left(\frac{f^*(e_j l / s)}{1 - F^*(e_j l / s)} - \frac{e_j l}{s} \right) \text{......................(8)}$$

Where *f** and F* are the values of the standard normal density and distribution functions respectively, evaluated at $\varepsilon_i \lambda / \sigma$ and σ2 = $s^2 = s_u^2 s_v^2 / s^2$. Consequently, Eqs. (7) and (8) provide estimates for *u* and *v* after replacing *ε,* σ, and *λ* by their estimates. If v is then subtracted from both sides of Eq. (7), we obtain:

$Y^* = f(X_a; \beta) - u = Z - v$................................(9)

where *Y** is the firm's observed output adjusted for the statistical noise captured by *v*. Eq. (10) is the basis for computing the vector X_t and for deriving the cost function algebraically. Applying Shephard's Lemma to the cost function yields the minimum cost factor demand functions, which, is used to obtain the vector X_e.

DATA AND EMPIRICAL PROCEDURES

Data for this study were generated from a survey of 240 rice farmers selected by multi stage sampling approach from Niger state (located in the central zone) a major rice producing state in Nigeria. The state is endowed with vast natural resources suitable for the two predominant rice production ecologies (rainfed upland and lowland) in Nigeria (Erestein *et al* 2003,). Three dominant rice producing Local Government Areas (LGAs) namely: Gurara, Gbako and Mokwa were selected out of the 25 LGAs in the state at the first stage followed by random selection of three villages each from the selected LGAs and finally 120 farmers each were randomly selected for each of the rice production ecologies. Input, output and other relevant socio-economic data were then collected from the farmers through personal interview schedules.

Notwithstanding its limitations, the Cobb-Douglas was chosen to estimate stochastic production frontiers for the two rice systems (using Frontier 4.1) because the methodology employed requires the production function to be self-dual and also the functional form was assumed to be an adequate characterization of technology in rice production for the purpose at hand. Moreover, the Cobb-Douglas functional form has been widely used in both developed and developing countries for farm efficiency analysis (Battese, 1992 and Bravo-Ureta and Evenson, 1994). Kopp and Smith, (1980) and Caves and Barton, (1990) justified the use of single-equation model as specified in Eq. (10) by assuming that farmers maximize expected profits, as is often done in studies like this. The specific model estimated is of the form:

$$\ln Y = \beta_0 + \beta_1 \ln Fz + \beta_2 \ln Lb + \beta_3 \ln Trct^2 + \beta_4 \ln Agch + \beta_5 \ln Sd + \beta_6 \ln Fert + \varepsilon \quad \text{...(10)}$$

where Y is total annual output of rice (kg) for each production system; Fz is the size of farm cultivated to rice; Lb is man -day of labour used, $Trct$. is total hours of traction engaged; $Agch$ the quantity of agrochemical used (litres); $Fert$ is the quantity of fertilizer used (kg), and Sd is the quantity of seeds used for the production of rice measured in kilograms; β_i parameters to be estimated (i = 0, 1,2,3,4,5,6); and ε is the composed error term defined earlier. The explanatory variables included in the model are similar to those used in previous studies of developing Nigeria agriculture (Imolehin and Wada 2000; and Awotide 2004).

2 The tractor variable was removed from the lowland rice farmers' model since this input was hardly used by this group of farmers.

EMPIRICAL RESULTS

Table 1 shows the maximum likelihood parameter estimates of the stochastic production frontier (Eqn. 10) for upland and lowland producers along with some descriptive statistics for the sample. For comparison, OLS estimates of average production functions are also shown. In general, the frontier estimates amount to neutral upward shift of the average function. The function coefficient for upland rice is very close to one (0.97) while the value for lowland rice is 1.05. These values are virtually unaffected by estimator used. Based on restricted least squares regression, the hypothesis of constant return to size cannot be rejected for either upland or lowland rice. These results are consistent with the fact that all farms in the sample are relatively small**.** The largest number of hectares devoted to upland rice production is five while the corresponding figure for lowland is greater than five hectares.

The dual cost frontier for upland (eq. 11) and lowland (eq. 12) rice systems derived analytically from the stochastic production frontier shown in table 1, given as

$$\ln C_U = -2.969 + 0.292 \ln P_{Fz} + 0.454 \ln P_{Lb} + 0.095 \ln P_{Trct} + 0.003 \ln P_{Agch} + 0.138 \ln P_{Sd} + 0.138 \ln P_{Fert} + 0.781 \ln Y_U^* \quad (11)$$

and

$$\ln C_L = -2.458 + 0.126 \ln P_{Fz} + 0.584 \ln P_{Lb} + 0.068 \ln P_{Agch} + 0.388 \ln P_{Sd} + 0.385 \ln P_{Fert} + 0.447 \ln Y_L^* \quad (12)$$

Where C_U is per farm costs of producing upland rice; C_L is the cost per farm of producing lowland rice, P_{Fz} is the price of fertilizer; P_{Lb} is daily wage rate of labour; P_{Trct} is the price of tractor service per hour; P_{Agch} per litre price of agrochemical; P_{Sd} is the price of seeds used as input; P_{Fert} is the price of fertilizer applied per hectare of land; Y_U^* and Y_L^* are the annual total farm output of upland and lowland rice in kilograms adjusted for any statistical noise as specified in Eqn. (9) above. The mean technical (TE) efficiency index computed for 120 rice farmers shown in table 2 are 81.6 and 76.9 for upland and lowland respectively. Given that the same crop is produced under different farming system, it is interesting to compare the efficiency levels for the two systems. The null hypothesis that the mean efficiency for both systems is equal, evaluated using t- tests is rejected. We therefore conclude that the technical efficiency in upland rice production system is significantly higher compared to the lowland production system.

Table1: Average production functions and stochastic production frontiers for upland and lowland rice based on sample of farmers in Niger State Nigeria

Variable	Upland (N=120)			Lowland (N=120)		
	Mean (SD)	Average function	Stochastic frontier	Mean (SD)	Average Function	Stochastic frontier
Intercept	-	1.844*	1.845*	-	1.946*	2.149*
		(0.330)	(0.403)		(0.336)	(0.289)
Farm size	3.27	0.327*	0.317* (0.104)	4.61	0.411*	0.391*
	(2.41)	(0.091)	0.252* (0.058)	(3.84)	(0.153)	(0.136)
Labour	35.36	0.212*	0.036*	52.21	0.223*	0.231*
	(15.67)	(0.075)	(0.012)	(105.41)	(0.078)	(0.063)
Tractor	143.20	0.033*	0.111*	-	-	-
	(28.56)	(0.012)	(0.043)			
Agrochemical	61.75	0.121**	0.141*	118.84	0.012	0.011
	(103.09)	(0.051)	(0.053)	(164.42)	(0.016)	(0.011)
Seed Quantity	32.92	0.134**	0.115	19.07	0.167**	0.165*
	(48.74)	(0.054)	(0.083)	(12.36)	(0.068)	(0.058)
Fertilizer	43.26	0.113	0.972	135.03	0.303*	0.249**
	(57.24)	(0.082)		(126.61)	(0.113	(0.104)
Quasi fun. coefficient		0.940	0.031*		1.116	1.047
Variance parameters			(0.004)			
σ^2	-	0.032	0.047	-	0.075	0.137*
			(0.098)			(0.029)
γ	-	0.050	41.63	-	0.64	0.77*
			4.837			(0.111)
Loglikelihood	-	39.21		-	-115.44	-188.11
LR test of one sided error	-	-		-	-	5.466

*Significant at the 0.01 level, ** at the 0.05 level, ***at 0.1 level

Several authors have investigated the relationship between efficiency and various socio-economic variables using two alternative approaches[3]. One approach is to compute correlation coefficients to conduct other simple non-parametric analysis. The second way, usually referred to as a two-step procedure, is to first measure farm level efficiency and then to estimate a regression model where efficiency is expressed as a function of socioeconomic attributes. Kalirajan (1991) observed that socio-economic attributes have roundabout effects on production and, and hence, should be incorporated into the analysis indirectly, while Ray (1988) argued that the two-step procedure is justifiable if one assumes that production function is multiplicatively separable in what he calls discretionary (included in production function) and nondiscretionary (used to explain variations in efficiency) inputs. Despite the controversy it is still useful to examine the possible relationship between efficiency and socioeconomic characteristic. For this purpose, the analysis of variance (ANOVA) was used in this study to investigate the association between EE, TE and AE, for the following seven socioeconomic characteristics; (1) Age, given by the age of the household head; (2) Education, the number of years of schooling completed by the household head; (3) Experience, the number of years of farming rice by the household head (4) Household size, the total number of people in the household both old and young (5) Farm size, the total number of hectares in the farm unit under each system, (6) Sex, equal to 1 for the female rice farmers and zero for the male farmers (7) Seed variety, equal to one for improved rice variety and zero for the traditional variety

The ANOVA results presented in Table 2 show there is the lack of consistent pattern of association between efficiency and some socioeconomic characteristics as age and education in both production systems; experience in the case lowland system;

[3] For a review of several of these papers, see Bravo- Ureta and Pinheiro (1997)

Table 2: Distribution of the Efficiency Scores and Socio economic characteristics of rice farmers.

Variable	Upland farmers				Lowland farmers			
	N	TE	EE	AE	N	TE	EE	AE
Age (Years)								
≤29	10	93.3	39.2	42.0	7	93.0	27.5	29.6
30-39	36	88.0	40.3	44.0	26	82.9	27.5	33.3
40-49	41	95.7	36.9	38.5	68	86.8	34.3	39.1
50-59	16	97.1	49.3	52.8	17	85.3	19.9	22.8
≥ 60	17	96.3	79.2	80.5	2	71.6	15.2	22.2
F-Value		6.1*	1.1	1.2		1.5	1.3	1.3
Education								
None	6	88.5	41.8	47.3	3	67.0	23.5	36.4
Primary	90	94.3	42.2	45.3	50	84.5	29.3	34.5
Junior Sec.	-	-	-	-	6	88.0	23.0	26.3
Senior Sec	24	94.9	38.9	39.4	61	88.6	31.7	35.7
F-Value		11.8*	0.2	0.5		2.5***	0.3	0.2
Experience (Years)								
≤ 9	10	95.4	44.6	47.3	16	76.0	23.7	31.9
10-19	19	94.2	33.2	34.9	81	86.8	30.5	35.0
20-29	41	89.5	38.6	41.7	21	89.5	35.2	37.9
30-39	31	95.6	47.3	49.8	2	88.8	9.9	11.4
40-49	10	96.4	43.2	48.3	-	-	-	-
50-59	7	96.4	34.5	35.3	-	-	-	-
≥60	2	98.4	89.9	91.5	-	-	-	-
F-Value		2.0***	2.1***	1.9***		3.7*	0.9	0.6
Household Size								
<10	97	92.6	39.5	42.0	58	83.0	23.9	29.1
10-20	19	97.5	51.1	54.3	62	88.5	35.8	40.0
>20	4	93.3	39.8	45.5	-	-	-	-
F-Value		3.4*	1.7	1.7		4.9**	6.8*	4.2**
Farm size (HA)								
<1	-	-	-	-	18	74.5	15.7	21.7
1-5	99	92.4	40.6	43.4	38	81.4	15.4	31.9
>5	21	98.5	45.7	47.9	64	91.7	36.9	40.1
F-Value		13.1*	0.7	0.5		18.1*	5.6*	3.2**
SEX								
0	41	86.7	36.6	41.7	15	77.7	14.7	20.1
1	79	96.9	44.0	45.5	105	87.0	32.3	36.8
F-Value		36.7*	2.18	0.5		6.3*	5.8*	4.4**
Seed Varity								
0	72	91.5	35.4	38.9	72	86.5	31.4	35.9
1	48	96.4	50.6	52.1	48	84.9	52.0	58.9
F-Value		48.8*	10.6*	7.0*		6.4*	8.5*	4.3**

*Significant at P≤ 0.01, ** Significant at P≤ 0.05, ***Significant at P≤ 0.1,

and household size, farm size and sex in the case of the upland system. Some of these results are consistent with findings reported by authors who have studied the productivity of traditional farmers. For instance, Bravo-Ureta and Evenson (1994), and Ajibefun (2003) reported the presences of a weak association between efficiency and education attribute for eastern Paraguay and southwest Nigeria respectively. Azhar, (1991) lend support to this notion by asserting that elementary education (4 - 6 years of schooling) does not have much effect on agricultural productivity in traditional farm settings. In this study, about 75% of the farmers had primary education, 20% had secondary education and 5% had no education.

The clearest pattern that emerges is that, all the socio-economic characteristics were positively related to efficiency. However, four of these characteristics- experience, household size, farm size and sex, had four out of the six cases statistically significant at various levels with marked influence on all efficiency measures under lowland production system except for experience. The significant influence of farm size relates to capturing variation in efficiency that arises from differences in scale and this effect has been widely reported by authors (Bravo-Ureta and Rieger 1991, Amara et al., 1998). Finally, variety of seed (especially the improved variety) exhibits the greatest number of significant relationships with efficiency in all of the six cases. The emergence of a clear-cut pattern thus shows the effect that improved seeds have on individual farm efficiency.

CONCLUSIONS

This paper used a stochastic efficiency decomposition methodology to derive technical, efficiency measures for a sample of rice farmers located in Niger state of Nigeria. The analysis is performed separately for the same crop (rice) but under two farming systems (upland and lowland). This analysis shows an average technical efficiency of 81.6% for upland rice and of 76.9% for lowland, which reveals that there is considerable room for improvement in the productivity of the lowland farms in the area. The results of this study suggest that, farmers could increase output and household income through better use of available resources given the state of technology in terms of improved varieties of rice seeds. Gains in output stemming from improvements in productivity are important to Niger State farmers considering that opportunities to increase farm production by bringing additional virgin lands into cultivation have significantly diminished over the years with the rise in population and consumption of rice in every household in Nigeria. The frontier function under-scores the significance of traction in improving technical efficiency of lowland rice farmers since the variable is hardly used in the area by the lowland rice farmers.

Relationship between efficiency and various socioeconomic variables did not reveal a clear strategy (except for seed variety) that could be recommended to improve performance despite their statistical significance. One possible explanation for the lack of a consistent relationship between efficiency and socioeconomic indicator's might be the existence of a stage of development threshold below which this type of relationship is not observed. If this is the case, then our results imply that Niger state rice farmers are yet to reach such threshold. Consequently, our analysis suggests that policy to improve education and adoption of new rice technology, for example, would be needed in order to go beyond this threshold. Once this is accomplished, additional productivity gains would be obtained by further investments in human capital and related factors. The argument for "threshold" in the literature is a potential explanation for the absence of a strong relationship between elementary education and agricultural output in traditional farming settings (Azhar, 1991, Moock, 1985). This is a typical case in our study with majority of farmers just having primary school education where they spend few years.

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