Economic Efficiency of Smallholder Sweet Potato Producers in Delta State, Nigeria: a Case Study of Ughelli South Local Government Area

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ABSTRACT

With declining sweet potato production trends in Delta State, this paper identifies and analyses factors that influence the economic efficiency of smallholder sweet potato producers in Delta State by drawing on data from random sample of 100 smallholder farmers from Ughelli South Local Government Area. The study employed stochastic frontier and Tobit model to measure the level of economic efficiency and its determinants in sweet potato production. Empirical results show decreasing returns to scale in production. The mean economic efficiency is 0.61 with a range of 0.13 to 0.99. Education, access to extension, access to credit and membership of farmers cooperative positively and significantly influence economic efficiency. Innovative institutional arrangements that enhance extension and farmer training accompanied with improved access to credit is likely to enhance sweet potato production efficiency.

Key words: Economic efficiency, smallholders farmers, sweet potato productivity, stochastic frontier functions.

Introduction

Agricultural production in Nigeria is dominated by smallholder farmers and is known to produce more than 90% of the food consumed in the country. The agricultural sector has been major export earner for the country prior to the discovery of crude oil. Sweet potato (Ipomoea batatas) is a root crop in tropical Africa belonging to the family convolvulaceae. It’s large, starchy, sweet tasting tuberous roots are an important root vegetable. The young leaves and shoots are sometimes eaten as green of the approximately 50 genera and more than 1000 species of convolvulaceae, I. batatas is the only plant of major importance, some others are used locally, but many are actually poisonous.

Sweet potato has a high yield potential that may be realized within a relatively short growing season and an adaptability to a wide ecological range of 0 to 2000 meters above sea levels and 30°N to 30°S.

Among the root and tuber crops, it is the only one that had a positive per capita annual rate of increase in production in sub-Saharan Africa. According to FAO (2000) production of sweet potato in Nigeria increased from 149,000 metric tones in 1961 to 2,468,000 metric tones in 2000. Area of cultivation increased from 13,000 ha to 381,000 ha while yield decreased from 11t/ha to 6.8t/ha over the same period. However, estimates of sweet potato production in Nigeria vary widely among different sources. FAO found that 80 percent of the sweet potato produced in Nigeria was used for human food. It is an important revenue earner for the country and employer of labour for rural people who are engaged in production of sweet potato. Sweet potato production in Nigeria has been low arising from lack of capital to boost production, use of improved planting materials amongst other factors. To harness the current potentials for sweet potato production and export, its production must be improved. Various government supported research and development activities have been undertaken in an effort to raise productivity of smallholder farmers. Efforts towards development of the sweet potato industry in Nigeria have focused on development and dissemination of high yielding varieties (Gbighi, 2001). Despite the efforts directed at improving sweet potato production over the years, low productivity remains a major challenge in the sub-sector.

The study hope to establish the current levels of economic efficiency of smallholder sweet potato producers
in Delta state, Nigeria and to identify factors influencing levels of farm production and economic efficiency. In so doing it is hope to provide insights to constraints to improved sweet potato production and provide avenues for possible policy intervention towards improved potato production in Delta State, Nigeria.

**Materials and method**

**Study Area:**

The study was carried out in Delta state. Ughelli south local Government Area of Delta State was purposively chosen for this study because of the prime importance of the local government area in terms of arable crops production. Major crops grown are sweet potato, cassava, cocoyam, yam, plantain and banana. Random sampling procedure was employed to get representative sample. Farmers are selected at random from the villages within the sampling frame. The sampling frame consists of 10 villages from the local government area. Then farmers were selected at random for interview from each of the villages resulting in a total of 100 respondents. The respondents are farmers who produce sweet potato regardless of whether or not they produce other arable crops. Resources on which data were obtained include land, family and hired labour, quantity of fertilizer, quantity of seed and quantity of pesticides were collected. Input and output prices for input and output was collected as well.

**Analytical Framework:**

Following Bravo-Ureta and Pinheiro (Bravo-Ureta, 1997) we use a parametric stochastic efficiency decomposition approach to measure the economic efficiency in sweet potato production. This is an extension of Kopp and Diewert (1982) economic efficiency estimation procedure. The advantage of this approach is the application of a stochastic frontier model with a disturbance term specification that captures noise, measurement error, and exogenous shocks beyond the production unit. The stochastic frontier production function model is specified as follows:

\[ Y_i = f(X_i; B) + \mu_i + \epsilon_i \]  

Where \( Y_i \) measure the quantity of output; \( X_i \) is a vector of the input quantities; \( B \) is a vector of parameters to be estimated; \( f(X_i; B) \) is a frontier production function; and \( \mu_i \) is a composite error term (Aigner, 1977). Following Aigner et al (1977) the composite error term is given as:

\[ \epsilon_i = V_i - \mu_i. \]

where \( V_i \) is assumed to be independently and \( V \sim N(0, \sigma^2_v) \) identically distributed as random error and represents random variability in production that cannot be influenced by producers \( m \) is a non-negative random variable associated with technical inefficiency in production and is identically and independently distributed (iid) as half-normal, \( \mu_i \sim N(0, \sigma \mu^2) \)

The frontier production function \( f(X_i; B) \) measures the maximum potential output for a given input vector, \( X_i \). Both \( V_i \) and \( \mu_i \) cause actual production to deviate from the frontier.

Using a Cobb-Douglas functional specification to model sweet potato production technology, the frontier production function in equation (1) is estimated using maximum likelihood estimation procedures which provides estimators for \( B \) and variance parameters,

\[ \sigma^2 = \sigma^2_v + \sigma^2 \mu \quad \text{and} \quad \gamma = \sigma^2 \mu / \sigma^2 \]

To empirically measure efficiency, deviations from the frontier are separated into a random (\( \nu \)) and an inefficiency (\( \mu \)) component. Following Jondrow et al. (1982) and given the distribution and independence assumptions on \( V_i \) and \( \mu \) in addition to the fitted values of \( \epsilon_i \) the conditional mean of \( \mu \) can be estimated as:
\[
E\left( \frac{\mu}{\varepsilon_i} \right) = \alpha \left[ \frac{f^*\left( \frac{\lambda e_i}{\sigma} \right)}{1-F^*\left( \frac{\lambda e_i}{\sigma} \right)} \right]
\]

where \( \sigma^2 = \frac{\mu^2}{\sigma^2} \) is the standard normal density function and \( F^* \) is the distribution function both functions being evaluated at \( \frac{\lambda e_i}{\sigma} \).

From this calculation, estimates of \( V \) and \( \mu \) may be determined.

According to Bravo-Ureta et al. (1997) the \( i \)th firm efficiency is measured using adjusted output. This output is derived by subtracting the random error \( V_i \) from both sides of equation (1). Thus:

\[
Y_i^* = f(X_i, B) - \mu_i = Y_i - V_i
\]

where \( Y_i^* \) is the adjusted output of the \( i \)th firm; and \( \mu_i \) is obtained from equation (3). Adjusted output \( Y_i^* \) is then used to derive the \( i \)th firm technically efficient input vector \( X_i \) by simultaneously solving equation (4) and the observed input ratios \( \frac{X_i}{X_{ik}} = K_i (\forall i > 1) \) where \( K_i \) is equal to the observed ratio of the two inputs in the production of \( Y_i^* \). Given the assumption of Cobb-Douglas technology the frontier production function is self-dual (Sharma, 1999). The dual cost frontier can be derived analytically from the production function in equation (1) thus:

\[
C_i = h\left( P_i, Y_i^*, \phi \right)
\]

where \( C_i \) is the minimum cost of the \( i \)th firm associated with output \( Y_i^* \), \( P_i \) is a vector of input prices for the \( i \)th firm and \( \phi \) is a vector of parameters to be estimated. The economically efficient input vector for \( i \)th firm, \( X_{ie} \), is derived by applying Shephard’s Lemma (Shephard, 1970) and substituting the firm’s input price and adjusted output levels into the derived system of input demand equations given by

\[
\frac{dc}{\partial P_k} = X_{ik} (P, Y^*; \phi)
\]

where \( \phi \) is a vector of estimated parameters. The observed and economically efficient costs of production of the \( i \)th firm are equal to and \( \sum X_{ik} P_i \), \( \sum X_{ie} P_i \) respectively. These cost measures are used to compute the economic (EE) efficiency index for \( i \)th firm as follows;

\[
EE_i = \frac{\sum X_{ie} P_i}{\sum X_{ik} P_i}
\]

To determine the relationship between socio-economic and institutional factors and the computed indices of economic efficiency we use a two-Limit Tobit Procedure. The Tobit model was adopted because the economic efficiency scores lie within the range of 0 to 1.

**Results and discussion**

**Production Performance:**
The summary statistics of variables involved in sweet potato production is presented in Table 1. The mean output of the sweet potato harvested by farmers was 732.51kg with a large variability as shown by the standard deviation of 1,422.402kg. This implies that the farmers operated at different levels of farm sizes. While the analysis of the inputs revealed an average farm size of 0.83ha per farmer an indication that the study covered small scale, family managed farm units. The labour used in sweet potato production had an average of 650.36kg of seed, 105.24kg of fertilizer are used by farmers. 469.38 gram of pesticides used, while the analysis of Gender of household had an average of 0.70 per farms. The average age of the sample farmers was 48 years. The average educational level of the farmers was 11 years. The average farming experience of farmers was 19 years. The sweet potato farmers received an average of three extension visit per year. About 63.5% of the farmers had access to credit while 60.3% belong to a farmers co-operative. The mean household size is 5.42 with 1.805 standard deviation.

Estimate of Stochastic Frontier Production Function:

The estimates of parameters of the stochastic frontier production function are presented in table 2. All the parameter estimates are statistically significant in the frontier model. The following elasticities were obtained: Farm size 0.373 (t=2.93), labour 0.205 (t=2.156), seed 0.175 (t=1.96), fertilizer 0.071 (t=3.13) and agrochemicals 0.031 (t=3.01). The sum of the output elasticities is 0.855 implying decreasing returns to scale. Farm size has the largest elasticity followed by labour. Agrochemicals recorded the lowest elasticity. This suggest that productivity would be higher if more hands is brought under sweet potato production, Table 3.

The parameters of the Tobit model are presented in Table 4. The results reveal that the level of education, farming experience, access to extension, and access to credit each has a positive impact on economic efficiency. Membership in a farmers co-operative has a negative and significant relationship with economic efficiency. The positive and highly significant coefficient of education at 1% level indicates that farmers with higher levels of education tend to be more efficient in production. Better performance by more educated farmers may be attributed to the fact that education gives the farmers the ability to perceive, interpret and respond to new information and improved technology such as fertilizers, pesticides and planting materials much faster than their counterpart. However, Mbanasor and Kalu (2008) in their study of economic efficiency of commercial vegetable production system in Akwa Ibom State, Nigeria found a negative relationship between education and economic efficiency. The estimated coefficient of the variable representing the producers experience is positive and significant which indicates that efficiency increases with the number of years spent by the household in potato production.

This suggests that the sweet potato farming in the study area is highly dependent on the experience of farmers which may lead to better managerial skills being acquired over time. This corroborates the findings by Shehu and Mshelia (Shehu, 2007). Farm households who receive regular extension visits by extension workers appear to be more economically efficient than their counterparts. The coefficient for the access to extension has a highly statistically significant positive relationship with economic efficiency (EE) at 1% level. Similar results were reported by Bozoglu and Ceyhan (Bozoglu, 2007) and Binam, Tonye, Wandji and Akoa (Binam, 2004) in Turkey and Cameroon respectively. The positive estimated coefficient for contact with extension workers imply that economic efficiency increases with the number of visits made to the farm household by extension workers. This result is in line with the arguments by Gbigbi (2001) who indicates that regular contact with extension workers facilitates practical use of modern techniques and adoption of improved agricultural production practices.

Table 1: Summary statistics of variables of the stochastic frontier production function for sweet potato production in Nigeria

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output of sweet potato (kg)</td>
<td>732.51</td>
<td>1,422.402</td>
</tr>
<tr>
<td>Farm size (ha)</td>
<td>0.83</td>
<td>0.526</td>
</tr>
<tr>
<td>Labour (man-days)</td>
<td>250.56</td>
<td>432.112</td>
</tr>
<tr>
<td>Seed (kg)</td>
<td>650.36</td>
<td>496.527</td>
</tr>
<tr>
<td>Fertilizer (kg)</td>
<td>105.24</td>
<td>132.373</td>
</tr>
<tr>
<td>Pesticides (grams)</td>
<td>469.38</td>
<td>560.763</td>
</tr>
<tr>
<td>Gender of household</td>
<td>0.70</td>
<td>0.459</td>
</tr>
<tr>
<td>Age of household</td>
<td>48.06</td>
<td>60.643</td>
</tr>
<tr>
<td>Educational level (years)</td>
<td>11.59</td>
<td>27.003</td>
</tr>
<tr>
<td>Farming experience (years)</td>
<td>19.13</td>
<td>31.232</td>
</tr>
<tr>
<td>Extension visit (No. of Visits)</td>
<td>3.09</td>
<td>7.362</td>
</tr>
<tr>
<td>Access to credit</td>
<td>6.35</td>
<td>4.501</td>
</tr>
<tr>
<td>Farmers co-operative</td>
<td>6.03</td>
<td>7.489</td>
</tr>
<tr>
<td>Household size</td>
<td>5.42</td>
<td>1.805</td>
</tr>
</tbody>
</table>

Source: Field Survey data, 2010
Table 2: Estimates of Stochastic Frontier Production Function

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1 (OLS)</th>
<th>Model 2 (MLE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.639 (0.747)</td>
<td>1.506** (0.616)</td>
</tr>
<tr>
<td>Ln Farm size</td>
<td>0.260 (0.146)</td>
<td>0.373*** (0.127)</td>
</tr>
<tr>
<td>Ln Labour</td>
<td>0.241** (0.103)</td>
<td>0.205** (0.095)</td>
</tr>
<tr>
<td>Ln Seed</td>
<td>0.216** (0.113)</td>
<td>0.175** (0.089)</td>
</tr>
<tr>
<td>Ln Fertilizer</td>
<td>0.082*** (0.024)</td>
<td>0.071*** (0.022)</td>
</tr>
<tr>
<td>Ln Pesticides</td>
<td>0.033*** (0.011)</td>
<td>0.031*** (0.010)</td>
</tr>
<tr>
<td>$\sigma^2$</td>
<td>0.282*** (0.055)</td>
<td></td>
</tr>
</tbody>
</table>

Log Likelihood function -50.32 -46.75

Note: Values in Parenthesis represent standard errors
Source: Field Survey Data, 2010
*, **, *** significant at the 10%, 5%, and 1% level, respectively.

Table 3: Elasticity of Production and return to scale

<table>
<thead>
<tr>
<th>Variable</th>
<th>Elasticity of production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm size</td>
<td>0.373</td>
</tr>
<tr>
<td>Labour</td>
<td>0.205</td>
</tr>
<tr>
<td>Seed</td>
<td>0.175</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>0.071</td>
</tr>
<tr>
<td>Pesticides</td>
<td>0.031</td>
</tr>
<tr>
<td>RTS</td>
<td>0.855</td>
</tr>
</tbody>
</table>

Table 4: Tobit model estimates for determinants of economic efficiency sweet potato production

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Deviation</th>
<th>T-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>3.094***</td>
<td>0.318</td>
<td>9.72</td>
</tr>
<tr>
<td>Gender of household</td>
<td>0.071</td>
<td>0.044</td>
<td>1.62</td>
</tr>
<tr>
<td>Age of household</td>
<td>-0.071</td>
<td>0.086</td>
<td>-0.83</td>
</tr>
<tr>
<td>Educational level</td>
<td>0.162***</td>
<td>0.058</td>
<td>2.79</td>
</tr>
<tr>
<td>Farming experience</td>
<td>0.086**</td>
<td>0.034</td>
<td>2.51</td>
</tr>
<tr>
<td>Access to extension</td>
<td>0.064***</td>
<td>0.017</td>
<td>3.74</td>
</tr>
<tr>
<td>Access to credit</td>
<td>0.212***</td>
<td>0.046</td>
<td>4.59</td>
</tr>
<tr>
<td>Membership of co-operative</td>
<td>-0.101**</td>
<td>0.050</td>
<td>-2.01</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-3.773</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Field Survey Data, 2010
*, **, *** represent significant at the 10%, 5% and 1% level respectively

The results also indicate that access to credit has a positive and statistically significant effect on economic efficiency levels at 1% level, which suggests, that on average, farmers with access to credit tend to exhibit higher levels of efficiency. This finding is consistent with the results by Binam et al. (2004). Access to credit permits a farmer to enhance efficiency by overcoming Liquidity constraints which may affect their ability to apply inputs and implement farm management decisions on time hence use of credit therefore loosens financial constraints, ensures timely acquisition and use of inputs and results in increased economic efficiency.

It is of crucial importance to provide smallholder farmers who are often cash constrained with credit in order to facilitate the timely purchase of critical inputs such as inorganic fertilizers and pesticides.

The results indicate a negative and significant relationship between membership in a farmers cooperatives and efficiency contrary to what could be expected.

However, this study found no statistically significant relationship of age and gender each on economic efficiency.

The frequency distribution of the estimated economic efficiency indices for the sample sweet potato farms are presented in Table 5.

The result indicates that it ranged from a minimum of 0.13 to a maximum 0.99. The mean economic efficiency was 0.61.

The estimates show that for the average sweet potato farmer to attain the level of the most economically efficient farmer in the sample, he or she would experience a cost savings of 38.38 (1 – 0.61/0.99%).

The least economically efficiency farmer will have an efficiency gain of 13.13% (1 – 0.13/0.99%) in sweet potato production if he or she is to attain the efficiency level of most economically efficient farmer in the state.

The sweet potato farmers in the sample were economically inefficient as a result of allocative inefficiency.
Table 5: Frequency distribution of Economic Efficiency

<table>
<thead>
<tr>
<th>Economic efficiency index</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.50</td>
<td>2</td>
<td>2.00</td>
</tr>
<tr>
<td>0.51 – 0.60</td>
<td>6</td>
<td>6.00</td>
</tr>
<tr>
<td>0.61 – 0.70</td>
<td>9</td>
<td>9.00</td>
</tr>
<tr>
<td>0.71 – 0.80</td>
<td>21</td>
<td>21.00</td>
</tr>
<tr>
<td>0.81 – 0.90</td>
<td>33</td>
<td>33.00</td>
</tr>
<tr>
<td>0.91 – 1.00</td>
<td>29</td>
<td>29.00</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Maximum economic efficiency 0.99
Minimum economic efficiency 0.13
Mean economic efficiency 0.61

Source: Field Survey Data, 2010

Conclusion:

This study estimates stochastic frontier production for sweet potato farmers in Delta State, Nigeria. The results indicate a significant variation in economic efficiency among sample households.

Estimated farm specific economic efficiency indices ranged from 0.13 to 0.99 with a mean economic efficiency of 0.61 which implies considerable production inefficiency. Nevertheless, this results show that there is a substantial potential for enhancing profitability by reducing costs through improved efficiency.

On average, by operating at full economic efficiency levels sweet potato production entrepreneurs would be able to reduce their cost by 38.38% depending on the method employed. Important factors directly related to economic efficiency are education, access to extension, access to credit and membership in farmers cooperative.

These results call for policies aimed at encouraging new entrants to cultivate sweet potato and the experienced ones to remain in farming.

Micro-credit from governmental and non-governmental agencies should be made available to rural farmers, for this will go a long way in addressing their inefficiency problems.

References