**Published** September, 2012 

# DETERMINANTS OF TECHNICAL EFFICIENCY OF RICE FARMERS IN TARABA STATE, NIGERIA

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## ABSTRACT

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*The study estimated the determinants of technical efficiency of rice farmers in Taraba State of Nigeria. It specifically examined the socio-economic characteristics of the rice farmers, estimated their level of technical efficiency, and examined the factors influencing the technical inefficiency of the farmers. Data for the study were obtained from a total of 133 respondents who provided useful information out of the 150 respondents interviewed using structured pre-tested questionnaires. Data analysis was done using descriptive statistics and inefficiency model estimated jointly with the maximum likelihood estimate of the stochastic frontier production function. The results indicated a significant ($p < 0.01$) presence of technical inefficiency effects in the farmers' production. The significance of the gamma coefficient (0.696) showed that about 70% of the variation of rice output from the production frontier was accounted by the technical inefficiency of the farmers. The results further showed that the determinants of the farmers' technical efficiency were age, gender, family size, level of education and farming experience. The inefficiency of the farmers increased with increase in age and decreased with increase in the number of male farmers, family size, level of education and farming experience. Inefficiency in rice production would be minimized if the socio-economic conditions of the farmers are improved.*

***Keywords**: Factors, technical, efficiency, Rice, Farmers, Nigeria*

## INTRODUCTION

Rice is one of the major staple crops produced in Nigeria. The country is the highest producer of rice in the West African Sub-region. The total paddy rice production in Nigeria stood at about 4.0 million metric tones, representing about 44% of the total production in the West African Sub-region (FAOSTAT, 2008). However, the country is also the highest importer of the commodity in the Sub-region (Akpokodje et al., 2001 and Daramola, 2005). The supply-demand gap keeps widening due to the increasing population growth and shift in consumers' preferences towards rice (Achike and Okoye, 2004 and Ugwuanyi et al; 2008). The inability of the Nigerian rice sector to meet the domestic demand may be due to the low hectarage under cultivation and inefficiency of the farmers in the use of production resources, among others.

Nigeria has about 4.8 million hectares of potential land area for rice production but only about 36% is under cultivation (Ilevbaoje and Ingawa, 2008 and NFRA, 2008) with the rice farmers cultivating average farm size of less than 2 hectares (Daramola, 2005). With the low farm size, increased rice production could be achieved by increasing rice productivity through efficiency in the use of the land and other scarce productive resources. But studies have shown that in Nigeria just as in other developing countries of the world, most resources are not efficiently used in production (Fan, 1999; Okoruwa and Ogundele, 2004; Tiamiyu et al; 2008 and Akighir and Shabu, 2011). The question now is, what are the factors responsible for the inefficiency of the farmers in the use of resources? It is with a view to provide answer to this question that this study was designed. The study is timely and needful now that the Nigeria government is determined to boost rice production and there is little study of this nature on rice, especially in Taraba State of Nigeria. Where such study exists, it was treated as a part of a study and hence might not be considered in detail. The study seeks to achieve the following specific objectives: to examine the socio-economic characteristics of the rice farmers in Taraba State of Nigeria; estimate the level of technical efficiency of the farmers; and examine the factors influencing the technical inefficiency of the farmers.

## METHODOLOGY

**Area of study**

The study was conducted in Taraba State of Nigeria. This choice was informed by the fact that Taraba is one of the major rice producing States of Nigeria. The State occupies land area of 54,473 square kilometers with a population of 2,300,736 people (1,199,849 males and 1,100,887 females) according to the 2006 Nigeria population census (Nigeria/Africa Masterweb, 2006). It comprises 16 Local Government Areas (LGAs) and is located between latitude $6^{o}\ 30^{1}$ and $9^{o}\ 36^{1}$ North and longitude $9^{o}\ 10^{1}$ and $11^{o}\ 50^{1}$ East of the Greenwich Meridian (Taraba State Ministry of Information, Youth, Sports and Culture, 1999). Taraba State has two distinct climatic

seasons – the wet season which starts in April and ends in October and dry season which starts in November and ends in March. Annual rainfall and relative humidity are relatively high, especially in the southern part of the State. The predominant occupation of the inhabitants of the study area is agriculture. Some of the arable crops produced in the State are rice, maize, guinea corn, millet, groundnut, beans, sesame, soyabeans, cassava, yam and tomatoes.

**Sampling technique**

The study combined both purposive and random sampling techniques for the selection of respondents. The purposive sampling technique was employed to select Taraba north, central and south agro-ecological zones of the State for the study. This is because rice is produced in all the 3 zones. Thereafter, 50 respondents (rice based farmers covering upland, lowland and deep water rice production systems) were selected at random (that is, the samples were drawn one at a time, giving every respondent equal chance of being represented) from each agro-ecological zone giving rise to a total of 150 respondents. However, a total of 133 respondents provided useful data that were processed and used for analysis. The rational for covering different categories of rice was to base the study on rice in general and not just a particular rice category.

**Validity and reliability of questionnaire**

The simplest and most direct method of content validity was used to determine the validity of the questionnaire. This involved the examination of the content of the questionnaire by an expert in the field of Agricultural Economics and the content was adjudged to be satisfied. The questionnaire was pre-tested to determine its reliability. Using the test-retest technique, the draft copies of the questionnaire were administered to some rice farmers twice and Pearson Correlation Coefficient was computed between the two sets of responses. A high Correlation Coefficient (0.85) was obtained indicating that the instrument was reliable.

**Data collection and handling**

The collection of data for the study was achieved using a set of well-structured and pre-tested questionnaire administered through personal interview by the researchers and 6 trained enumerators. The enumerators were those who were conversant with the local languages of the respondents. This was to ensure effective communication with the non-literate respondents. The researchers ensured strict monitoring of the enumerators in the administration of the questionnaires. Both the researchers and the enumerators took notes during the interview which were used to check the respondents' responses in each completed questionnaire during data handling process (data standardization, coding and extraction). Data collected covered the socio-economic characteristics of the farmers (age, gender, family size, educational level, farming experience, etc.), production inputs used such as farm land (ha), labour (mandays), rice seed (kg), fertilizer (kg) and herbicide (litres), and output of rice harvested (kg).

**Data analysis**

Data analysis was done using descriptive statistics and inefficiency model estimated jointly with the Maximum Likelihood Estimates (MLE) of the Stochastic Frontier Production Function (SFPF) using the computer program, FRONTIER Version 4.1 proposed by Coelli (1994).

Descriptive Statistics: The descriptive statistics used include means, frequency distribution and percentages in Tables.

**Stochastic frontier production function**

The stochastic frontier production function independently proposed by Aigner et al. (1977) and Meeusen and Van den Broeck (1977) has two error components, viz: the symmetric error term ($V_i$) which accounts for noise (factors beyond the control of the farmers in production) and the non-negative asymmetric error ($U_i$) accounting for the technical inefficiency of the farmers. In model specification, the stochastic production frontier is expressed as:

$$Y_i = f(X_i B) \text{ Exp } (V_i - U_i) \text{ ---------- eqn. (1)}$$

Where:

$Y_i$ = Output of rice of the ith farmer

$X_i$ = Vector of inputs used by the ith farmer. The inputs included $X_1$ = farm size (ha), $X_2$ = family labour (mandays), $X_3$ = hired labour (mandays), $X_4$ = rice seed (kg), $X_5$ = fertilizer (kg), $X_6$ = herbicide (litres)

B = Vector of the unknown parameters to be estimated

$V_i$ = Error term due to noise

$U_i$ = Error term accounting for technical inefficiency in production

f () = suitable functional form and in this study, the Cobb-Douglas function

Other vital parameters estimated in this stochastic function included the sigma squared ($\delta_s^2$), gramma ($\gamma$) and the log-likelihood ratio test. The $\delta_s^2$ indicates the goodness of fit of the model used. The gamma gives the proportion of the deviation of the rice output from the production frontier caused by technical inefficiency. If $\gamma = 0$, it means

$U_i$ is absent from the model and hence all deviations from the frontier are attributed to noise. If $\gamma = 1$, it means all deviations from the frontier are due to technical inefficiency. The log-likelihood ratio test was used to test for the significant presence of technical inefficiency effects in the farmers' production. The log-likelihood ratio statistic has asymptotic distribution equal to chi-square distribution.

The $\delta_s^2$ and $\gamma$ are respectively expressed as:

$\delta_s^2 = \delta_v^2 + \delta_u^2$ ---------- eqn. (2)

where:

$\delta_v^2$ = variance of the error term due to noise

$\delta_u^2$ = variance of the error term resulting from technical inefficiency

$\gamma = \delta_u^2/\delta_s^2$ ---------- eqn. (3)

$o \leq \gamma \leq 1$

where all variables are as earlier defined.

According to Aigner et al., 1977, and Meeusen and Van den Broeck, 1977, the technical efficiency of the farmers is expressed as:

$TE_i = Y_i/Y_i^*$ ---------- eqn. (4)

where :

$TE_i$ = Technical efficiency of the ith farmer

$Y_i$ = Observed output of the ith farmer (kg)

$Y_i^*$ = Frontier output (kg)

The inefficiency model, according to Coelli and Battese (1996), is given as:

$U_i = bo + b_1 Z_1 + b_2 Z_2 + b_3 Z_3 + b_4 Z_4 + b_5 Z_5 + e_i$ ---------- eqn. (5)

Where:

$Z_1$ = Age of the farmers (years)

$Z_2$ = Gender (Male = 1, Female = 0)

$Z_3$ = Family size

$Z_4$ = Level of education (years)

$Z_5$ = Farming experience (years)

$e_i$ = Error term

b's = Coefficients to be estimated

## RESULTS AND DISCUSSION

**Socio-economic characteristics of rice farmers**

The results of the study presented in Table 1 indicate that males dominated the rice production industry in the study area and this is in agreement with the finding of Ibrahim et al. (2008). This may be due to the fact that in most societies the core agricultural production activity is the sole responsibility of the men who are the household heads while food processing and marketing are handled by the women. Ugwuanyi et al. (2008) confirmed this when they reported highest percentage of females in locally milled rice marketing in Enugu State of Nigeria. The age distribution of the respondents showed that most of the rice farmers were relatively young; hence they might be vibrant and economically productive. Majority (77%) of the respondents were married with high family sizes. This underscores the importance of family labour for the rice production.

The results further showed that most of the respondents were literate with 54% of them having at least secondary education. The implication of this is that they could access formal sources of information that could improve their production business. This is because studies have shown that education improves the ability of farmers to make rational production decisions and to adopt innovations (Omoregbee, 1996). As regards farming experience, 64% of the respondents had over 9 years of experience, a report that is similar to the finding of Ugwuanyi et al. (2008). The level of farming experience may affect the farmers' managerial ability in the business. Farming was found to be the major occupation of the farmers in the study area. In their production practices, the farmers relied more on the use of local rice varieties for cultivation as against improved varieties, a practice which may have negative effect on their productivity. It is either the numerous improved varieties of rice developed through research efforts (NCRI, 2008) were inaccessible by the farmers or they were unaffordable. This calls for a drastic effort to bridge the gap between the development of new technology and technology transfer to farmers in Nigeria.

Table 1: Socio-economic characteristics of rice farmers in Taraba State

| Variable | Frequency (133) | Percentage ( |
|---|---|---|
| Sex | | |
| Male | 121 | 91 |
| Female | 12 | 9 |
| Age (years) | | |
| 20-29 | 21 | 16 |
| 30-39 | 24 | 19 |
| 40-49 | 59 | 44 |
| > 49 | 29 | 22 |
| Range | 20 - 65 | |
| Average | 44.29 | |
| Marital Status | | |
| Single | 18 | 14 |
| Married | 103 | 77 |
| Divorce | 1 | 1 |
| Widow/Widower | 11 | 8 |
| Family Size | | |
| 0 | 18 | 14 |
| 1-10 | 72 | 54 |
| 11-20 | 43 | 32 |
| Range | 2 – 20 | |
| Average | 9 | |
| Educational Level | | |
| No formal education | 36 | 27 |
| Primary education | 25 | 19 |
| Secondary education | 31 | 23 |
| OND/NCE | 25 | 19 |
| HND/B.Sc and above | 16 | 12 |
| Farming experience (years) | | |
| < 10 | 48 | 36 |
| 10-19 | 36 | 27 |
| 20-29 | 37 | 28 |
| >29 | 12 | 9 |
| Range | 2 - 31 | |
| Average | 14.44 | |
| Occupation | | |
| Farming | 84 | 63 |
| Civil service | 29 | 22 |
| Trading | 8 | 6 |
| Others (clergy, mechanic, carpentry) | 12 | 9 |
| Rice variety cultivated | 28 | 21 |
| Improved variety | 105 | 79 |
| Local variety | | |

Source: Field survey, 2009

Table 2: Average Quantities of Inputs and Output of Rice Production

| Variable | Average statistics |
|---|---|
| Farm size (ha) | 4.06 |
| Family labour (mandays) | 33.69 |
| Hired labour (mandays) | 33.61 |
| Rice seed (kg) | 73.09 |
| Fertilizer (kg) | 24.62 |
| Herbicide (litres) | 1.85 |
| Rice output (kg) | 2011.13 |
| Frontier output (kg) | 3838.03 |

Source: Field survey, 2009

Table 3: Maximum likelihood estimates of production function for Rice in Taraba State

| Variable | Coefficient | t-ratio |
|---|---|---|
| Constant | 2.948 | 3.905 |
| Farm size ($X_1$) | 0.733 | 3.665* |
| Family labour ($X_2$) | 0.319 | 1.653*** |
| Hired labour ($X_3$) | 0.412 | 2.452** |
| Rice seed ($X_4$) | 0.794 | 2.656* |
| Fertilizer ($X_5$) | - 0.080 | - 2.222** |
| Herbicide ($X_6$) | 0.158 | 1.736*** |
| Sigma squared ($\delta_s^2$) | 0.122 | 11.091* |
| Gamma ($\gamma$) | 0.696 | 6.052* |
| Log-likelihood ratio test | - | 41.465* |
| Variance of error due to noise ($\delta_v^2$) | 0.037 | - |
| Variance of error due to TIE ($\delta_u^2$) | 0.085 | - |

t-value tabulated at: 1% level of significance ($t_{0.01}$) = 2.576, $t_{0.05}$ = 1.980, $t_{0.1}$ = 1.645,
chi-square value tabulated at 1% level of significance = 21.666
*Significant at 1%, ** Significant at 5%, *** Significant at 10%,
Source: Field survey, 2009

Table 4: Level of technical efficiency of rice farmers

| Technical efficiency range | Frequency | Percentage |
|---|---|---|
| 0.201 – 0.400 | 24 | 18 |
| 0.401 – 0.600 | 53 | 40 |
| 0.601 – 0.800 | 32 | 24 |
| 0.801 – 1.000 | 24 | 18 |
| Total | 133 | 100 |
| Minimum | 0.270 | - |
| Maximum | 0.912 | - |
| Mean | 0.524 | - |

Source: Field survey, 2009

**Inputs and output of rice production**

The average inputs used in rice production and the output realized by the rice farmers are shown in Table 2. The average farm size of the farmers fell within the range of 0.10 – 5.99 hectares reported for small-scale farms in Nigeria (Olayide et al., 1980) indicating that rice production in Taraba State was still on small-scale basis. In this case, to increase rice production in the State, inefficiency of resource use must be addressed to increase the productivity of the farm land. Labour usage was low compared with the existing finding of total family and hired labour of 144 mandays per hectare (NCRI, 2008). Other quantities of inputs (rice seed, fertilizer and herbicide) used per hectare by the farmers were also lower than the recommended rates by the NCRI (2008). These low levels of inputs usage might have negative effect on the productivity of the crop, all things being equal. Furthermore, the rice farmers harvested about 2 metric tones (MT) of rice per hectare, which is low relative to the

potential yield of rice (2.0 – 6.5 MT/ha) given by NCRI (2008). This may not be unconnected with the inadequate use of production inputs. The average frontier output (3.84 MT/ha) which is the average output of the most efficient farmers, given the available technologies in the area was still low compared with the average potential yield. The implication is that, besides technical inefficiency of the rice farmers, levels of technologies also limited rice productivity. Thus, there is need for further studies to ascertain the levels of various agricultural technologies in the State and their effects on rice production.

**Production function for rice**

The production function for rice based on the maximum likelihood estimates (Table 3) showed that farm size, family and hired labour, rice seed, fertilizer and herbicide all had significant effect on the output of rice. All the inputs except fertilizer affected the output positively which is in accordance with a priori expectation. The negative coefficient of fertilizer is against a priori expectation as the sign indicates that increase in fertilizer quantity will reduce the level of output of rice. The log-likelihood ratio test which is asymptotically distributed as a chi-square random variable was significant ($P<0.01$) indicating the significant presence of inefficiency parameters in the stochastic model used. This means that variation in the output of rice from production frontier was not only explained by error due to noise (weather, topography, soil fertility, diseases outbreak, government policy, etc) but also occasioned by error due to the technical inefficiency of the farmers in production. In fact, the error due to technical inefficiency dominated the error due to noise as confirmed by the coefficient of gamma which indicated that about 70% of the variation of the rice output from the production frontier was accounted by the technical inefficiency of the farmers. The significant value of the estimated sigma squared indicated a good fit for the model used. Previous study by Okoruwa and Ogundele (2004) on rice in Nigeria also showed the presence of technical inefficiency effects in the farmers' production. The question now is, what is the level of the technical inefficiency of the farmers? The answer to this question is the next focus.

**Level of technical efficiency of rice farmers**

As shown in Table 4, the rice farmers had varying levels of technical efficiency (TE) ranging from about 27 to 91% with the mean of 52%. This means that the farmers still had ample opportunity (48%) to improve their technical efficiency in rice production. This result compares favourably with the finding of Tiamiyu et al. (2008) who reported technical efficiency of 65% for rainfed upland rice farmers in Nigeria. It is however at variance with the finding of Onoja and Achike (2008) who reported high technical efficiency of 95% for rice production under small-scale farmer-managed irrigation scheme and rainfed systems.

**Determinants of technical inefficiency of rice farmers**

Table 5 presents the results of the inefficiency parameters of the rice farmers in the study area. All the variables under consideration (age, gender, family size, educational level and farming experience) were found to have significant effect on the farmers' technical inefficiency. Only age and educational level of the farmers were significant at 5% level of significance, the remaining three (3) variables (gender, family size and farming experience) were marginally significant at 10% level, justifying why the inefficiency of the farmers only ranged from 0.09 – 0.73 (table 4). Age was positively signed while all other variables had negative sign. Positive sign indicates that the inefficiency of the farmers increased as the variable increased and vice versa for negative sign.

The positive influence of age on technical inefficiency of the farmers implies that the older farmers were more technically inefficient than the younger ones. This was expected because younger farmers are more likely to have some formal education and therefore might be more successful to access information and understand new technology which could improve their ability to be technically efficient (Tiamiyu et al., 2008). On gender, since the dummy 1 and 0 were used for male and female respectively, it therefore means that male farmers were more efficient than their female counterparts. This may not be unconnected with the fact that males might be more favourably disposed to accessing productive resources than females. Increased family size decreased inefficiency of the farmers in production, corroborating the findings of Okoruwa and Ogundele (2004) and Tiamiyu et al. (2008) and agrees with the assertion of Adewuyi and Okunmadewa (2001) that large household size decreased inefficiency through labour contribution to production operations.

Furthermore, higher level of education of the farmers led to lower technical inefficiency. This is because, as earlier stated, education brings enlightenment and exposes the farmers to access vital information which could improve their ability to make rational production decisions and to innovate. It means, intensification of effort to provide both adult and extension education to rice farmers would minimize the challenge of inefficiency in the use of resources by the farmers and boost rice production in the country. In the same vein, farming experience correlated negatively with the inefficiency of the farmers confirming the saying that 'practice makes perfect'. This result of farming experience is in consonance with a priori expectation and agrees with the findings of Ajibefun et al. (2002), Onyenweaku and Nwaru (2005) but is contrary to the of finding Okoruwa and Ogundele (2004).

Table 5: Inefficiency parameters of Rice Farmers

| Indicator | Coefficient | t-ratio |
|---|---|---|
| Constant | 2.265 | 0.030 |
| Age of farmers | 0.004 | 2.000** |
| Gender | - 0.147 | - 1.960*** |
| Family size | - 0.011 | - 1.833*** |
| Level of education | - 0.006 | - 2.000** |
| Farming experience | - 0.007 | - 1.750*** |

t-value tabulated at: 1% level of significance ($t_{0.01}$) = 2.576, $t_{0.05}$ = 1.980, $t_{0.1}$ = 1.645
*Significant at 1%, ** significant at 5% Source: Field survey, 2009

## CONCLUSION/RECOMMENDATIONS

The study has established that the rice farmers were about 48% technically inefficient in their production and about 70% of the variation in the output of rice from the production frontier was occasioned by their technical inefficiency. Inefficiency in production increased with increase in the age of the farmers but decreased with increase in the number of male farmers, family size, level of education and farming experience. It was also established that the average output of the most efficient farmers, given the available agricultural technologies at their disposal was still low indicating that besides the inefficiency of the rice farmers, levels of technologies also limited rice productivity. Thus, there is need for further studies to ascertain the levels of various agricultural technologies in the State and their effects on rice production.

On the basis of the findings of this study, the following recommendations are made:

Policy thrust of the Government on the youths who are more efficient than the older farmers should be intensified. The youths should be settled and empowered specifically for rice production. To achieve this, the farm settlement scheme across the country should be revitalized and new ones established.

Since education correlated negatively with technical inefficiency, provision of both adult and extension education to rice farmers will minimize the challenge of inefficiency in the use of resources by the farmers. Government as well as private sectors should intensify effort in this direction.

Also, since increased in the family size of the farmers decreased inefficiency in production, the fight against household poverty should be increased to empower the farm families for efficient rice production.

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