AN APPLICATION OF THE STOCHASTIC FRONTIER MODEL TO MAIZE PRODUCTION IN BIU L.G.A., BORNO STATE, NIGERIA

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ABSTRACT

It is quite lamentable that about 70% of the population is farmers but Nigeria is yet to attain sustainable food production. In lieu of the above, this study was conducted to investigate the farmers’ technical efficiency to see whether or not resources are optimally utilized via the Stochastic Frontier Production Model approach. Data from ninety six randomly selected farmers were subjected to analysis using descriptive statistics and stochastic frontier production model. Socio-economic characteristics of the farmers revealed that (71.9%) are middle aged with mean age of 45 years and (70.2%) male and (56.7%) are married. About half (51%) of them have family size of 6-10 persons and (74%) had at least primary education. Majority (77%) are small scale farmers. Bulk (74%) of which has poor access to loan and (62.9%) used local varieties. Parameters in the inefficiency model had negative signs except family size and membership of association. Mean technical efficiency of the entire farmers is 73 percent while elasticity of production is 3.21. Constraints identified with maize production in Biu include: problems of land tenure system, poor access to credit facilities and quality seeds, and fertilizer at affordable prices, as well as poor extension service. Others are problems of pest and diseases, bad road network and poor market prices especially at harvest. Hence government should come to their rescue by making loan accessible to farmers at affordable rate, provide rural areas with infrastructure, price incentives and also strengthen the extension services so as to boost efficiency of farmers.

Keywords: Application, Stochastic Frontier, Production, Maize

INTRODUCTION

Maize (Zea Mays) is the important cereal crop in Sub-Saharan Africa (SSA), (FAO, 1996). Along with rice and wheat, maize is one of the three most important cereal crops in the world. According to FAO data, the land areas planted to maize in west and Central Africa alone increased from 3.2 million in 1961 to 8.9 million in 2005. This phenomenal expansion of the land area devoted to maize cultivation resulted in increased production from 2.4 million metric tons in 1961 to 10.6 million metric tons in 2005. While the average yield of maize in developed countries can reach up to 8.6 tons per hectare, production per hectare in many SSA countries is still very low (1.3 tons per hectare) Oyekale and Idjesa (2009).

In Nigeria, maize is a staple food of great social-economic importance. It is now widely accepted as a major source of food and cash crop among its predominantly smallholder producers in Nigeria (Philip, 2009). Ironically the demand for maize as a result of various domestic uses sometimes outstrips supply. Similarly, the unfolding performance of maize can be attributed to the fact that bulk of the country’s farm, over 90 percent is dependent on smallholder farmers with rudimentary farming system, low capitalization and low yield per hectare. Additionally, other factors like price fluctuation, diseases and pests; poor storage facilities have been associated with low maize production in the country. In view of this, national and international bodies have developed interest in promote maize production for households’ food security and poverty alleviation. Some of these efforts have been channeled through biological and agronomic research into the development of high-yielding varieties along with best cultural practices. The agricultural extension arms of several government parastatals have therefore been saddled with the responsibility of ensuring that farmers use the hybrid varieties in order to increase production. This is important if the research-extension-farmer linkage will be strengthened for maximum impact.

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METHODOLOGY
A total of ninety six respondents were randomly sampled using stratified random sampling technique. The data for the study was obtained from primary sources with the aid of structured questionnaires administered through interview process. The data was subjected to analysis using descriptive statistics, to describe the socioeconomic characteristics of the farmers. Stochastic Frontier Production Model was used to elicit the effect of various constraints against increased maize productivity. Biu was divided into four blocks. These include Mandaragrau, Buratai, Biu north, Biu south and Mirnga.

Stochastic frontier model
The stochastic production function model by Coelli (1995) is specified in the implicit form as follows:
\[ Y_i = f(X_i, \beta) + (V_i - U_i) \]
Where:
- \( Y_i \) is the output of the \( i \)-th farm
- \( X_i \) is a \( k \times 1 \) vector of input quantities of the \( i \)-th farmer.
- \( \beta \) is a vector of unknown parameters to be estimated.
- \( V_i \) are random variables which are assumed to be normally distributed \( N(0, \sigma_v^2) \) and independent of the \( U_i \).
- It is assumed to account for measurement error and other factors not under the control of the farmer. The non-negative random variables, called technical inefficiency effects which are assumed to be half normally distributed \( N(0, \sigma_u^2) \) (Aigner et al., 1977). A Cobb-Douglas production form of the frontier used for the study is presented as follows:
\[ \ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 \ln X_e + V_i - U_i \]
(1)
Where:
- \( Y \) = Output (Kg)
- \( X_{1i} \) = farm size (ha)
- \( X_{2i} \) = Labor (man-day)
- \( X_{3i} \) = Fertilizer (kg)
- \( X_{4i} \) = Herbicide (liters)
- \( X_{5i} \) = Seeds (kg)
- \( \beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6 \) - parameters to be estimated.

The inefficiency model is represented by \( U_i \), which is defined as follows:
\[ U_i = d_0 + d_1 Z_{1i} + d_2 Z_{2i} + d_3 Z_{3i} + d_4 Z_{4i} + \ldots + d_n Z_{ni} \]
(2)
Where:
- \( Z_{1i} \) = Age (years)
- \( Z_{2i} \) = Household size (number)
- \( Z_{3i} \) = Fanning experience (years)
- \( Z_{4i} \) = Usage of extension information (yes = 1, No = 0)
- \( Z_{5i} \) = Level of education (None - 0, Primary school - 1, S.S.C/TC II - 2, O.N.D-3)
- HND - 4, Degree 5, Postgraduate - 6)
- \( Z_{6i} \) = Membership of association (yes = 1, No = 0)
- \( Z_{7i} \) = Contact with extension agent (yes = 1, No = 0)
- \( d_0, d_1, d_2, \ldots, d_n \) - parameters to be estimated.

Since the dependent variable of the inefficiency model represents the mode of inefficiency, a positive sign of an estimated parameter implies that the associated variable has a negative effect on efficiency but positive effect on inefficiency and vice-versa (Yao and Liu, 1998; Rahji, 2006)

RESULTS AND DISCUSSIONS
Distribution of technical efficiency of the maize farmers
The result in table 1 shows that majority (89.6%) of the farmers fall into the range (0.50-0.98) while only (10.4%) are within the range (0.15-0.49). The mean technical efficiency of the maize farmers is 0.73 (i.e. 73%). This implies that their efficiency can still be raised by 27 percent through improved resource allocation. The anticipated technical efficiency varies across the respondents, ranging from 0.15 and 0.98. This is contrary to the findings of Ogunfowora and Olayide (1981) who stated that resources are not efficiently utilized or allocated under the small-scale farming which is mainly traditional in style. Furthermore, Johnson (1982) added that there is the problem of deciding how much of the available factor productivity or resources should be devoted for future growth as well as how much to satisfy consumption needs.
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**Table 1: Frequency Distribution of Technical Efficiency of the Respondents**

<table>
<thead>
<tr>
<th>Range of Technical Efficiency</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.65 - 0.32</td>
<td>3</td>
</tr>
<tr>
<td>0.50 - 0.49</td>
<td>7</td>
</tr>
<tr>
<td>0.50 - 0.66</td>
<td>25</td>
</tr>
<tr>
<td>0.67 - 0.83</td>
<td>25</td>
</tr>
<tr>
<td>0.84 - 0.98</td>
<td>36</td>
</tr>
<tr>
<td>Minimum = 0.15</td>
<td></td>
</tr>
<tr>
<td>Maximum = 0.98</td>
<td></td>
</tr>
<tr>
<td>Mean = 0.73</td>
<td></td>
</tr>
<tr>
<td>Mode = 0.73</td>
<td></td>
</tr>
</tbody>
</table>

Source: computer printout from Frontier analysis 4.1, 2010

**Result of the stochastic production function analysis**

The result shows the maximum likelihood estimates of the parameters as well as the technical efficiency analysis of the maize farmers. Table 2 presents the estimates of the parameters of the model. It reveals that there exist a positive relationship between farm size, labor, fertilizer chemicals, and seed. It portrays a relationship which is significant at 1 percent for farm size, fertilizer, chemicals as well as seed. However, there is no significant relationship for labor. The positive and significant relationship between farm size, labor, fertilizer, chemicals, and seed signifies that they are significantly different from zero. Thus, if more of these variables are used in maize production, there will be more than proportionate increase in the output of maize. Since chemicals, particularly herbicides and pesticides, and farm size have the highest coefficients; it implies that there will be high tendency of increase in output if chemicals and farm size are proportionately increased compared to other factors that influence maize output, as specified in this model.

**Table 2: Maximum Likelihood Estimates of Parameters of Cobb-Douglas Stochastic Frontier Production Function for Maize Farmers**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Parameters</th>
<th>Coefficient</th>
<th>T-Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stochastic frontier</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>β₀</td>
<td>2.232*</td>
<td>3.714</td>
</tr>
<tr>
<td>Farm size</td>
<td>β₁</td>
<td>0.284</td>
<td>3.023</td>
</tr>
<tr>
<td>Labor</td>
<td>β₂</td>
<td>-0.180*</td>
<td>-0.810</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>β₃</td>
<td>0.380*</td>
<td>4.936</td>
</tr>
<tr>
<td>Chemical</td>
<td>β₄</td>
<td>2.368*</td>
<td>3.227</td>
</tr>
<tr>
<td>Seed</td>
<td>β₅</td>
<td>0.355*</td>
<td>3.227</td>
</tr>
<tr>
<td><strong>Inefficiency model</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>δ₀</td>
<td>2.395*</td>
<td>6.369</td>
</tr>
<tr>
<td>Age</td>
<td>δ₁</td>
<td>-1.739</td>
<td>0.619</td>
</tr>
<tr>
<td>Family size</td>
<td>δ₂</td>
<td>-0.420*</td>
<td>2.866</td>
</tr>
<tr>
<td>Farming experience</td>
<td>δ₃</td>
<td>-0.800*</td>
<td>10.846</td>
</tr>
<tr>
<td>Usage of extension information</td>
<td>δ₄</td>
<td>-0.443*</td>
<td>-3.083</td>
</tr>
<tr>
<td>Literacy level</td>
<td>δ₅</td>
<td>-0.346*</td>
<td>7.135</td>
</tr>
<tr>
<td>Membership of association</td>
<td>δ₆</td>
<td>0.065</td>
<td>0.067</td>
</tr>
<tr>
<td>Contact with extension agent</td>
<td>δₗ</td>
<td>-0.059</td>
<td>0.413</td>
</tr>
<tr>
<td><strong>Variance parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sigma-squared</td>
<td>δ²</td>
<td>0.498*</td>
<td>3.247</td>
</tr>
<tr>
<td>Gamma</td>
<td>γ</td>
<td>0.994*</td>
<td>65.45</td>
</tr>
</tbody>
</table>

Source: *cited out from frontier 4.1. Estimates significant at 1% level

The result of the inefficiency model indicates that the negative coefficients of age, family size, farming experience, usage of extension information, literacy level and contact with extension agents have the expected signs, while membership of association shows positive sign. Age, farming experience, usage of extension information, literacy level, contact with extension agents are all significant at 1 percent level in the inefficiency model. This suggests that inefficiency is less among maize farmers. Similarly, membership of...
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association which shows positive sign in the model implies that inefficiency is more associated with the variable. Thus, the signs and the coefficients in the inefficiency model are interpreted in the opposite manner, such that a negative sign increases efficiency and vice versa.

The inefficiency parameters indicate that the inefficiency of maize farmers in the area decreases with increase in age, family size, farming experience, usage of extension information, literacy level and contact with extension agent. While inefficiency increases with decrease in membership of association. The table also shows that the estimate of variance sigma-squared ($\sigma^2$) of 0.498 is statistically significant at 1 percent level of significance. This figure is also significantly different from zero. It also shows a good fit and correctness of the distributional form assumed to for the composite error term.

Table 2 shows that the estimated gamma ($\gamma$) was 0.994 and is highly significant at 1 percent level of the measurement error. Thus, portraying that about 99 percent of the variation in farmers’ output is accounted by their differences in their technical efficiencies. This implies that the ordinary least square estimate (OLS) will not be sufficient in explaining the inefficiencies in maize production. Hence, Stochastic Frontier Production Function is recommended and is suitable. The elasticity estimates (summation of coefficients of farm size, labor, fertilizer, chemicals and seed) is 3.21. Since the elasticity is greater than one, it means that maize farmers are operating at stage 1 in the production curve. At this stage, marginal physical product (MPP) of maize is greater than the average physical product (APP) and elasticity of production ($E_p$) is greater than one. At this point, all factors are variable. It is also an irrational zone of production since the point of diminishing returns or efficiency is far from being reached. It pays the farmer when he continues to add more of the variable inputs to the fixed inputs where MPP does not equal APP until APP is maximum at the beginning of stage II otherwise known as “the point of inflection”. At stage II, $E_p$ equals to one. Thus, a percentage change in inputs will produce a percentage change in output. This is the stage of best interest to the farmer because it is the stage where profit margin is maximized. This zone lies between stages II and III.

CONCLUSION

Based on the outcome of the study the following conclusions are made that;

Maize farming in the study area is profitable. Given their technical efficiency of 73%, vast experience, and elasticity of 3.21 (that is greater than one) signifying that if an efficient extension service is put in place, their productivity is likely to increase tremendously. Majority of them had at least primary education which may be adequate for them to comprehend messages from an extension agent with a sound communication skills.

RECOMMENDATIONS

Based on the foregoing conclusions, the following recommendations are made that;

1. Farmers are advised to adopt the use of improved maize seed varieties, as this will boost their output, which will in turn enhance their income.

2. They should restructure their cooperative association and encourage farmers to form groups, in order to facilitate their access to loan facilities from either Nigeria Agricultural & Rural Development Bank or commercial banks.

3. The extension agents must change their attitude to work, while government on its part should overhaul the agricultural extension service by employing adequate and qualified personnel, on a very sound condition of service for efficient service delivery.

4. Government should provide farm villages with good access roads so as to facilitate easy transportation of produce.

REFERENCES


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