ANALYSIS OF FACTORS AFFECTING TECHNICAL INEFFECTIVENESS OF SMALLHOLDER FARMERS IN NIGERIA: STOCHASTIC FRONTIER APPROACH

J. O. OLADEEBO

Department of Agricultural Economics, Faculty of Agricultural Sciences, Ladoke Akintola University of Technology, Ogbomso, Nigeria

ABSTRACT

This study estimated the technical efficiency of small holder farmers and also identified the socio-economic factors which influence the farmers’ specific technical inefficiencies in Oyo State, Nigeria. Stochastic frontier production function, using the maximum likelihood estimation technique was used in the analysis of data obtained from 150 smallholder food crop farmers.

The results of the study showed that the technical efficiency of farmers ranged from 84.4% to 99.4% with a mean technical efficiency of 94.3%. The mean technical efficiency of 94.3% obtained implied that there is scope for increasing output by 5.7% technical efficiency through more efficient resource utilization. Results also show that contact with extension agents, farming experience and credit availability are factors which reduce the technical inefficiency of farmers.

KEYWORDS: Technical Inefficiency, Small Holder Farmers, Nigeria

INTRODUCTION

Agricultural growth in Nigeria is increasingly recognized to be central to sustained improvement in economic development. The sector plays a very crucial role in the food security, poverty alleviation and human development chain in Nigeria (Aye and Oboh, 2006). The agricultural sector in Nigeria is dominated by the small holder farmers who produce the bulk of food requirements in the country (Ajibefun, 2002). They are involved in the production of grains, such as rice, maize, sorghum and tuber crops such as cassava, cocoyam and yam which supply the bulk of energy requirements to the populace, as well as involved in raising livestock such as goat and sheep which are source of protein to the populace. In spite of the unique position of small holder farmers in agricultural production in Nigeria, they belong to the poorest segment of the population and therefore, cannot invest much on their farms (Ajibefun, 2002).

Rice food crop which was the focus of this study, is one of the food crops grown by small holder farmers with average farm size of 1 to 3 hectares, has become a major staple in Nigeria (Tijani, 2006). It has a great potential and can contribute to income generation and poverty alleviation of small holder farmers in Nigeria. In order to alleviate the poverty confronting small holder rice farmers, two things may be done according to Aye and Oboh (2006). Firstly, they suggested increasing the land area planted to food crops; and secondly, increasing the yield per unit of production resource. However, doubling the land area planted to crop may create environmental damage (Aye and Oboh, 2006). Increasing rice yield per unit of production resource under the present technology could be achieved by improving the socio-economic characteristics and production management of farmers (Srisompun and Isvilanonda, 2012).

Technical efficiency is defined as the ability to produce maximum output from a given set of inputs, given the available technology (Yao and Liu, 1998). This definition indicates that differences in technical efficiency exist between farms. According to Mijindadi and Norman (1982) the observed differences might be attributed to at least four sets of factors such as:
(i) differences in management ability;
(ii) the employment of different levels of technology --- indicated by the qualities and of types of inputs used;
(iii) different environmental factors-soil quality, rainfall, solar radiation, and,
(iv) non-economic and non-technical factors such as family structure and motivational differences which can prevent some farmers from working hard enough on their plots thus failing to achieve the highest level of farm output.

In order to alleviate poverty of the small holder farmers and promote economic growth in Nigeria, the study estimated the technical efficiency of small holder farmers and also identified the socio-economic factors which influence the farmers’ specific technical inefficiencies.

**METHODOLOGY**

**Theoretical and Analytical Framework**

Empirical estimation of technical efficiency is normally done with the methodology of stochastic frontier production function. The stochastic frontier production model has the advantage of allowing simultaneous estimation of individual technical efficiencies of the respondent farmers as well as determinants of technical efficiency (Battese and Coelli, 1995).

The stochastic frontier production function independently proposed by Aigner et al (1977) and Meeusen and Van Den Broeck (1977) assumes that maximum output may not be obtained from a given input or a set of inputs because of the inefficiency effects. It can be written as:

\[ Y_i = f(X_{ai}, \beta) + \epsilon_i \]

Where:

- \( Y_i \) = the quantity of agricultural output,
- \( X_{ai} \) = a vector of input quantities and,
- \( \beta \) = a vector of parameters

\( \epsilon_i \) is an error term defined as:

\[ \epsilon_i = V_i - U_i \quad i=1,2,...,n \text{ farms} \]

\( V_i \) is a symmetric component that accounts for pure random factors on production, which are outside the farmers’ control such as weather, disease, topography, distribution of supplies, combined effects of unobserved inputs on production etc. and \( U_i \) is a one-sided component, which captures the effects of inefficiency and hence measures the shortfall in output \( Y_i \) from its maximum value given by the stochastic frontier \( f(X_a; \beta) + V_i \). The model is expressed as:

\[ Y_i = \exp(X_i\beta + V_i - U_i) \]

The farm specific technical efficiency (TE) of the \( i^{th} \) farmer was estimated using the expectation of \( U_i \) conditional on the random variable \( \epsilon_i \) as shown by Battese and Coelli (1988). The parameters of stochastic frontier production were estimated by the method of Maximum Likelihood Estimation (MLE), using the computer program FRONTIER Version 4.1 (Coelli, 1996).
The TE of an individual farmer is defined in terms of the ratio of the observed output to the corresponding frontier output given the available technology, that is:

\[
TE_i = \frac{Y_i}{\hat{Y}_i} = \exp\left(X_i'\beta + V_i - U_i\right) / \exp\left(X_i'\beta + V_i\right) = \exp(-U_i) \tag{4}
\]

So that \(0 \leq TE \leq 1\) (Tadesse and Krishnamoorthy, 1997)

The Study Area and Data used

The study was conducted in Oyo State of Nigeria. The State covers an area of 28,454 square kilometers (2,845,400 Ha) (FOS, 1997). According to the National Population Commission (2006), Oyo State has a population of 5,580,894 people with females being 2,778,462 people and males being 2,802,432. The State has two distinct ecological zones: The moist forest to the south and the intermediate savannah to the north. The State shares borders with Peoples’ Republic of Benin in the west, Kwara State in the north, Ogun State in the south and Osun State in the east. Oyo State is currently made up of thirty three Local Government Areas.

Primary data obtained through sample survey with the use of structured questionnaire, were essentially used for this study. The primary data used were supplemented with secondary data. The secondary data were obtained from publications of the Federal Office of Statistics (FOS), National Population Commission of Nigeria (NPC), Oyo State Agricultural Development Programme (OYSADEP), journals and other relevant publications.

Purposive and multi-stage random sampling techniques were used to obtain the relevant data. The first stage involved purposive selection of two Local Government Areas (LGAs) noted for rice cultivation in Oyo State. These are Ogo-Oluwa and Surulere LGAs from Ogbomoso agricultural zone of the State. The second stage involved random selection of six towns/villages from the list of rice-growing towns/villages obtained from the Information Unit of each LGA-making a total of twelve villages from the state.

The last stage involved a simple random sampling of thirteen rice farmers from each of the twelve villages in the States. Thus, a total of 156 farmers sampled were interviewed to elicit the necessary information relevant to the study. However, 150 well-completed copies of the questionnaire were used for the analysis.

The Empirical Model

The Cobb-Douglas frontier production function proposed by Battese and Coelli (1995) and used by Yao and Liu (1998) was used in the analysis of data for this study. The Cobb-Douglas functional form is easily adaptable for most agricultural productions. It has been widely used in many empirical studies in both developed and developing agricultural countries (Battese, 1992; Bravo-Ureta and Pinheiro, 1993; Xu and Jeffrey, 1998; Onyenweaku et al, 2004; Onyenweaku and Nwaru, 2005 and Raphael, 2008).

The specific log-linearised model estimated is specified as:

\[
\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 \ln X_{6i} \\
+ \beta_7 \ln X_{7i} + V_i - U_i \tag{5}
\]

Where subscript \(i\) refers to the observation of the \(i^{th}\) farmer, and

\(Y = \text{output of rice grain (kg)};\)
\[ X_1 = \text{land area devoted to rice cultivation (ha);} \]
\[ X_2 = \text{family labour used (man-days);} \]
\[ X_3 = \text{hired labour used (man-days);} \]
\[ X_4 = \text{quantity of fertilizer used (kg);} \]
\[ X_5 = \text{quantity of rice seed planted (kg);} \]
\[ X_6 = \text{amount spent on agrochemicals (₦);} \]
\[ X_7 = \text{amount spent on implements (₦);} \]
\[ \beta_0 = \text{intercept} \]
\[ \beta_i's = (i=1, 2, 3, \ldots, 7) \text{ the parameters to be estimated.} \]
\[ \ln's = \text{natural logarithms.} \]

Determinants of Technical Efficiency

To determine the factors that affected technical efficiency, the model specified in equation (6) was simultaneously estimated with the technical efficiency model specified in equation (5)

\[ U_i = \delta_0 + \delta_1 Z_{i1} + \delta_2 Z_{i2} + \delta_3 Z_{i3} + \delta_4 Z_{i4} + \delta_5 Z_{i5} \]

Where:

\[ U_i = \text{technical inefficiency of the } i\text{th farmer;} \]
\[ Z_{i1} = \text{age of farmer (years);} \]
\[ Z_{i2} = \text{years of education;} \]
\[ Z_{i3} = \text{number of contacts with extension agent;} \]
\[ Z_{i4} = \text{years of farming experience;} \]
\[ Z_{i5} = \text{amount of credit available;} \]
\[ \delta_0 = \text{intercept} \]
\[ \delta_i's = (i=1, 2, 3, \ldots, 5) \text{ the parameters to be estimated.} \]

RESULTS AND DISCUSSIONS

Table 1 shows the maximum likelihood estimates of the stochastic production function. The coefficients of the variables are very important in discussing the results of the analysed data. The variables with positive coefficients implied that any increase in such a variable would lead to an increase in rice output, while an increase in the value of the variable with a negative coefficient would lead to a decrease in output of rice. Negative coefficient on a variable might indicate an excessive utilization of such a variable. The results presented in table 1 shows that all the variables carried positive signs with the coefficients of farm size, family and hired labour being significant at 5.0% level of significance. The estimated gamma parameter is 0.159 indicating that about 16% of variation of smallholder farmers output is accounted for by
differences in technical efficiency. The generalized likelihood ratio test (\( \chi^2 \)) result showed that the test for the absence of technical inefficiency effects (null hypothesis, \( \gamma = 0 \)) was accepted.

\[
\chi^2_{\text{Computed}} = 6.98 < \chi^2_{0.05} = 14.07
\]

This implied that the technical inefficiency effects were not strong in the production of rice in the State and that variation in their production processes was only due to random effects.

**Table 1: Maximum Likelihood Estimates for the Parameters of the Stochastic Frontier Production Function for Rice Food Crop Farmers in Oyo State**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Parameter</th>
<th>Coefficient</th>
<th>T-Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>( \beta_0 )</td>
<td>2.376</td>
<td>9.603</td>
</tr>
<tr>
<td>Farm Size</td>
<td>( \beta_1 )</td>
<td>0.314*</td>
<td>3.933</td>
</tr>
<tr>
<td>Family labour</td>
<td>( \beta_2 )</td>
<td>0.142*</td>
<td>2.563</td>
</tr>
<tr>
<td>Hired Labour</td>
<td>( \beta_3 )</td>
<td>0.284*</td>
<td>3.588</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>( \beta_4 )</td>
<td>0.001</td>
<td>0.044</td>
</tr>
<tr>
<td>Seed planted</td>
<td>( \beta_5 )</td>
<td>0.026</td>
<td>0.346</td>
</tr>
<tr>
<td>Agrochemicals expenditure</td>
<td>( \beta_6 )</td>
<td>0.010</td>
<td>0.437</td>
</tr>
<tr>
<td>Expenditure on implements</td>
<td>( \beta_7 )</td>
<td>0.051</td>
<td>0.794</td>
</tr>
<tr>
<td>Sigma squared</td>
<td>( \delta )</td>
<td>0.018*</td>
<td>8.047</td>
</tr>
<tr>
<td>Gamma</td>
<td>( \gamma )</td>
<td>0.159</td>
<td>1.613</td>
</tr>
<tr>
<td>Log likelihood function</td>
<td>( \Lambda )</td>
<td>93.65</td>
<td></td>
</tr>
<tr>
<td>LR-Statistic</td>
<td>( \chi^2 )</td>
<td>6.98</td>
<td></td>
</tr>
</tbody>
</table>

Notes: * indicates estimated coefficients which were significant at 5.0% level.

Source: Obtained from data analysis.

Table 2 shows the determinants of technical inefficiency among the smallholder farmers in the study area. According to Ajibefun and Aderinola (2004), variables with positive coefficients lead to increase in technical inefficiency or decrease in technical efficiency while variables with negative coefficients lead to decrease in technical inefficiency or increase in technical efficiency.

The coefficients of age and years of education were positive against a priori expectation (Coelli and Battese, 1996) while the coefficients of contact with extension agent, years of experience, and amount of credit available to farmers were negative, a priori. The positive sign on age variable indicated that increasing age would lead to increase in technical inefficiency, based on the fact that ageing farmers would be less energetic to work on the farm, hence, they would have low technical efficiency.

The positive sign on years of education indicated that more educated farmers in the study area were probably involved in other enterprises and occupations and had less time for efficient supervision of their farms. The coefficients of contact with extension agents, years of experience and amount of credit available obtained were negative and conformed with a priori expectation.

The negative coefficients on the amount of credit available conformed to the findings of Onu et al (2000) as well as Raphael (2008) and the result implied that availability of more credit enhances technical efficiency of farmers in farm production because availability of credit will facilitate easy procurement of fertilizers, agrochemicals and other yield-improving inputs on timely basis.
Table 2: Determinants of Technical Inefficiency

<table>
<thead>
<tr>
<th>Variables</th>
<th>Parameter</th>
<th>Coefficient</th>
<th>T-Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>$\delta_0$</td>
<td>0.061</td>
<td>0.609</td>
</tr>
<tr>
<td>Age of Farmer</td>
<td>$\delta_1$</td>
<td>0.001</td>
<td>0.573</td>
</tr>
<tr>
<td>Years of Education</td>
<td>$\delta_2$</td>
<td>0.008</td>
<td>1.526</td>
</tr>
<tr>
<td>Contact with Extension Agents</td>
<td>$\delta_3$</td>
<td>0.067</td>
<td>1.195</td>
</tr>
<tr>
<td>Farming experience</td>
<td>$\delta_4$</td>
<td>0.002</td>
<td>0.491</td>
</tr>
<tr>
<td>Amount of Credit</td>
<td>$\delta_5$</td>
<td>0.00001</td>
<td>1.471</td>
</tr>
</tbody>
</table>

Source: Obtained from data analysis

Table 3 shows the distribution of technical efficiency level of smallholder farmers. The predicted farm specific technical efficiency indices ranged from a minimum of 84.4% for the least practiced farm to a maximum of 99.4% for the best practiced farm, with a mean of about 94.0% and a standard deviation of 4.3%. According to Idiong et al (2006), the high level of efficiency attained is an indication that only a small fraction of the output can be attributed to wastage.

Thus, in the short run, there is a scope for increasing rice food crop production of an average farmer by about 6.0% by adopting the technology and technique used by the best-practiced (most efficient) rice farmer. The results conformed to the findings of Bravo-Ureta and Pinheiro (1997); Aye and Oboh (2006); as well as Raphael (2008).

This could be achieved by addressing the issue of low elasticities obtained for quantity of fertilizer, amount spent on agrochemicals and expenditure on implements (Table 1). The decile range of the frequency distribution of the technical efficiency indicates that about 83.0% of the rice farms had technical efficiency of over 90.0% and about 17.0% had technical efficiency ranging between 71.0% and 90.0%.

Table 3: Distribution of Technical Efficiency

<table>
<thead>
<tr>
<th>Range of Technical Efficiency (%)</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 90</td>
<td>124</td>
<td>82.67</td>
</tr>
<tr>
<td>81 – 90</td>
<td>25</td>
<td>16.67</td>
</tr>
<tr>
<td>71 – 80</td>
<td>1</td>
<td>0.66</td>
</tr>
</tbody>
</table>

Total Number of Farms 150

Mean % 94.3
Minimum % 84.4
Maximum % 99.4
Standard Deviation 4.3

Source: Results obtained from Data Analysis

CONCLUSIONS

The results of the study showed that the technical efficiency of farmers ranged from 84.4% to 99.4% with a mean technical efficiency of 94.3%. The mean technical efficiency of 94.3% obtained implied that there is scope for increasing output by 5.7% technical efficiency through more efficient resource utilization. Results also show that contact with extension agents, farming experience and credit availability are factors which reduce the technical inefficiency of farmers.
REFERENCES


