PRODUCTION ELASTICITIES, RETURN TO SCALE AND ALLOCATIVE
EFFICIENCY IN YAM PRODUCTION IN EDO STATE, NIGERIA.

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ABSTRACT
The study estimated the production elasticities, the return to scale and analysed the allocative
efficiency of resources used in yam production in Edo State. A four-stage sampling process
involving simple random sampling was employed to select 180 yam farmers and a set of
questionnaire was used to collect data from the respondents. The Data collected were analysed
using stochastic frontier production function and marginal analysis. The result of the study
showed that none of the inputs used by the farmers was efficiently allocated and utilised. Land
(15.72), planting material (7.27) and fertilizer (2.38) were under-utilised, while labour (0.63) and
agrochemical (0.52) were over-utilised. This showed that there was the existence of disequilibria
in the allocation and utilisation of inputs by yam farmers in Edo State. Also, production elasticity
estimates indicated that the farmers' production was in stage 1 (irrational stage) of the production
function indicating that there is room for expansion in output and productivity of yam farmers in
Edo State. This can be actualised by cropping higher hectarage of farm land with increased
quantity of planting material and controlled usage of higher quantities of fertilizer as these were
found to be under-utilised. A return to scale of 1.434 indicated increasing returns to scale.
Keywords: Allocative Efficiency, Elasticity of Production, Return to Scale, Yam.

INTRODUCTION
Yam constitutes the predominant starchy staple especially in sub-Saharan Africa where food
security for a growing population is a central issue (Fu et al., 2011). Although, Nigeria is the
largest yam producer in the world accounting for 65% of the global production in 2008 (FAO,
2010) yet there has been a decline in yam production in Nigeria over the years (IITA, 2002). The
area under cultivation and total yam output were also declining (IITA, 2002 and Ayanwuyiet al,
2011). Studies have shown that food crop farmers in Nigeria have low productivity because of
inefficiency in resource use (Idionget al, 2002). Production is the process of transforming inputs
such as capital, labour and land into goods and services called output. One of the major targets
of any society is the attainment of an optimal level of production with a given amount of effort.
This has been the focus of many individuals, private and government organisations worldwide
aiming at poverty alleviation, high productivity and food sufficiency, especially in developing
countries including Nigeria (Jacobi, 1998; Mougeot, 2000). Thus, any increase in the productivity
of resources employed in the production enterprise would amount to progress. In view of this, productivity gains in agricultural production (including yam production) are considered as a pre-requisite for overall economic development (Mafimisebi and Adams, 2003). Efficiency analysis is an issue of interest among economists in recent times. Optimisation can be obtained either by minimising the cost of producing a given level of output or maximising the output attainable with a given level of cost. Both optimisation problems require the proper allocation of input for the goal to be achieved (Oluwatayo et al., 2008). Maximum resource productivity implies obtaining the maximum possible output from the minimum possible set of input. In this context, optimal productivity of resources involves an efficient utilisation of resources in the production process as stated by Kyi and Oppen, (1998) and sited by Ezeaku et al (2013). To achieve economic optimum output and thus profitability, resources have to be optimally and efficiently utilized. Though, yam production in Edo State is a good source of income to the farmers, yet no records have shown it to have attained optimal level which proper allocation of inputs can achieve. The question therefore is whether yam farmers in Edo State are efficient in the allocation of the resources employed in the production process; what could be the value of their marginal product of the inputs? What are the production elasticities and the status of their input utilisation? Allocative efficiency studies help farmers to determine the extent to which they can appropriately adjust productive resources in order to achieve optimum productivity, therefore the need to carry out such a study.

The objective of this study therefore was to ascertain the level of allocative efficiency of resource use among yam farmers in Edo State with a view to facilitating investment decision making as well as give an indication of optimal input utilisation necessary to obtain maximum return. The specific objectives included the estimation of the value of marginal product, the production elasticities, return to scale and the determination of the input utilization status and hence the allocative efficiency.

**RESEARCH METHODOLOGY**

**Study Area**

The study was carried out in Edo State. The State lies approximately between longitude 06° 04' E and 06° 43'E and latitude 05° 44'N and 07°34'N (NPC, 2006). It is bound in the south by Delta State, in the west by Ondo State, in the north by Kogi State and in the east by Kogi and Anambra States. It is important to note that Edo State is located in the yam producing belt of Nigeria (NFRA, 2007) where the crop plays an important role in the social and religious festivals of the people and it is viewed as an integral part of their heritage.

**Sampling Procedure**

A four stage sampling process was employed in selecting the samples needed for the study. Firstly, the study area was stratified based on the Edo State Agricultural Development
Programme delineation that is Edo South, Edo Central and Edo North agro-ecological zones, so as to get a State wide coverage. The second stage involved the simple random selection of two (2) wards which were the Local Government Areas (LGAs) from each of the agro ecological zones. The selected wards were Orhiomwon and Uhunmwonde for Edo South agro-ecological zone, Esan West and Esan South East for Edo Central agro-ecological zone, Owan East and Estako West for Edo North agro-ecological zone. The third stage involved the random selection of three villages from each ward, while the last stage involved a compilation of the list of yam farmers in each village to serve as the sampling frame out of which ten (10) yam farmers were selected using simple random sampling technique. The result of the above selection gave 30 respondents per ward, 60 respondents for each zone and 180 respondents State wide.

Data Collection
The primary data used in this study were collected with the use of a well-structured questionnaire and interview schedule personally administered to the 180 respondents sampled for the study.

Analytical Technique
- Simple descriptive statistics such as percentage and frequency distribution were used to describe the socio economic characteristics of the respondents.
- The Stochastic Frontier Production function (SFPF) using the Cobb –Douglas functional form was used to determine the production function in this study. This functional form has been used in other empirical studies (Emokaro and Erhabor, 2006; Agbaje et al., 2008; Ojo et al., 2009; Okon et al., 2010; Shehu et al., 2010; Areerat et al., 2012; Ezeh et al., 2012and Mohammed et al., 2011)) to assess both technical and allocative efficiencies. The SFPF estimates the regression coefficients that are used to calculate the marginal physical product (MPP) for the estimation of the value of marginal product (VMP) The production function model was explicitly specified in its linear form as:

\[
\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \varepsilon_i - (1)
\]

Where, \(\ln = \text{Natural logarithm}\)
\(Y = \text{Quantity of yam produced (Kg)}\)
\(X_1 = \text{Farm Size (Ha)}\)
\(X_2 = \text{Planting Material (Yam Sett) (Kg)}\)
\(X_3 = \text{Labour (Man days)}\)
\(X_4 = \text{Quantity of Fertilizer used (Kg)}\)
\(X_5 = \text{Quantity of Agro Chemicals used (Litres)}\)
\(\beta_0 - \beta_5 = \text{Parameters to be estimated (Regression coefficients)}\)
\(\varepsilon_i = \text{Composite error term defined as } V_i - U_i\)
Vi = Random variables which are assumed to be independent of Ui, identical and
normally distributed with zero mean and constant variance N (0, \( S_v^2 \)).

Ui = Non – negative random variables which are assumed to account for the
technical inefficiency in production and are often assumed to be independent of Vi such that
Ui is the non-negative truncated normal distribution.

- **Marginal Analysis** Efficiency of resource/ input used was determined by the ratio of the
  Value of the Marginal Product (VMP)(which is MPP \( x \) \( P_y \)) to Marginal Factor Cost (MFC).
  The relationship (as indicated by Olayide and Heady (1982); Goni et al., (2007), Tambo and
  Gbemu (2010) is given as:

\[
r = \frac{VMP}{MFC} \quad (2)
\]

The decision rule is that:
- If \( r = 1 \), resource is efficiently utilised
- \( r > 1 \), resource is under utilised
- \( r < 1 \), resource is over utilised

where \( r \) = Efficiency coefficient

VMP = Value of Marginal Product which is the same as Marginal Value Product (MVP)

MFC = Marginal Factor Cost

MFC = \( P_x \)

\( P_x \) = Unit price of input Xi

The marginal physical product (MPP) for each of the production inputs was estimated from
the regression coefficient of the SFPF and was used to determine the value of the marginal
product (VMP) as explained above.. According to Adesimi (1982) and Fasasi (2006) the
estimates with the widest application are those derived at the geometric mean of input, especially with the Cobb Douglas production function. The value of the marginal product (VMP) for this study as used by Fasasi (2006), Emokaro and Erhabor (2006), Tambo and Gbemu (2010) was given as

\[
VMP = MPP \cdot P_y \quad (3)
\]

Where,
- MPP = Marginal Physical Product
- \( P_y \) = Unit Price of Output

\[
MPP = \frac{b \cdot Y}{X_i}
\]
Where

\[
\begin{align*}
    b & = \text{Regression Coefficient} \\
    X_i & = \text{Geometric mean of input } X_i \\
    Y & = \text{Geometric mean of Output}
\end{align*}
\]

The elasticity of production which is the degree of responsiveness of the output to a unit change in input used was computed using the Cobb Douglas function. The coefficients of the independent variable \((X_i)\) of the Cobb Douglas function were the direct elasticities of production. The value of the elasticity indicated whether each additional input used results in constant \((Ep=1)\), increasing \((Ep>1)\) or decreasing \((Ep<1)\) productivity. The sum of the individual elasticities gave the rate of return to production and indicates the stage of production (that is whether stage 1, 2 or 3) where the respondent is operating (Olukosi and Ogungbile1989).

- Likert scale was used to determine the level of seriousness of the various constraints of the yam farmers. The responses to the various constraints were scored such that the most serious constraint was assigned the highest score as shown below:
  - Very serious = 5
  - Serious = 4
  - Moderately serious = 3
  - Least serious = 2
  - Not serious = 1

The Mean Item Score (MIS) was calculated and the constraint with MIS between 3.0 and 5.0 was considered to be significant while those with MIS < 3.0 were assessed as not relevant.

RESULTS AND DISCUSSION

Socio-economic Characteristics of Respondents

Table 1 shows the socio-economic characteristics of yam farmers in Edo State. More males (83.33%) were involved in yam farming than females (16.67%). This result was similar to that of Agbaje et al., (2008) who note that yam farmers were mostly males in Ondo State. Majority of the respondents were married (87.22%), while the others were either single (0.56%), separated (8.89%) or divorced (3.33%). The result further showed that the farmers were fairly educated with about 45.56% of the respondents having secondary school education and 35.56% had primary school education. The average age of yam farmers in Edo State was 51 years which showed that yam farmers in the study area were relatively old. This finding corroborated that of Ajibefun and Abdulkadiri (1999), stating that small scale farmers in Nigeria were old and ageing. It further corroborated the finding of Pius and Oduvwuedrhie (2006) that concluded that yam farmers in south-eastern Nigeria were relatively old, with a mean age of 43 years. They had an average household size of six persons, indicating that yam farmers in the study area had relatively low household size. This finding has implications for labour source, productivity and efficiency of yam
production, as most of the farmers were likely to depend more on hired labour for the yam production activities. These findings are closely supported by those of Ekunwe et al., (2008) who indicate that yam farmers in Delta and Kogi States had an average of seven and nine persons per family respectively. The yam farmers in the study area were relatively experienced with an average farming experience of fifteen years, implying a reasonable level of specialization and expertise in yam production. This compared favourably with the findings of Oluwatusin (2011) that indicate a farming experience of 14 years for yam farmers in Osun State.

**Table 1. The Socio-Economic Characteristics of Respondents**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Frequency</th>
<th>Percentage</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>150</td>
<td>83.33</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>30</td>
<td>16.67</td>
<td></td>
</tr>
<tr>
<td>Marital Status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>1</td>
<td>0.56</td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>157</td>
<td>87.22</td>
<td></td>
</tr>
<tr>
<td>Separated</td>
<td>16</td>
<td>8.89</td>
<td></td>
</tr>
<tr>
<td>Divorced</td>
<td>6</td>
<td>3.33</td>
<td></td>
</tr>
<tr>
<td>Educational Level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Formal Education</td>
<td>28</td>
<td>15.56</td>
<td></td>
</tr>
<tr>
<td>Primary</td>
<td>64</td>
<td>35.56</td>
<td></td>
</tr>
<tr>
<td>Secondary</td>
<td>82</td>
<td>45.56</td>
<td></td>
</tr>
<tr>
<td>Tertiary</td>
<td>6</td>
<td>3.33</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 – 39</td>
<td>13</td>
<td>7.22</td>
<td></td>
</tr>
<tr>
<td>40 – 49</td>
<td>59</td>
<td>32.78</td>
<td>51</td>
</tr>
<tr>
<td>50 – 59</td>
<td>99</td>
<td>55.00</td>
<td></td>
</tr>
<tr>
<td>≥ 60</td>
<td>9</td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>Household Size</td>
<td>82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 5</td>
<td>65</td>
<td>45.56</td>
<td></td>
</tr>
<tr>
<td>6 – 8</td>
<td>27</td>
<td>36.11</td>
<td>6</td>
</tr>
<tr>
<td>9 – 12</td>
<td>6</td>
<td>15.00</td>
<td></td>
</tr>
<tr>
<td>&gt;12</td>
<td></td>
<td>13.00</td>
<td></td>
</tr>
<tr>
<td>Farming Experience</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>˂ 5</td>
<td>55</td>
<td>3.33</td>
<td></td>
</tr>
<tr>
<td>5– 10</td>
<td>52</td>
<td>30.56</td>
<td>15</td>
</tr>
<tr>
<td>11 – 15</td>
<td>30</td>
<td>28.89</td>
<td></td>
</tr>
<tr>
<td>16 – 20</td>
<td>10</td>
<td>16.67</td>
<td></td>
</tr>
<tr>
<td>21 – 25</td>
<td>27</td>
<td>5.56</td>
<td></td>
</tr>
<tr>
<td>&gt;25</td>
<td></td>
<td>15.00</td>
<td></td>
</tr>
</tbody>
</table>


**Allocative Efficiency levels of Inputs Used in Yam Production**

The estimated results of the ordinary least squares (OLS) and the maximum likelihood estimates (MLE) of the production function for yam farmers in Edo State are presented in Table 2. The sigma square value of 2.910 indicated a good fit and the correctness of the specified distributional assumption of the error term. The gamma estimate of 0.9910 indicated that 99.10% variation of the output of yam in Edo State was due to the inefficiency factors. The ratio of the log likelihood function when compared to the joint effect of efficiency on output was 31.614. This diagnostics statistics confirmed the significance of the stochastic frontier production function (SFPF). This compared favourably with the findings of Pius and Odjuvwederhie (2006) who report that the average response function is not an adequate representation for yam production in south eastern Nigeria and Ojo et al., (2009) who concluded that the OLS is not an adequate representation for yam production in Niger State.

The allocative efficiency level of inputs used in yam production was presented in Table 3. The results indicated that farmland (15.72), planting material (7.27) and fertilizer (2.38) were underutilized. This implies that yam farmers could increase their output and profit by increasing these resources. This finding was in consonance with that of Fasasi (2006), Sanusi and Salimonu (2006), Olorunsanya et al., (2009), with results showing under utilisation of land input by yam farmers in Ondo, Oyo and Ekiti States respectively. These values were more than unity confirming the existence of disequilibria. This result supported the findings of Ekunwe et al., (2008) who reported the under utilisation of planting materials (yam sett) by farmers in Delta and Kogi States and Fasasi (2006), for farmers in Ondo State.

Labour and agrochemicals were over utilised with efficiency ratios of 0.62 and 0.52 respectively. On the whole, these results imply that none of the inputs were being efficiently utilized by yam farmers in Edo State since it was either over utilised or under-utilised.
Table 2. The Ordinary Least Square (OLS) and Maximum Likelihood (MLE) Function for Yam Production

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter</th>
<th>OLS Function</th>
<th>MLE Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>$b_0$</td>
<td>4.564 (2.451)</td>
<td>1.363 (1.754)</td>
</tr>
<tr>
<td>Farm land (Ha)</td>
<td>$b_1$</td>
<td>0.783 (2.306)*</td>
<td>0.495 (3.599)**</td>
</tr>
<tr>
<td>Yam sett (kg)</td>
<td>$b_2$</td>
<td>0.478 (3.528)**</td>
<td>0.540 (8.254)**</td>
</tr>
<tr>
<td>Labour (Man day)</td>
<td>$b_3$</td>
<td>0.061 (0.390)</td>
<td>0.367 (6.698)**</td>
</tr>
<tr>
<td>Fertilizer (kg)</td>
<td>$b_4$</td>
<td>0.056 (1.141)</td>
<td>0.040 (2.221)*</td>
</tr>
<tr>
<td>Agro chemical (litres)</td>
<td>$b_5$</td>
<td>0.057 (0.492)</td>
<td>0.008 (0.193)</td>
</tr>
<tr>
<td>Sigma square</td>
<td>$\sigma^2$</td>
<td>2.910 (8.517)**</td>
<td>0.990 (120.175)**</td>
</tr>
<tr>
<td>Gamma</td>
<td>$\gamma$</td>
<td>0.990 (120.175)**</td>
<td></td>
</tr>
<tr>
<td>Log likelihood ratio</td>
<td></td>
<td>31.614</td>
<td></td>
</tr>
</tbody>
</table>

Figures in parentheses are t-ratios, ** Significant at 1% level of significance
* Significant at 5% level of significance

Table 3. Allocative Efficiency Levels of Inputs Used in Yam Production

<table>
<thead>
<tr>
<th>INPUT</th>
<th>MPV</th>
<th>MFC</th>
<th>RATIO</th>
<th>INFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm Land</td>
<td>60871.02</td>
<td>3871.43</td>
<td>15.72</td>
<td>Under-utilised</td>
</tr>
<tr>
<td>Yam sett</td>
<td>324.36</td>
<td>44.62</td>
<td>7.27</td>
<td>Under-utilised</td>
</tr>
<tr>
<td>Labour</td>
<td>485.55</td>
<td>766.67</td>
<td>0.63</td>
<td>Over-utilised</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>150.66</td>
<td>63.30</td>
<td>2.38</td>
<td>Under-utilised</td>
</tr>
<tr>
<td>Agro Chemical</td>
<td>900.63</td>
<td>1732.59</td>
<td>0.52</td>
<td>Over-utilised</td>
</tr>
</tbody>
</table>
Elasticity of Production and Return to Scale

The estimated coefficients of the regression model were also elasticities of production, presented in table 4. The result showed that elasticities for farm size, yam sett, labour and fertilizer were 0.495, 0.540, 0.367 and 0.040. The elasticities less than unity were estimated to be positive decreasing functions indicating that the allocation and utilisation of the variables were in stage of economic relevance of the production function (Stage II). The elasticity for agro-chemical (-0.008) less than zero showed a negative decreasing function to the factors, indicating the over-utilization of the input implying that its allocation and utilisation were in irrational stage of production (stage III) of the production process. The return to scale was 1.434, which was an indication that on the whole, yam production in the study area was in stage 1 implying that inputs were under-utilized by the yam farmers. This suggested that yam farmers could benefit from the economies of scale linked to increasing returns. At this stage of irrational production (stage 1), production could be increased by using more of the production resources. This result was in consonance with the findings of Ojo et al., (2009), that yam farmers in Ondo State operated in the irrational stage (stage 1) of the production function with a return to scale of 1.269 and Oluwatusin (2011) that concluded that yam production in Osun State was in the irrational stage (stage 1) with return to scale of 1.119.

Table 4. The Elasticities of Production and Return to Scale

<table>
<thead>
<tr>
<th>Variable</th>
<th>Production Elasticities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm Size</td>
<td>0.495</td>
</tr>
<tr>
<td></td>
<td>0.540</td>
</tr>
<tr>
<td>Yam sett</td>
<td>0.367</td>
</tr>
<tr>
<td>Labour</td>
<td>0.040</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>-0.008</td>
</tr>
<tr>
<td>Agro chemical</td>
<td></td>
</tr>
<tr>
<td>Return to Scale</td>
<td>1.434</td>
</tr>
</tbody>
</table>

The Production Constraints of Yam Farmers

The constraints faced by yam farmers in the study area were presented in table 5. The major constraints identified to confront yam farmers in the study area were high cost of acquiring land ($X = 4.86$), inadequate capital ($X = 4.28$), high cost of labour ($X = 4.24$), difficulty in acquiring land ($X = 3.96$) and difficulty in accessing quality planting materials ($X = 3.84$). The others also identified included transportation problems ($X = 2.73$), pest and disease attack ($X = 2.36$) and
high cost of fertilizer and agro chemicals ($X = 2.30$). This result compares favourably with the findings of Sanusi and Salimonu (2006), that inadequate capital to invest in yam production, scarcity of labour and storage problems were major problems facing yam production in Oyo State.

**Table 5. The Production Constraints of Yam Farmers**

<table>
<thead>
<tr>
<th>Constraints</th>
<th>Mean ($X$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Cost of acquiring land</td>
<td>4.86</td>
</tr>
<tr>
<td>Inadequate capital</td>
<td>4.28</td>
</tr>
<tr>
<td>High cost of labour</td>
<td>4.24</td>
</tr>
<tr>
<td>Difficulty in acquiring land</td>
<td>3.96</td>
</tr>
<tr>
<td>Difficulty in accessing quality Planting materials</td>
<td>3.84</td>
</tr>
<tr>
<td>Transportation problems</td>
<td>2.73</td>
</tr>
<tr>
<td>Pest and Disease attack</td>
<td>2.36</td>
</tr>
<tr>
<td>High cost of fertilizer and agro chemicals</td>
<td>2.30</td>
</tr>
</tbody>
</table>

**CONCLUSION**

The study showed that yam farmers in Edo State were not efficient in the use of production resources, while farmland, planting materials (yam sett) and fertilizer were under-utilized, labour and agrochemical were over-utilized. This showed that none of the production inputs was optimally allocated and utilised. The overall productivity of yam was however in the irrational stage of production (stage I) suggesting that there was room for expansion in output and productivity. This can be actualised by cropping higher hectarage of farmland with increased quantity of planting material and controlled usage of higher quantity of fertilizer as these were found to be under-utilised. Since the under-utilisation of some of the resources may not be unconnected with inadequate capital, the yam farmers should be given assistance in form of loans or organise themselves into cooperatives to curb the problem of inadequate finance and also afford the high cost of inputs especially labour and land as these were their major constraints.
REFERENCES


