

## Determinants of Yam Production and Technical Efficiency among Yam Farmers in Benue State, Nigeria

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**ABSTRACT** This paper investigates the determinants of yam production and technical efficiency of yam farmers using stochastic frontier production function which incorporates a model of inefficiency effects. Farm-level data were collected from a sample of 100 yam farmers in Benue State using structured questionnaires. The empirical results indicate that land, seed yam, family labour and fertilizer were the major factors that influence changes in yam output. Farmer-specific variables such as education, membership of association and household size were found to have significant effects on the observed variation in technical efficiency among the yam producers. The technical efficiency of farmers varied from 0.67 to 0.99 with a mean of 0.95. The implication of the study is that efficiency in yam production among the farmers could be increased by 5% through better use of land, seed yam, family labour and fertilizer in the short term given the prevailing state of technology. This could be achieved through policy interventions that would contribute to better access to land, improved seed and fertilizer as well as provision of labour saving technologies to ease farm operation. Also, improved farmer's educational levels through adult education and literacy campaign would probably increase efficiency in the long term.

### INTRODUCTION

Yam (*Dioscorea* spp) has been described as one of the major staple in West and Central Africa where it provides food for over 160 million people (Orkwor et al. 1995). Average statistics shows that the West African yam belt produced 95% of the world's output of 34 million metric tonnes (mmt) of yam in 2001 and Nigeria alone produced 75% of West African output.

The yam tuber is a good source of energy mainly from their carbohydrate contents since it is low in fat and protein. The yam tuber is said to contain pharmacologically active substances such as dioscorine, saponin and sapogenin. Dioscorine, which is the major alkaloid in yam, is medicinally a heart stimulant (Eka 1985). Also, it has been reported that yam is a good source of industrial starch whose quality varies with species.

Despite this importance of yam, its production in Nigeria has not been accorded the needed attention (Orkwor and Asiedu 1999). This is reflected in the fall in output percentage growth

rate of yam from 42% in 1990 to 16.3% in 2001 despite the increase in land devoted for the production of the crop from 1270 million hectares to 2742 million hectares in the same period (Federal Ministry of Agriculture, FMA 2001). Since increased productivity is directly related to production efficiency, it is imperative to raise productivity of the farmers by helping them reduce technical inefficiencies.

Efficiency is concerned with the relative performance of the processes used in transferring given inputs into outputs. Farrel (1957) identified three types of efficiency- technical, allocative and economic. An important assumption relating to efficiency measurement is that firms operate on the outer bound production function, that is, on their efficiency frontier. When firms fail to operate on outer bound production function, they are said to be technically inefficient. The stochastic frontier production function, which is often used for efficiency studies was first independently proposed by Aigner et al. (1977) and Meeseun and van den Broeck (1977). A stochastic frontier production function comprises a production function of the usual regression type with a composite disturbance term equal to the sum of two error components. One error component represents the effects of statistical noise (e.g.

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and

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \dots \dots \dots (4)$$

Battese and Corra (1977) on the other hand defined  $\lambda$  as the total variation in output from the from the frontier which is attributable to TE, that is

$$\gamma = \sigma_u^2 / \sigma^2 \dots \dots \dots (5)$$

so that  $0 \leq \gamma \leq 1$ . An estimate of  $\gamma$  can be obtained from estimates of  $\sigma^2$  and  $\lambda$ .

The frontier production functions 1 and 2 is defined by the logarithm of production, thus the production for the  $i$ th farm is  $\exp(Y_i)$ . The measure of technical efficiency (TE) for the  $i$ th farm is thus:

$$TE_i = \exp(-u_i) \dots \dots \dots (6), \text{ so that } 0 \leq TE_i \leq 1.$$

This measure of technical efficiency is equivalent to the ratio of the production for the  $i$ th farm,  $\exp(Y_i) = \exp(X_i\beta + v_i - \mu_i)$  to the corresponding production value if the effect of  $i$  was zero,  $\exp(X_i\beta + v_i)$ . The technical efficiency measure (6) is not dependent on the level of factor input for the given firm.

The mean technical efficiency of the farms that corresponds to the measure of equation (6) is

$$TE = \{1 - \Phi\{\sigma - (\mu/\sigma)\} / 1 - \Phi(-\mu/\sigma)\} \exp(-u + \frac{1}{2}\sigma^2) \dots \dots \dots (7)$$

where  $\Phi(\cdot)$  represents the density function for the standard normal random variables.

The frontier production function specified for the yam enterprises in the prevailing state was defined by  $Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + v_i - u_i \dots \dots \dots (8)$  where the subscript  $i$  ( $i=1, \dots, 100$ );  $Y$  denotes the logarithm of output of yam (kilogramme);  $X_{1i}$  denotes logarithm of the hectares of land cultivated;  $X_{2i}$  denotes logarithm of the quantity of seed yam (in kilogramme);  $X_{3i}$  denotes logarithm of the quantity of family labour used (in man-days);  $X_{4i}$  denotes logarithm of the quantity of hired labour used (in man-days);  $X_{5i}$  denotes logarithm of the quantity of fertilizer used (in kilogramme);  $X_{6i}$  denotes logarithm of the quantity of herbicide used (in litres). The random variables  $v_i$  and  $u_i$  in model (2) were assumed to have the properties specified for the corresponding unobservable random variables in the frontier production function model (1) and (2).  $\mu_i$  which denotes inefficiency effects is defined thus:

$$\mu_i = \delta_0 + \delta_1 \ell_n Z_1 + \delta_2 \ell_n Z_2 + \delta_3 \ell_n Z_3 + \delta_4 \ell_n Z_4 + \delta_5 - \ell_n Z_5 \dots \dots \dots (9)$$

where,  $\ell_n$  denotes logarithm (to base  $e$ );  $Z_1$  education (number of years of formal schooling);  $Z_2$  denotes

dummy variable (1 for membership of association and 0 otherwise);  $Z_3$  denotes number of visits by extension agent (days);  $Z_4$  = denotes household size (number of persons in household);  $Z_5$  denotes dummy variable (1 for ownership of land by inheritance and 0 otherwise).

Given functional and distributional assumptions, the variance parameters defined by equations (4) and (5), the technical efficiency defined by equation (6) and the maximum-likelihood (ML) estimates for all parameters of the stochastic frontier production and inefficiency model defined by equations (8) and (9) were simultaneously estimated using the program, FRONTIER 4.1 (Coelli 1996).

## RESULTS AND DISCUSSION

The parameters of the production factors and related statistical test results obtained from the Cobb-Douglas stochastic frontier production function defined by equation (1) are presented in table 1. The production function estimates indicate the relative importance of factor inputs in yam production. From the results, all except hired labour and herbicide had the expected positive sign. This suggested that more output of yam would be obtained from the use of additional quantities of these variables, *ceteris paribus*. The estimated coefficient of land resource was positive and significant ( $P < 0.01$ ). This is in line with the finding of Umoh (2006). The significance of the variable could be attributed to its importance in crop production in the sense that its shortage would not only have a direct negative effect on production but also an indirect negative effect on output by reducing the marginal productivity of non-land inputs. The coefficient of seed yam was positive which conforms to a *priori* expectation and significant ( $P < 0.01$ ). This indicated that higher seed rate would result in high yam population and subsequently higher yield except where there is overcrowding leading to competition of available nutrients which will consequently lead to lower yield. The estimated coefficient of family labour was positive and significant ( $P < 0.005$ ). The positive sign of the coefficient is in agreement with the *a priori* expectation and imply that as the quantity of man-days of family labour is increased the output of yam also increased. The significance of the variable (family labour) derive from the fact that yam production is labour-intensive from land

preparation to harvesting; hence for optimum yield to be realized high man-days of labour is required. Fertilizer input was positive as expected and significant ( $P < 0.01$ ). This implied that fertilizer was a significant factor that influences changes in the output of yam. The significance of the fertilizer variable derives from the fact that it is a major land augmenting input in the sense that it improves the productivity of land thus leading to increased yield.

The yield function was expressed as a Cobb-Douglas function; hence, the coefficients of the variables were direct elasticities. The elasticities with respect to land, seed yam and fertilizer were positive and have values between 0 and 1 (Table 1). This indicated that allocation and use of these resources were in the rationale (stage 2) of the production process and increase in the use of the resources would result in increase in yield, *ceteris paribus*. The estimated return to scale (RTS) computed as the sum of the estimated output elasticities was 0.98, suggesting decreasing returns to scale. The return to scale indicates what would happen to output if all the inputs are increased simultaneously. The result of this study implied that a unit increase in the quantities of the productive resources would lead to less than proportionate increase to output of yam, *ceteris paribus*.

The variance ratio ( $\gamma$ ), defined by equation (5) which is associated with the variance of technical inefficiency effects in the stochastic

frontier was estimated to be 0.97. This suggested that systematic influences that are unexplained by the production function were the dominant sources of random errors. In other words, it means that 97% of the total variability of yam output for the farmers was due to differences in technical efficiencies.

The sources of inefficiency were examined by using the estimated  $\delta$ -coefficients associated with the variables in equation (9). The inefficiency variables were specified as those relating to farmer's socio-economic characteristics. They include the farmer's level of educational attainment, membership of association, contact with extension agents, household size and system of land ownership. Analysis of the estimated coefficients of the inefficiency variables of the efficiency model tells us the contribution of the variables to technical efficiency. The results of the inefficiency model are given in table 2. The coefficient of education was estimated to be negative and significant ( $P < 0.10$ ). This indicates that farmers with more years of formal schooling tend to be more technically efficient. This agreed with the findings of Pius and Odjuvwuederhie (2006). The data asserted that more years of formal education is imperative to better understand and adapt new technology which subsequently make it possible to move close to the frontier. Furthermore, educated farmers are expected to be more receptive to improved farming techniques and therefore should have higher level of technical efficiency than farmers with less education (Ajibefun and Aderinola 2003). Farmers with low level of education would be less receptive to improved farming techniques. The predicted

**Table 1: Maximum-likelihood estimates for parameters of the Cobb-Douglas Stochastic frontier production function for yam farmers during the 2005/2006 cropping season in Benue State, Nigeria.**

| Variable                     | Parameters | Coefficients | t-ratio   |
|------------------------------|------------|--------------|-----------|
| <i>Production Factors</i>    |            |              |           |
| Constant                     | $\beta_0$  | 1.986        | 10.728    |
| Land                         | $\beta_1$  | 0.648        | 9.602***  |
| Seed yam                     | $\beta_2$  | 0.184        | 2.860***  |
| Family labour                | $\beta_3$  | 0.139        | 2.225**   |
| Hired labour                 | $\beta_4$  | -0.0019      | -0.574    |
| Fertilizer                   | $\beta_5$  | 0.015        | 3.615***  |
| Herbicides                   | $\beta_6$  | -0.005       | -1.285    |
| <i>Diagnostic Statistics</i> |            |              |           |
| Model variance               | $\sigma^2$ | 0.039        | 2.048**   |
| Variance ratio               | $\gamma$   | 0.970        | 52.265*** |
| -ln likelihood               |            |              | 148.111   |
| Number of observations       |            |              | 100       |

\*\*\* Significant at 1% level \*\* significant at 5% level  
Source: Computer print out of field data

**Table 2: Maximum-likelihood estimates for parameters of the Cobb-Douglas Inefficiency model for yam farmers during the 2005/2006 cropping season in Benue State, Nigeria.**

| Variable                      | Parameters | Coefficients | t-ratio |
|-------------------------------|------------|--------------|---------|
| <i>Inefficiency Variables</i> |            |              |         |
| Constant                      | $\delta_0$ | 0.317        | -1.433  |
| Education                     | $\delta_1$ | 0.828        | -1.675* |
| Membership of association     | $\delta_2$ | 0.364        | -1.780* |
| Extension contact             | $\delta_3$ | -0.274       | 1.577   |
| Household size                | $\delta_4$ | 0.141        | -1.898* |
| System of land ownership      | $\delta_5$ | -0.186       | 1.590   |

\*significant at 10% level:  
Source: Computer print out of field data

coefficient of membership of association was negative and in consonance to the hypothesized expected sign and significant ( $P < 0.10$ ). Membership of association provides a network connection among farmers which lead to mutual commitment. It affords the farmers access to soft loans and productive inputs such as improved seeds and fertilizer which are better sought by group rather than individuals. The predicted coefficient of household size was negative and significant ( $P < 0.10$ ). The negative coefficient was in agreement with the hypothesized expected sign and implied that as the number of adult persons in a household increases, efficiency also increases. This agreed with the findings of Villano and Fleming (2004). A possible explanation is that more adult persons in a household meant that more quality labour would be available for carrying out farming activities in timely fashion, thus making the production process more efficient.

The technical efficiencies of the sampled yam farmers were less than one. The predicted technical efficiencies for the farmers ranged from 0.67 to 0.99 with a mean of 0.95 (Table 3). The relatively wide differential in technical efficiency of the 'least' practice and the 'best' practice farmer was an indication of potential for efficiency improvement. A possible explanation to this variation could be the varying socio-economic characteristics of the sampled farmers such as educational levels, membership of association, number of visit by extension agents, household size and system of land ownership must have influence the farmer's ability to effectively use the available technology; a situation that must have contributed to the observed variation in their

efficiency levels. An average level of technical efficiency for the farms was estimated to be 95%. In other words, on the average yam output falls 5% short of the maximum possible level and 4% from the 'best' practice farmer.

## CONCLUSION

From the results of the study, it can be said that the yam farmers appear somewhat inefficient in their use of inputs. The attainment of an average technical efficiency of 95% indicated that efficiency of the farmers could be increased by about 5% to attain maximum possible output. The results suggests that farmers could increase output through more intensive use of land, family labour, seed yam and fertilizer inputs given the prevailing state of technology. This could be achieved through development of land by the government as well as removal all distributional bottlenecks, which affect the availability and prices of improved seeds and fertilizers at the grass root. In the long term, higher technical efficiency could be achieved by improving farmers' educational status through adult education and literacy campaigns. Also, extension agents should be adequately trained and equipped to help the farmers imbibe the culture of sound agronomic practices that would ensure increased yam production in the study area.

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**Table 3: Frequency distribution of the technical efficiencies of yam farmers during the 2005/2006 cropping season in Adamawa State, Nigeria**

| Range              | Number of farms | Percentage of farms |
|--------------------|-----------------|---------------------|
| 0.65 - 0.70        | 1               | 1.00                |
| 0.71 - 0.75        | 5               | 5.00                |
| 0.76 - 0.80        | 1               | 1.00                |
| 0.81 - 0.85        | 2               | 2.00                |
| 0.86 - 0.90        | 1               | 1.00                |
| 0.91 - 0.95        | 20              | 20.00               |
| 0.96 - 1.00        | 70              | 70.00               |
| Total              | 100             | 100                 |
| Mean efficiency    | 0.95            |                     |
| Minimum efficiency | 0.67            |                     |
| Maximum efficiency | 0.99            |                     |

Source: Computed from MLE result

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