A JOURNAL OF SCIENCE, TECHNOLOGY AND MATHEMATICS EDUCATION (JOSTMED)

Volume 6, Number 1 ISSN 0748-4710

JOURNAL OF SCIENCE, TECHNOLOGY AND MATHEMATICS EDUCATION (JOSTMED)

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

Published by
DEPARTMENT OF SCIENCE EDUCATION
FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

Journal of Science, Technology and Mathematics Education (JOSTMED)
Volume 6, Number 1

May, 2009
ISSN 0748 4710

Technical Efficiency and its Determinants in Yam Production in Bosso Local Government Area, Niger State, Nigeria

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Abstract
This paper investigates farm level technical efficiency of production and its determinants in a sample of 80 yam producing farms in Bosso Local Government Area (LGA), Niger State, Nigeria using a stochastic frontier production function approach applied to cross-sectional data generated during the 2006 cropping season. Farmers were selected using random sampling procedure. Results indicate that technical efficiency of production in the sample of yam producing farms investigated ranges from a minimum of 18.60 per cent to a maximum of 92.60 per cent with an average technical efficiency estimate of 80.90 per cent. This suggests that there are prospects for increasing their production by as much as 19.10 per cent by reallocating the existing resources more optimally. Results also show that the estimated coefficients in the technical efficiency model indicate that farm size and level of personal income have positive effects on technical efficiency of yam farmers. However, a negative relationship between technical efficiency and extension contact is found. It is recommended that farmers should expand their farm sizes which necessitates the introduction and re-strengthening of existing favourable credit policies. The central body coordinating extension services should be encouraged by motivating staff directly involved in disseminating production information to increase output.

Introduction
One of the major problems facing developing countries in the tropics is the production of sufficient food, fuel, fibre and shelter for their population (Akinwumi and Youdeowei, 1999). The problem of eliminating hunger is now a big challenge especially in third world countries and sub-Saharan Africa in particular.
Agriculture has been the mainstay of the economy ever before independence and early post independence (Olajide, 1992). But since the discovery of oil and its boom in the late 60's, the Nigerian governments' attention was diverted from agriculture to the non-agricultural sector. This was characterized by a paradigm shift of labour from agriculture to take up available employment opportunities in these non-farm sectors (Olajide, 1992).
The diffusion of managerial skills has not been observed, while the expected increase in productivity has not been commensurate with the level of incentives and other financial support given to them. It should be noted however, that productivity enhancement can be achieved through the use of improved technology efficient utilization of resources. (Omotayo, *et al*, 2001). Given the low rate of adoption of yam technologies by farmers, improvement in efficiency remains the most cost effective way of enhancing productivity in the short run. Improving efficiency of resource use in crop production by farmers will require knowledge of the current efficiency levels as well as identification of some policy variables that can be tinkered with bringing improvement. Even though Nigeria has the potential resources to produce more food than the current population requires, factors like biological,

May, 2009
ISSN 0748-4710

economical, socio-cultural and climatic variables which are beyond the control of the farmer have continued to undermine production. Low crop yield, high cost of labour, late or inadequate inputs to farmers, use of indigenous or unimproved crop varieties and breeds of livestock, poor marketing system, low technology and limited ratio of extension workers to farmers are some of the associated problems with agriculture since the colonial period.

Yam belongs to the genus *Dioscorea*. The most economically important are the white yam (*D. alata*). These yams are indigenous to West Africa except water yam which originated from South-East Asia. Production of yam in Nigeria contributed an average of 72% to the total yam production of West Africa and Nigeria alone account for 70% of the world's yam production. (FAO, 1998). Not much research has been carried out on the improvement of its quality and quantity compared to other food crops. Yam production has continued to decrease over the past years following poor production pattern, processing, storage, transportation and marketing system of the crop (I.I.T.A, 2006), yet, breeding works in Nigeria resulted in the selection of clones that do not require staking and capable of yielding an estimate of 20 tons/ha. Nigeria has the potential to be self-sufficient in yam production as virtually all the ecological zones are suitable for its cultivation. Another big constraint in the production of yam apart from those listed earlier is the cost and unavailability of planting materials. This is a major constraint to increased yam production, and this material is scarce (NCRI, Umudike, 1985). Seed yam alone constitutes over 40% of capital outlay in yam production in Nigeria (NCRI, Umudike, 1985). In their investigation, Lyubor and Helen (1996) observed that recent measures of efficient production of yam have been incongruous with the production motive of the entrepreneurs in the farming business. The reason being that, bureaucratic obstacles inherent in the Ministry of Agriculture have continued to foster unnecessary delays in the release of credit and other production inputs to the practicing farmers.

Industrially, alkaloids content in yam makes it very important to the pharmaceutical companies for the production of drugs, particularly steroids, though poisonous and that is why it must be properly cooked before it is consumed. Yam is also prepared as yam flour and play vital roles in traditional culture, rituals and local commerce especially the *D. rotundata*, which is most cherished.

Okike (2005) found that increased resource use associated with agricultural intensification was not always accompanied by an increased in production efficiency; and while agricultural intensification based on high external input strategies yields higher marginal returns in the northern guinea savanna, a similar strategy is not critical to success in the Sudan Savanna given current use levels and the biophysical endowments of the latter ecological zone.

Ali and Byerlee (1991) opined that variables related to managerial ability of farmers including education and technical know-how are found to be significant sources of measuring efficiency or inefficiency. In the same vein, Ajibefun and Daramola (2003) emphasized that variables such as age of farmers, level of education and level of investment are most significant in both technical and allocative efficiency. Other factors like family size, health status, hired work-force, credit accessibility, fragmentation of land and extension services are possible significant determinants of efficiency either technically or allocatively (Obwona, 2000). Furthermore, low literacy level of the farmers, lack of records, which lead to memory re-call system, poor condition of rural roads and transportation which affect mobility of extension workers and sources of input used contribute to inefficiency of yam production in most producing areas. Most empirical studies therefore show that socio-economic characteristics and farm characteristics are main sources of technical efficiency among practicing farmers.

Biggs, (1995) also lending credence to this, found that farm sizes, age of farmers are positively related to technical efficiency. Inefficiency is mostly noticed among ageing farmers and those obtaining loans as they redirect the facility towards other livelihood strategies or consumption of goods to ensure an improved living standard. This directly or indirectly affects productivity and lead to default hence, payback becomes difficult.

Yam is highly cultivated in most rural areas in Niger State and especially in the study location, but unfortunately, less attention has been paid to developing its production as a result of low technology and lack of implementation of government policies by government and it agencies. Farmers in Nigeria, particularly yam farmers in Niger State need to improve the efficiency in yam production so that output could be raised to meet the growing demand. Little has been done to ascertain the technical efficiency in yam production in Niger State in recent past. An increase in efficiency would lead to an improvement in the welfare of farmers and consequently a reduction in their poverty level and food security. The challenge is how to get this done by redirecting policy focus to improve efficiency in its production especially in the subsistence system of farming to improve their gross margins through bumper harvest. This study aims at examining the technical efficiency of yam production in Bosso LGA, Niger State, Nigeria and making policy recommendations towards improving the technical efficiency of farmers by reallocating the existing resources more optimally.

Methodology

Study Area and Location

Niger State of Nigeria is a major yam growing area of the country. The state was created on 3rd February, 1976 with Minna as the capital city. The state is located between latitude 3^0 and 7^0 and longitude 8^0 and 14^0 West of the Greenwich Meridien. The population of Niger State as at 2006 was 3,300,000 people according to National Population Census 2006. Bosso Local Government Area (LGA) has a population of 247,359 persons (NPC, 2006). Bosso LGA shares border with Shiroro, Paikoro, Gbako and Wushishi LGAs. It has a low land type landscape and experiences an annual rainfall of about 6 months i.e (April to September) with an average temperature of 32^0C -35^0C. Agriculture is the mainstay of the inhabitants. Besides, they also engage in petty trading and few are civil servants. The vegetation of the state falls within the guinea savanna agroecological zone of Nigeria. Minna town is the commercial city and is located at a valley between Chanchaga and Bosso town. The main crops under cultivation are cereals (millet, guinea corn, maize, rice, etc); vegetables; root and tuber crops such as yam, cassava, potatoes, etc; melon, groundnuts, sugar cane, soyabeans and some fruits among others. There are two major rivers traversing the state namely, Rivers Kaduna and Niger with dams located at Shiroro and Kainji which generate hydro electric power.

Sampling Procedure

Four villages within the Local Government Area were selected using random sampling technique. They are Gidan Kwano, Garatu, Sabon Daga and Gidan Mangoro. A total of 80 yam farmers were selected randomly for this study. From each of the sample villages, 20 yam farmers were selected. The household heads were identified and copies of the questionnaire administered to them complemented by interview schedules.

Data Collection

Well structured questionnaire were administered by the researchers with the assistance of ADP extension agents as well as trained enumerators in each of the locations. Data were collected on: quantity of yam produced (in tonnes), hectares of land cultivated, labour inputs for yam production (in man-days), years of farming experience, sources of credit available to yam farmers, other operating costs and various materials used in yam production such as fertilizer (in kg) and household size and other socio-economic variables during the 2006 cropping season.

Method of Data Analysis

Descriptive statistics and stochastic production function model were used in the analysis of data. To examine the socio-economic characteristics of yam producers, descriptive statistics were used.

Measurement of Technical Efficiency

Technical efficiency is measured considering the farm input utilization and technology. Estimating technical efficiency involve either a deterministic or stochastic frontier production function. The stochastic model, which is the focus of this study, is based on the assumption that the frontier production function depends on production and technology related parameters as well as random disturbances. The stochastic frontier approach amounts to specifying the relationship between output and one or more input levels, using two error term. One error term is the traditional normal error term in which the mean is zero and the variance is constant. The other error term represents technical efficiency and may be expressed as a half-normal, truncated normal, exponential, or two parameter gamma distributions. Technical efficiency is subsequently estimated via maximum likelihood estimation technique of the production function subject to the two error terms following Aigner, *et al* (1977); Coelli, (1996); and Essien, (2000).

The Empirical Model

The stochastic frontier production function was used. The idea of frontier production function can be illustrated with a farm using 'n' inputs (X_i, X_2 ------ X_n) to produce output Y. Efficient transformation of inputs into output is characterised by the production function f(x), which shows the maximum output obtainable from various input vectors. (Ajibefun and Daramola, 2003).

The model begins by considering a stochastic production with a multiplicative disturbance term of the form:

$$Y = f(X_i, \beta)e^{\epsilon} \qquad (1)$$

Where,

Y = quantity of output, X_i = a vector of input quantities, β = a vector of parameters and

e = exponential base and ϵ is a stochastic disturbance term, consisting of two independent elements, hence the term stochastic frontier whereby

$$\epsilon = u_i - v_i \qquad (2)$$

i.e

$$Y = f(X_i, \beta)e^{(U_i - V_i)} \qquad (3)$$

The symmetric component v_i accounts for random variation in output due to factors not under the control of the farmer such as weather, diseases or fire disaster. It is assumed to be independently and identically distributed as N $(0, \sigma v^2)$ random variables independent of the u_is. A one sided component $u \leq 0$ reflects technical inefficiency relative to the stochastic frontier, $f(X_i, \beta)e^{\epsilon}$. Thus $u_i = 0$ for a farm output which lies on the frontier and $u_i < 0$ for one whose output is below the frontier as /N ~ $(0, \sigma u^2)$/

The frontier of the farm is given by combining equation (1) and (2).

$$Y = f(X_i, \beta)e^{(ui-vi)} \quad - \quad - \quad - \quad (4)$$

Technical efficiency of an individual farmer is defined in terms of the ratio of the output observed to the corresponding frontier output, given the available technology.

Technical efficiency (TE) = Y_i/Y_i^*

$$= f(X_i, \beta)\exp(vi-ui)/*f(X_i, \beta)\exp(vi) \quad - \quad - \quad - \quad (5)$$

$$= \exp(-u_i) \quad - \quad - \quad - \quad - \quad - \quad - \quad (6)$$

Where Y_i is the observed output, and Y_{i*} is the frontier output. Technically efficient farms are those that operate on the production frontier and the level by which a farm lies below its production frontier is regarded as the measure of technical efficiency.

For this study therefore, and as has been used in various investigations, as mentioned above, the production technology of yam farmers is assumed to be specified by a Cobb-Douglas frontier production function of the form:

$$\text{Ln } Y = \beta_0 + \beta_1 \text{Ln } X_1 + \beta_2 \text{Ln}X_2 + \beta_3 \text{Ln}X_3 + \beta_4 \text{Ln}X_4 + \beta_5 \text{Ln}X_5 + v_i - u_i \quad - \quad - \quad - \quad (7)$$

Where; Ln represents the natural logarithm, Y represents the output of yam in tonnes, X_1 represents the farm size in hectares, X_2 represents the cost of planting materials in naira (₦), X_3 represents the quantity of fertilizer used in kg (kilogramme), X_4 represents the labour inputs in man days, X_5 represents the capital inputs in naira (i.e depreciation on fixed cost items, rent, interest payment etc.). β_1 to β_5 are coefficients to be estimated.

The v_i's are assumed to be independent and identically distributed normal random errors, having zero mean and unknown variance, σ_v^2. u_i's are the technical efficiency effects, which are assumed to be independent of v_{is} such that U_{is} is the non-negative truncation (at zero) of the normal distribution with mean, u_i and variance, σ_v^2, where U_{is} defined by,

$$U_i = \sigma_0 + \sigma i D i + \sigma_2 Z_{1i} + \sigma_3 Z_{2i} + \sigma_4 Z_{3i} + \sigma_5 Z_{4i} + \sigma_6 Z_{5i} + \sigma_7 Z_{6i} + \sigma_8 Z_{7i} \quad - \quad - \quad (8)$$

Where; D = dummy variable for credit status of the yam farmers, whereby one (1) denote farmers that have access to credit and zero(0) denotes those that do not have access to credit. Z_1 = Age of the farmer (in years), Z_2 = level of education (No. of years spent in school), Z_3 = farming experience (in years), Z_4 = Household size (number), Z_5 = Extension contact, Z_6 = membership of co-operative (dummy variable, where (1) denote farmers that belong to a cooperative society and zero (0) otherwise), Z_7 = level of personal income of the farmer in Naira.

These variables are assumed to influence technical efficiency of the farmer and have been widely acknowledged.(Ajibefun and Daramola, 2003). The β and σ – coefficients are unknown parameters to be estimated, by the method of maximum likelihood, using the computer program FRONTIER version 4.1 (Coelli,1994).

Results and Discussion

Socio-economic Profile of Respondent Farm households

The average farm household had nine family members and the typical household head interviewed was male, married, 40 years old, has an average of 36 years farming experience and had attained at least quaranic level of education. An

May, 2009
ISSN 0748-4710

average farm sampled is 0.56 hectares. Household labour source was relied upon for the accomplishment of farm operations. Mean annual personal income of households is ₦431,927.21 while capital used in yam production is sourced majorly from personal savings. Most of the land cultivated by respondents is inherited.

Maximum likelihood (MLE) and Ordinary Least Squares (OLS) Estimates of the Production Factors

The stochastic frontier production function and OLS estimates obtained and the relevant statistical test results are presented n Table 1.

The results presented in Table 1 indicate that some of the estimated coefficients are positive while others are negative in sign. The estimated coefficients are direct elasticities of the dependent variables with respect to the independent variables with which the dependent variable is associated. The estimated sigma – squared (δ^2) value, which is 0.651 in Table 1 is significantly different from zero at 0.05 level indicating a good fit and the correctness of the specified distributional assumptions of the composite error term. The magnitude of the variance ratio i.e the gamma (γ) which is 0.917 is statistically significant at 0.01 level suggesting that systematic influences that are unexplained by the production function are the dominant sources of error. Out of the five explanatory variables modeled, only two, namely: farm size and capital input are the only production factors significantly affecting yam production in the survey area. The estimated coefficient of farm size is appropriately signed, that is, positive which is 1.043. This implies that larger farm size coupled with good management practices should translate into increased output of yam. The coefficient for capital inputs is also positive i.e 0.076 and is significant at 0.01 level. This coefficient, though small in magnitude

Table 1: Stochastic Frontier Production Function and OLS Estimates for Yam Production in Bosso Local Government Area, Niger State, 2006.

Variables	Parameters	OLS	MLE
Constant	β_0	2.761 (2.001)**	3.554 (3.617)***
Farm size (ha)X_1	β_1	0.970 (7.110)***	1.043
(10.573)***			
Cost of planting materials X_2	β_2	0.087 (0.117)	-0.019 (-0.314)
Quantity of fertilizer X_3	β_3	0.012 (-0.557)	0.005 (0.267)
Labour inputs (mandays) X_4	β_4	-0.032 (-0.217)	-0.098 (-0.764)
Capital inputs (₦) X_5	β_5	-0.086 (2.192)	0.076 (2.730)***
Log likelihood		-35.374	
Average Technical Efficiency	0.809		
Minimum Technical Efficiency	0.186		
Maximum Technical Efficiency	0.926		
Sigma – Squared (δ^2)		0.153	0.651 (2.283)**
Gamma (γ)		0.840	0.917
(18.854)***			

Source: Derived from output of computer programme Frontier 4.1 by Coelli, (1994).
Note: *** ; ** ; and * implies statistically significant at 1%, 5% and 10% levels respectively. Values in parentheses are the respective t-ratios.

implies that an increase in investment on capital inputs would lead to an increase in farmers' output. In traditional agriculture, capital investment on fixed assets is negligible.

May, 2009
ISSN 0748-4710

Levels of Technical Efficiency in Yam Production in Bosso LGA, Niger State

The levels of technical efficiency in yam production in Bosso Local Government Area Niger State is summarized in Table 2.

Table 2: Distribution of Respondents According to Level of Technical Efficiency of Yam Production in Bosso Local Government Area, Niger State, 2007

Efficiency class	No of Farmers	Percentage(%)
<0.51	4	5.00
0.51 – 0.60	1	1.25
0.61 – 0.70	4	5.00
0.71 – 0.80	17	21.25
0.81 – 0.90	40	50.00
0.91 – 1.00	14	17.50
Total	80	100.00

Source: Derived from output of computer program Frontier 4.1 by Coelli (1994).

The results presented in Table 2, indicate a technical efficiency range of between 0.186 to 0.926 in the production of yam with a mean technical efficiency of 0.809. Overall, the technical efficiency of sample farmers is less than 1 (100%) indicating that all the farmers are producing below the maximum technical efficiency frontier. The efficiency distribution shows that, about 95 per cent of the yam farmers which represents an overwhelming majority attained more than half, that is, 0.5 (50%) level of technical efficiency while just 5% operated below 0.50 level of efficiency. This moderately high level of efficiency indicates that only a small fraction of the output can be attributed to wastage. The findings in Table 2 also indicate that the best farm has a technical efficiency of 0.93 (94%) while the worst has a technical efficiency of 0.19 (19%) implying that some farmers are operating far away from the frontier region. A mean technical efficiency of 0.809 indicates that the respondents are able to get a little over 81% of potential output from a given mix of production inputs suggesting a scope for improvement by reallocating existing resources more optimally. Results show that it will take an average yam farmer in the survey area (1 – 0.81/80) i.e 99% cost saving to become the most technically efficient.

Estimates of Parameters of Efficiency Factors

The sources of inefficiency in yam production are examined by observing the σ – coefficients. The results are presented in Table 3. The results indicate that extension contact and level of personal income are the only significant determinants of the level of technical efficiency in yam production. In particular, extension contact has an estimated coefficient of -5.019 and significant at 0.1 level of significance. The negative sign does not conform to a priori expectation, because, previous findings have indicated that extension contact have a positive contribution in influencing the behavioral orientation of the farmer to improved farm practices which in turn leads to increase in efficiency of production.

Extension contact with farmers enhance acquisition of new knowledge, skill and practices on improved technology by the farmers as well as their innovativeness (Dey, 2001) which is expected to translate into increased outputs. Contacts with extension agents afford the farmers the opportunity of sharing ideas and information on modern yam production practices by interacting with other farmers. This finding is not

 May, 2009
ISSN 0748-4710

consistent with earlier results by Ajibefun and Daramola (2003) who found out that the coefficient with respect to extension contact is positive. This suggests that extension services are not adequate in the survey area given the recommended extension agent to farmer ratio. The estimated coefficient of personal income variable is positive (0.780) as expected and statistically significant at 0.1 level. This implies that yam farmers with more income tend to be more technically efficient which enables them to operate more closer to the frontier output. Cash at hand enables the farmers to purchase production inputs such as improved seeds, agrochemicals, facilities, hire labour and even adopt improved technology.

Table 3: Maximum Likelihood Estimates of the parameters of the inefficiency factors in Yam Production in Bosso LGA, Niger State, 2006.

Variable	Parameters	Coefficient	T – ratio
Constant	Δo	-0.235	-0.288
Age of farmers	δ_1	-0.016	-0.022
Level of education	δ_2	-0.016	-0.022
Farming experience (years)	δ_3	+0.020	0.534
Household size	δ_4	-0.014	-0.376
Extension contacts	δ_5	-5.019	-1.795*
Members of cooperative	δ_6	-0.235	-0.288
Level of personal income	δ_7	0.780	2.931***

Note: ***; * Significant at 1% and 10% levels respectively.
Source: Output of Frontier 4.1 by Coelli (1994).

Conclusion and Recommendations

The findings indicate that farmers were not equally technically efficient in yam production. A typical farmer realized a little above 80 per cent of potential output from a given mix of production inputs suggesting a scope for improvement by reallocating the existing resources more optimally to attain production goals. Since farm size was found to be a significant determinant of the output of yam, increasing the farm size can be an effective vehicle for stimulating greater output. Given that prospects abound for increased yam production in the survey area, the need to evolve appropriate favourable policies that will encourage farmers increase their farm sizes become paramount in our quest for increased agricultural food crop production. The Niger State Agricultural Development Project which is an arm of the State Ministry of Agriculture which is the central body coordinating extension services should be encouraged by committing more resources in terms of fund to motivate and encourage the staff to disseminate useful production information for increased output.

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