Socio-economic characteristics and allocative efficiency of upland rice farmers in Ogun State, Nigeria

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ABSTRACT

The paper analysed the relationship between allocative efficiency and a set of socio-economic variables. A multi-stage sampling procedure was used to select 165 rice farmers from six local government areas (LGAs) from the 10 rice-producing LGAs in Ogun State. The paper considered a Cobb-Douglas stochastic frontier cost function applied to farm-level data of upland rice farmers in Ogun State to empirically determine the level of allocative inefficiency, using a single-stage model. The theoretical model predicts a positive relationship among cost of production, capital and output of paddy rice. The study showed a positive and significant relationship between allocative efficiency and farmers' age, access to technical assistance and extension services. Policy measures aimed at increasing rice farmers' access to technical assistance and extension services will go a long way toward boosting rice production in the study area.

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Introduction

Rice is the most important staple food for about half of the human race (Hawksworth, 1985; Oteng & Sant'Anna, 1999). It ranks third after wheat and maize for indigenous production. Wudiri & Fatoba (1992) and Ladebo (1998) estimated that rice contributed about 12 to 14 per cent of the food requirement of the Nigerian populace. They further opined that production capacity of Nigeria's peasants is well below the national requirement. For over two decades, the nation has relied on importation to meet local demand. Rice is important in Nigeria for several reasons, and it is a major contributor to internal and subregional trade (Longtau, 2003).

A major issue that agricultural economists, other researchers, and policy makers are facing today is determining whether agricultural production under existing technology could be increased without using high capital investment or developing new technology (Leibenstein, 1978; Bravo-Ureta & Rieger, 1991; Bravo-Ureta & Evenson, 1994; Xu & Jeffery, 1998). It is no surprise, therefore, that considerable effort has been devoted to analysing farm-level efficiency in developing countries. An underlying factor behind these works is that if farmers are not making efficient use of existing technology, then efforts designed to improve efficiency would be more cost-effective than introducing new technologies to increase agricultural output (Shapiro, 1983). If farmers are efficient in allocating inputs, it leads to minimization of cost for a given level of output. As a result, they maximize profit and are encouraged to produce more; thus, leading to food security, import substitution and competitiveness in rice production.

In the theoretical literature, the efficiency of a firm is defined with two separate concepts, technical efficiency and allocative efficiency (Farrell, 1957). Following the classical definition of Farrell (1957), a firm is considered to be technically efficient if it obtains the maximum attainable output, given the amount of inputs and the technology used; while allocative efficiency reflects the extent to which firms use the inputs in optimal proportion, for a given set of input prices and a given technology. The two measures of efficiency can be combined into a measure of total economic efficiency.

Measuring efficiency is important because it is the first step in a production process that may lead to substantial resource savings. The resource savings have important implications for policy formulation and firm management. For individual farms, gains in efficiency are particularly important in periods of financial stress. Efficient farms are more likely to generate higher incomes and, thus, stand a better chance of surviving and prospering (Bravo-Ureta & Rieger, 1991).

Although resource use efficiency has been studied in recent times in Nigeria (Amaza & Olayemi, 1999; Oredipe & Akinwunmi, 2000; Adewuyi & Okunmadewa, 2001; Amaza, 2001; Ajibefun, Battese & Daramola, 2002; Awotide, 2004), research focused explicitly on the relationship between allocative efficiency and some socio-economic variables, using single-stage estimation procedure, has been wanting.

This paper attempts to bridge the gap in knowledge by analyzing the relationship between socio-economic characteristics and allocative efficiency among upland rice farmers in Nigerian agriculture with particular reference to Ogun State.

Materials and methods

Sampling procedure and sample size

A multi-stage sampling procedure was used in selecting the sample. Six local government areas (LGAs) (Abeokuta North, Ewekoro, Ifo, Ikenne, Obafemi-Owode and Yewa North) were selected from the 10 rice-producing LGAs based on the intensity of rice production, varying from low, medium to high levels. One LGA (Ikenne) was selected from low rice-producing LGAs, while two LGAs (Yewa North and Ifo) and three LGAs (Abeokuta North, Ewekoro and Obafemi Owode) were selected from the medium and high rice-producing LGAs, respectively. The LGAs constituted the first stage of sampling.

From the list of the rice-growing villages in each LGA identified by Ogun State Agricultural Development Programme (OGADEP), proportionate random sampling was used to select 30 villages. It was necessary because the number of rice-producing villages in each LGA varied. Cost and time informed the use of 30 villages. It constituted the second stage of sampling.

In each village, rice farmers were identified with the assistance of OGADEP village extension agents (VEAs). From these, six farmers were randomly selected in each village as a third stage of sampling. The proportionality factor used is stated as $V = n / N * 30$; where, *V* is the number of villages to be sampled from each LGA, *n* is the number of rice-producing villages in the LGA, *N* is the summation of rice-producing villages in the six LGAs, and 30 is the desired number of villages for the survey. In all, 180 farmers were sampled. However, only 165 questionnaires were used for the analysis. Fifteen were rejected for inconsistency and inadequate information.

Empirical model

Stochastic frontier cost function

Following Aigner, Lovell & Schmidt (1977) and Meeusen & Van den Broeck's (1977) method of estimating a stochastic frontier production function in which the disturbance term (   ) is composed of two parts, a systematic term (V) and one-sided (U) component, a Cobb-Douglas production function of the following form was specified:

$$Q = g\,(X_a;\ ß) + \qquad 1$$

where Q is the quantity of agricultural output, X_a is vector of input quantities, and ß is a vector of parameters;

$\in_j =$ (error term) is defined as:

$$\in_j = v_j + u_j \qquad j = 1, 2, \ldots\ldots \text{ n farms} \qquad 2$$

If the functional form of the production frontier is self-dual, for example Cobb-Douglas, then the corresponding cost frontier can be derived analytically and written in general form as:

$$C = h\,(K, Q;\ \gamma\,) + \qquad 3$$

where C is the minimum cost associated with the production of Q, K is the capital input, and r is a vector of parameters;

$\in_j$ is as defined above.

Allocative efficiency of farm j (AE_j) is given by:

$$AE_j = \exp\,(+u_j) \qquad 4$$

The efficiency estimates from the cost function, exp (+U) must be > 1 because U > 0, by construction. AE_j obtained in Equation 4 were inverted; that is, $AE_j = 1/\exp\,(+U_j)$ so that $0 \leq AE_j \leq 1$ (Personal communication with Prof. Tim Coelli, 2004). In this cost function, the non-negative random variable u_j, which is assumed to account for the cost of inefficiency, defines how the farm operates above the cost frontier. If allocative efficiency is assumed (Coelli, 1996), the non-negative random variable u_j is closely related to the cost of technical inefficiency.

Several empirical studies (Pitt & Lee, 1981; Awotide, 2004) have used the two-stage procedure to estimate stochastic frontiers and predict firm-level efficiencies using specified production or cost functions or both, and then regressed the predicted efficiencies on firm-specific variables (such as managerial experience and ownership characteristics) in an attempt to identify some reasons for differences in predicted efficiencies between firms in an industry. This has been recognized as a useful exercise, but the two-stage estimation procedure has also been recognised as one, which is inconsistent in its assumptions regarding the independence of the inefficiency effects in the two estimation stages (Coelli, 1996; Kyi & von Oppen, 1999; Ajibefun *et al.*, 2002). The two-stage estimation procedure is unlikely to provide estimates that are as efficient as those that could be obtained using a single-stage estimation procedure (Coelli, 1996).

For this study, a Cobb-Douglas cost frontier specification was estimated: v_i is a random noise term assumed to be distributed as $N(0, \sigma^2_v)$; ui is farm-specific inefficiency effect assumed to follow a truncated (at zero) normal distribution with mean μ and variance σ^2 $\{N(\mu_i, \sigma^2_u)\}$ where $\mu_i = f\,(Z_i, \beta_i)$ and Z_i is a vector of farmer-specific factors and a constant; β is a vector of parameters to be estimated; and f () is a suitable functional form, usually assumed to be linear. The specific equations for the stochastic cost frontier and the inefficiency model are presented in Equations 5 and 6. For this study, the specific Cobb-Douglas cost frontier estimated is:

$$\text{In}\,(C_i/w_i) = \delta_0 + \delta_1 \text{ In } Q_i + \delta_2 \text{ In }(K_i/w_i) + (v_i + u_I) \qquad 5$$

It is assumed that the inefficiency effects are independently distributed and U_{ij}, arises by truncation (at zero) of the normal distribution with mean uij and variance σ^2, where u_{ij} is defined by equation:

$$\mu_i = \beta_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5 + \beta_6 Z_6 \qquad 6$$

where the subscript i indicates the i[th] farmers in the sample

C	=	cost incurred in rice production (₦)
Q	=	output of rice in kilogrammes
K	=	capital (value of implements used in rice production in Naira)
W	=	labour price (wage rate per day in Naira)
δ	=	parameters to be estimated (i = 0, 1, 2)
v	=	two-sided, normally distributed

random error

u = one-sided efficiency component with a half-normal distribution

μ_{is} = are allocative inefficiency effect predicted by the model itself

Z_1 = age of the rice farmer in years

Z_2 = the number of years of schooling completed by the rice farmers

Z_3 = the number of years the farmer has been in rice production

Z_4 = equal to 1 for farmers that received credits and zero otherwise

Z_5 = equal to 1 for those farmers that received technical assistance from sources other than the state ADP and zero otherwise

Z_6 = equal to 1 for farmers that reported having contacts with the extension services from the state ADP and zero otherwise

The βi coefficients are unknown parameters to be estimated, by the method of maximum likelihood, using the computer programme FRONTIER Version 4.1 (Coelli, 1996).

A priori *expectations of variables included in the frontier model*

Age variable was measured in years. In this study, it is hypothesized that effect of age on allocative efficiency could be either negative or positive. Education measured by years of schooling of farmers is hypothesized to be positively related to allocative efficiency as done in previous studies (Bravo-Ureta & Evenson, 1994; Xu & Jeffrey, 1998; Seyoun, Battese & Fleming, 1998; Ogundele & Okoruwa, 2004). Experience represents the farmer's experience measured by the number of years he or she has been engaged in maize production. Studies have shown that farming experience is positively related to efficiency (Parikh, Farman & Shah, 1995; Seyoun *et al.*, 1998). Credit is variable that measures farmers' access to credit facilities. Studies have shown that credit has positive impact on efficiency (Lingrand, Castillo & Jayasuriya, 1983; Bravo-Ureta & Evenson, 1994). Technical assistance and extension are variables that measure the number of times the farmers had contact with research institutions and extension field staff respectively. Extension has been shown to have positive relationship with efficiency (Bravo-Ureta & Evenson, 1994; Amaza & Olayemi, 1999).

Results and discussion

Stochastic cost function: results from half-normal model

Table 1 presents the maximum likelihood estimates (MLE) (Greene, 1980) of the parameters of the stochastic frontier model using the programme FRONTIER 4.1 (Coelli, 1996), which can predict the variance parameter in terms of sigma square and gamma. The estimate of the gamma parameter was high, showing the value of 0.72 and significant, which suggests that the inefficiency effects are highly significant in analyzing the output in physical terms for the rice farmers. The coefficient of output (0.496) was statistically significant at 1 per cent level and had expected positive sign. The coefficient was highly significant and had a positive correlation with the cost of production. It suggested that farmers whose output were high might have increased gross margins (from sales of output), which may be ploughed back into production. Farmers with higher output have better capacity to use improved farm inputs with the associated cost that are usually higher. The coefficient of capital (0.235) was significant at 1 per cent level and positively related to the cost of production of rice paddy in the study area. This is in line with *a priori* expectation. As the use of improved farm implements is desirable for improved output, the implements usually have associated costs, which might increase the cost of production.

Socio-economic, demographic, farm environment, and non-physical factors are likely to affect efficiency (Kumbhakar & Bhattacharya, 1992; Ali & Chaudhary, 1990). Using the inefficiency model in the cost frontier, the study

TABLE 1

Stochastic Cost Frontier for Rice Based on a Sample of Ogun State Rice Farmers in 2002

Variable	*Coefficient*	*T-value*
Stochastic frontier		
Constant	0.332	1.117
Output (Q)	0.496	10.57***
Capital (K)	0.235	3.352***
Inefficiency model		
Constant	1.111	3.042***
Age	-2.010	-2.171***
Level of education	-3.135	-1.403
Experience in rice farming	1.871	2.056***
Access to credit	0.445	2.257***
Access to technical assistance	-0.477	-1.901***
Access to extension services	-0.585	-2.985***
Variance parameters		
Sigma square $s^2_s = s^2 + s^2_v$	0.111	
4.506***		
Gamma $\{¡ = s^2/(s^2 + s^2_v)\}$	0.72	2.626***
Log likelihood	33.48	

Results from data analysis (2002) ***Significant at 1%

captured the determinants of the farmers' allocative efficiency. The estimated coefficients are of interest and have important implications.

The negative coefficients for the age variable implied that older farmers were allocatively efficient than younger ones. This could be explained with the adoption of modern technology. Older farmers tend to be more conservative and less receptive to modern and newly introduced agricultural technology; because newly introduced technology comes with additional cost. Coefficient for age variable was significant. The variable of education showed negative relation with allocative efficiency though not significant. The negative coefficient for education shows that high level of education results in increased allocative efficiency of rice farmers.

The positive coefficient for rice farming experience implies that farmers with more years of experience tend to be less efficient. This does not conform to *a priori* expectation. Adoption studies have shown that older farmers have lower probability of adopting new production technologies, and this might lower their efficiency of production *vis-à-vis* their productivity. Similar result was recorded by Ajibefun *et al.* (2002). In this study, experience in rice farming was found to be significant in determining allocative efficiency of rice farmers in the study area.

Access to credit was used to capture the effect of credit on the efficiency of farmers. The availability of credit is expected to loosen the constraints of production, facilitate timely access to inputs, and increase the efficiency of farmers. Contrary to expectation, the variable had a positive sign and is statistically significant; suggesting that availability of credit hinders attainment of higher level of allocative efficiency. One possible explanation is that access to credit facilities may prompt farmers to overuse productive resources.

There was a negative relation between access to extension and inefficiency effect. This implies that access to extension services tends to increase the allocative efficiency of rice farmers. This is in line with the general belief that farmers learn from the extension services; and if farmers decide to follow the advice of extension agents, then it can certainly enhance the level of efficiency of farmers. Similar result was reported by Kyi & von Oppen (1999). The negative coefficient for access to technical assistance implies that access to it tends to increase the allocative efficiency of rice farmers. The coefficients for access to technical assistance and extension are significant at 1 per cent.

The distribution of allocative efficiency of the rice farmers in Table 2 showed that none of the farmers had an allocative efficiency of less than 70 per cent, while 78 per cent of the rice farmers had an allocative efficiency greater than 90 per cent. The results suggested that the sampled farmers were fairly allocatively efficient. The mean allocative efficiency of 92 per cent suggests that there is the scope for increasing rice production in the study area by 8 per cent if they would operate at the frontier.

TABLE 2

Frequency Distribution of Allocative Efficiency (AE) Estimates for Rice Based on a Sample of Ogun State Rice Farmers in 2002

AE level	*No. of farmers*	*Percentage*
90-100	129	78.2
81-90	27	16.3
70-80	9	5.5
Total	165	100
Mean (%)	91.61	
Minimum (%)	70	
Maximum (%)	98	
Skewness	-1.592	

Computed from results from data analysis (2002)

Conclusion

The paper presented the empirical relationship between allocative efficiency and some socio-economic variables of upland rice farmers in Ogun State, Southwest Nigeria, using a Cobb-Douglas stochastic frontier cost function in application to farm-level data. The theoretical model predicts a positive relationship among cost of production, capital, and output of paddy rice. The study showed a positive and significant relationship between allocative efficiency and farmers' age, access to technical assistance and extension services. Policy measures aimed at increasing the managerial ability of the rice farmers will go a long way toward boosting rice production in the study area.

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