Economic Efficiency of Yam Production in Oyo State of Nigeria

Laudia T. OGUNNIYI (✉)
Olajide A. AJAO

Summary

This study estimates economic efficiency of yam growing farmers in Oyo State of Nigeria using stochastic frontier production function. The empirical application used farm level data collected from 120 farms following 2007/2008 growing season. The results indicate that farm size, hired labour, yam set and equipment are the major factors that influence changes in yam output. Farm specific variables, such as farming experience, diversification and extension, were the significant factors influencing inefficiency among yam producers. Predicted economic efficiencies range between 0.0094 and 0.876 with a mean economic efficiency of 0.594. Based on these results, sample yam producers could increase their output by 40.6% through better use of available resources.

Key words

economic efficiency, yam, stochastic frontier function

[1] Ladoke Akintola University of Technology Ogbomoso, Department of agricultural economics and extension ,Oyo State, Nigeria
✉ e-mail: titiogunniyi@yahoo.com

Received: December 21, 2009 | Accepted: September 3, 2012

Introduction

Yams are members of the genus Dioscorea which contains about 600 species of which only six are important as staples in the tropics. The economically important species grown are *Dioscorea rotundata, Dioscorea alata, Dioscorea esculenta, Dioscorea bulbifera and Dioscorea dumenterum* (Ajayi, 2008).

Yam is a preferred food and food security crop in some Sub-Saharan African countries (IITA, 1997). It is widely consumed in West Africa. It is often pounded into a thick paste after boiling (pounded yam) and it is eaten with soup. Yam can also be processed into flour that is used in the preparation of the paste. Yam tuber contains pharmacologically active substances including dioscorine, saponin and sapogenin. According to Eka (1985), dioscorine, which is the major alkaloid in yam, is medicinally a heart stimulant. The bitter principles of *Dioscorea bulbifera* (called the aerial or potato yam) include a 3 furanoside nord-iterpene called diosbulbin. These substances are toxic, causing paralysis. Extract are sometimes used in fishing to immobilize the fish and thus facilitate capture. Zulus use this yam as bait for monkeys and hunters in Malaysia use it to poison tiger (Food-Info, 2008).

According to FAO statistics, the world production of yam was 48.7 million tones in 2005. Out of this 97% came from Sub-Saharan Africa, the main producer being Nigeria with 34 million tones of the world production (IITA, 2007). In the humid tropical countries of West Africa, yams are one of the most highly regarded food products and are closely integrated into the social, cultural, economic and religious aspects of life. Traditional ceremonies still accompany yam, indicating the high status given to the plant (Food-Info, 2008).

Yam is grown for its energy rich tuber. It is adaptable to fairly fertile soils and it is suitable for intercropping with grain legumes such as cowpea, soybean and a variety of leafy vegetables. A well-drained, rich, loamy soil however is the most favorable. It gives more calories per unit of land area than most other crops and matures within seven months. On soils of average fertility, between 20 and 30 tonnes per hectare of tubers can be obtained, and up to 55 tonnes per hectare on fertile soils.

In spite of the tremendous importance attached to the yam, in the West African Sub-region, the crop has hitherto been neglected in policy decisions related to research, production and marketing (Babaleye, 2003). According to Akoroda and Hahn (1995), the production of yam in Nigeria is grossly inadequate and cannot meet the ever increasing demand under present level of input use. In order to meet the level of demand there is a need to assess the level of economic efficiency and its determinants among yam producers.

Materials and methods

Firm efficiency measurement has received considerable attention from both theoretical and applied economists. From a theoretical point of view, there has been a spirited exchange on relative importance of the various components of firm efficiency (Leibenstein, 1996). From the applied perspective, measuring efficiency is important because this is the first step in a process that might lead to substantial resource savings. These resource savings have important implications for both policy formulation and firm management.

The term efficiency is often used synonymously with that productivity, the most common measures that relate output to some input (Lund and Hill, 1979). According to Lovell (1993) the term efficiency refers to the comparison between the real or observed values of input (s) and output (s) with the optimal values of input (s) and output (s) used in a particular production process. Farm efficiency can be measured in terms of technical efficiency, allocative efficiency and economic efficiency. According to Njeru (2004), technical efficiency is the ability of a firm to maximize output for a given set of resource inputs while allocative (factor price) efficiency reflects the ability of a firm to use the inputs in optimal proportions given their respective prices, and production technology. Economic efficiency is the combination of technical and allocative efficiencies (Farrell, 1957).

Taking into account that not all the firms are efficient and the efficient ones have varying levels of efficiency, there arises then the need to measure efficiency. The techniques for measuring efficiency are referred as frontier techniques. Thus, two main approaches can be used to estimate efficiency in a production process: the non-parametric approach and the parametric approach. The non-parametric approach use the Data Envelopment Analysis (DEA) based on linear programming and consists of estimating a production frontier through a convex curve formed by the line segments joining observed efficient production (Charnes *et al.*, 1978). The main advantage of this technique in the estimation of technical efficiency is that it does not require prices neither for the outputs nor for the inputs. One of the main disadvantages of the non-parametric approach is the absence of accommodation of random shocks or measurement errors in the estimation of efficiency. However, DEA is deterministic and attributes all deviation from the frontier to inefficiency. To measure efficiency using parametric approach, we impose a functional form on the production function between deterministic and stochastic frontiers. Deterministic frontiers assume that all the deviations from the frontiers are result of farm's inefficiency, while stochastic frontiers decompose deviations into random components reflecting measurement error and statistical noise and a component reflecting farm specific inefficiency (Coelli *et al.*, 1998). The study was conducted in Oyo State, Nigeria. Primary data were collected with the aid of a well-structured questionnaire. One hundred and twenty (120) yam farmers were randomly selected from areas of intensive yam cultivation that were earlier purposively selected. Baseline information on socio-economic characteristics, input use and output levels as well as their unit prices were collected and analysed. Descriptive statistics were used to explore the socio-economic characteristics and input used of the respondents. Stochastic frontier production function was used to measure economic efficiency.

The stochastic production frontier model used for analysis is of the form

$$Q_i = f(Xi; \beta)\, e^{\varepsilon} \quad (1)$$

where

Q_i = output of the ith farmer (obtained using gross margin)
Xi = vector of inputs
β = vector of parameters to be estimated
ε= stochastic disturbance term consisting of two independent elements U and V

$$\varepsilon = U+V \quad (2)$$

V is a symmetric random error that is assumed to account for measurement error and other factors not under the control of the farmer e.g. weather and luck (Thanda and Mathias, 1998), while U reflects the technical inefficiency i.e. what is left for the farmer to reach the outer bound production function or the frontier.

The empirical stochastic frontier production model that was applied to the analysis of data is specified as follows

$$\text{In } Q_i = \beta_0 + \beta_1 \text{ In } x_1 + \beta_2 \text{ in } x_2 + \beta_3 \text{ In } x_3 + \beta_4 \text{ In } x_4 + \beta_5 \text{ In } x_5 + v_i - u_i \quad (3)$$

where subscript i refers to the ith farmers.

Q_i = is the farm gross margin. Hence the measure of efficiency is economic efficiency (this is done because of the difficulty of getting the output of the farmers in kilograms). This is consistent with earlier work of Coelli and Battese (1996) and Awoniyi and Omonona (2006) that investigate productive efficiency in yam based enterprise using two production systems. Their study found the efficiency index from the two systems to be similar (0.8 and 0.79) with yam set overused. Our study goes further to look at the sources of this efficiency differential that was overlooked by Awoniyi and Omonona (2006)

X_1 = farm size (hectares)
X_2 = family labour used in man-days
X_3 = hired labour used (₦)
X_4 = yam set (₦)
X_5 = cost of equipment (₦)
V_i = is a two-sided, normally distributed random error
U_i = is a one-sided efficiency component with a half normal distribution where μ_i is defined by

$$\mu_i = \delta_0 + \sum_{i=1}^{n} \delta_i z_i \quad (4)$$

where

Z_1 = farming experience in yam production
Z_2 = years of formal education
Z_3 = amount of credit available to the farmer
Z_4 = crop diversification variable (number of other crops grown)
Z_5 = number of extension visits in the cropping season.
δ_0 and δ_i are parameters to be estimated (i = 1, 2, ... , 5)

The parameters of the stochastic frontier functions were estimated by the method of maximum likelihood using the computer program FRONTIER version 4.1 (Coelli, 1994).

Results and discussion

Summary Statistics

The summary statistics of variables for the production frontier estimation is presented in Table 1. It was revealed that the average gross margin was ₦88,044.38 k with a standard deviation of ₦50,252.23 k. The large variability by the standard deviation implied that the farmers operated at different levels of farm size that tends to affect their output levels. The mean farm size was 0.47 ha with a standard deviation of 0.22 ha. The variability was due to change in hectares of yam under the production seasons. The mean farm size of 0.47 ha implied that yam producers were small-scale farmers. The mean family labour used was 61.58 man-days with a standard deviation of 16.84 man-days. This is an indication that yam production is labour intensive exercise considering the large variability recorded. The average cost of yam set planted was ₦23,767.50 k with a standard deviation of ₦24,397.38 k indicating a large variability in the yam set usage among the farmers. The average farming experience was 25.0 years with a standard deviation of 11.03 years. This implies that farming experience varied significantly among the farmers. The average years of education was 8.74 years with standard deviation of 3.82 years showing low literacy level of the respondents.

Estimates of the parameters of the production function.

The estimated parameters and related statistical test result obtained from the analysis were presented in Table 2. All the coefficients except that of equipment in the model have the expected a priori signs and they were mainly significant. There was a positive relationship between farm size and gross margin.

Table 1. Summary statistics of socio-economic characteristics of yam producers

Variable	Mean	SD	Min	Max
Gross margin (Nara)	88,044.38	50,252.24	2,700	197,900
Farm size (Ha)	0.47	0.22	0.1	0.8
Family labour (Man-days)	61.58	16.84	32	122
Hired labour (Naira)	13,871.88	6,085.21	1,000	27,000
Yam set (₦)	23,767.50	24,397.38	2,300	221,600
Farming experience (years)	25.09	11.03	2	45
Education (years)	8.74	3.82	6	18
Credit (Naira)	33,887.50	15,482.94	20,000	80,000
Extension (number)	2.65	0.99	1	4

Source: Field Survey data.

Table 2. Maximum likelihood estimates of the parameters of the stochastic production function

Variable	Parameter	Coefficient	t-value
General model			
Constant	β_0	5.42	5.95
Farm size	β_1	0.13	7.61***
Family labour	β_2	0.17	0.65
Hired labour	β_3	0.98	5.39***
Yam set	β_4	0.01	1.85**
Equipment	β_5	-0.38	-3.24***
Inefficiency model			
Constant	δ_0	1.08	1.02
Farming experience	δ_1	0.12	2.66***
Education	δ_2	0.01	0.08
Credit	δ_3	-0.03	-0.05
Diversification	δ_4	0.56	1.90**
Extension	δ_5	0.65	1.764**
Variance parameter			
Sigma-Squared	σ^2	4.38	4.33***
Gamma	γ	0.96	9.37***
Likelihood function		-96.33	
RTS		0.82	

Source: computed from Field survey data; *** Significant at the 0.01 level, ** at the 0.1 level

The magnitude of this coefficient was 0.13. This showed that the gross margin in the yam enterprise is inelastic to changes in the level of cultivated land area. The coefficient was significant at 0.01 levels. Land (farm size) was therefore a significant factor associated with changes in the gross margin in yam production.

The estimated coefficient for hired labour was positive and statistically significant at the 0.01 level. Yam production was labour intensive from cultivation to harvesting. Thus the 0.89 elasticity of labour with respect to gross margin implied that a 1% increase in labour, *ceteris paribus* will lead to an increase of 0.89% in the farm gross margin and vice versa. The elasticity of labour was a positive decreasing function to the gross margin indicating optimum use and in stage II of the production region.

The elasticity of output with respect to yam set was positive and statistically significant at the 0.18 level. Hence, an increase in the quantity of yam set planted leads to an increase in gross margin. This study was not in line with earlier findings by Awoniyi and Omonona (2006) who reported a negative and insignificant relationship between yam set and gross margin in Ekiti State.

Sources of inefficiency

The sources of inefficiency were examined by using the estimated δ-coefficient associated with the inefficiency effects in Table 3. The inefficiency effects were specified as those relating to farming experience, education, credit, diversification and extension contact.

Three of the five variables were statistically significant at different levels. The estimated coefficient of farming experience is positive and statistically significant at the 0.01 level. This indicated that farmers with more years of farming experience were relatively more economically efficient in yam production as the coefficient suggests a positive relationship between experience and the gross margin, and vice versa. This finding agrees with Ike and Inoni (2006).

The coefficient of crop diversification variable was positive and statistically significant at the 0.1 level. As diversification increases as a result of farmers growing more crops, economic efficiency increases. The implication was that greater diversification was associated with higher relative efficiency in yam production.

Contact with extension agents had a positive effect on inefficiency. The result was statistically significant at the 0.1 level. This implies that increase in number of extension visits leads to an increase in economic efficiency of the farmers. This finding differs from earlier findings of Ike and Inoni (2006) that found a negative relationship between revenue and extension contact.

Variance parameter

The estimated sigma-squared for yam production was 4.38 and statistically different from zero at the 0.01 level. This indicated a good fit and the correctness of the specified distributional assumption of the composite error term. This suggests that the conventional production function was not an adequate representation of the data. Also the magnitude of the variance ratio (γ) estimated at 0.96 was high suggesting that systematic influence that was unexplained by the production function was the dominant source of errors. This means that 96% of the variance in gross margin among the farms was due to differences in economic efficiency.

Table 3. Efficiency distribution of yam producers

Efficiency level	Frequency	Percentage
<0.5	39	32.5
0.5 – 0.59	3	2.5
0.6 – 0.69	32	26.7
0.7 – 0.79	28	23.3
0.8 – 0.89	18	15.0
Mean	0.594	
Minimum	0.0094	
Maximum	0.876	

Source: Field survey data.

Efficiency estimates of the farmers

Given the specification of the Cobb-Douglas frontier production function in equation 3 and 4, the economic efficiencies of yam farmers in Oyo State were calculated. The result indicated that economic efficiency (EE) indices ranged from 0.0094 to 0.876 with a mean of 0.594. The low mean economic efficiency was an indication of inefficiency in resource use by yam farmers in the study area. It also means that for an average efficient farmer to reach the economic efficiency level of his most efficient counterpart, he could experience about (1-0.594/0.876) saving in cost or increase in production. This gave about 32.2% increase in production or cost savings. The least efficient farmer can now save a cost or increase in production of 98.9% (1-0.0094/0.876) to achieve the required economic efficiency of the most efficient farmer in the study area. Also there exists a gap between the efficiency of best economically efficiency and that of average farmer. This type of wide variation in farmer specific efficiency levels was a common phenomenon in developing countries (Amaza, 2000).

Conclusion

Stochastic frontier production function was estimated for yam production in Oyo State of Nigeria with farm size, family labour, hired labour, yam set and equipment as explanatory variables. Farm size, hired labour, yam set and equipment however found to be the significant factors that influence yam output.

In the inefficiency model, the coefficient of farming experience, diversification and extension were found to significantly account for the observed variation in efficiency level among yam producers in Oyo State of Nigeria.

The implication of the study therefore was that the level of efficiency among yam producers in Nigeria could be increased by 40.6% through better utilization of available resources, given the current state of technology.

References

Akoroda, M.O. and Hahn, S.K. (1995): "Yams in Nigeria-Status and Trend". African Journal of Roots and Tuber Crops 1 (1): 38-41

Ajayi, O.A (2008): Economic Efficiency of Yam Production in Surulere Local Government Area of Oyo State. An unpublished B.Tech Project, Department of Agricultural Economic and Extension. Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria.

Amaza, P.S (2000): Resource-use Efficiency in Food Crop Production in Gombe State, Nigeria. An unpublished Ph.D. Thesis. University of Ibadan, Ibadan, Nigeria.

Awoniyi, O.A and Omonona, B.T (2006): "Production Efficiency in Yam based Enterprises in Ekiti State, Nigeria". Journal of Central European Agriculture, 7 (4): 627-636.

Babaleye, T. (2003): West Africa; "Improving Yam Production Technology". ANB-BIA Supplement Issue/Edition Nr 463-2003.

Charnes, E.W; Cooper, W. and Rhodes E., (1978): "Measuring the Efficiency of Decision Making Units". European Journal of Operational Research, 2, 429-444.

Coelli, T.J. (1994): "A Guide to Frontier version 4.1: A computer program for stochastic Frontier Production Function and cost function Estimation", Unpublished paper, Department of Econometrics, University of New England Armidale, pp. 32.

Coelli, T.J and Battese, G.E (1996): "Identification of Factors which Influence the Technical Inefficiency of Indian Farmers". American Journal of Agricultural Economics, 40 (2): 103-128.

Coelli T., Prasada - rao, D.S. and Battese, G.E, (1998):"An Introduction to Efficiency and Productivity Analysis", Kluwer Academic Publishers.

Eka, O.U(1985): The Chemical Composition of Yam Tubers, in:Osuji,G(ed), Advances in Yam Research, Frontline Publishers, Enugu-Nigeria, pp61-83

Farrell, M.J. (1957): "The measurement of Productive Efficiency". Journal of Royal Statistic Society 120: 253-81.

Food-Info (2008): Yams.www.mft.wur.nl/uk/vageningen+city+of+food.

IITA (1997): Annual Report, International Institute for Tropical Agriculture. Ibadan.

IITA (2007): Root and Tuber System: Yam. International Institute for Tropical Agriculture. Ibadan.

Ike, P.C. and Inoni, O.E (2006): "Determinations of Yam Production and Economic Efficiency among Small holder Farmers in South-Eastern Nigeria". Journal of Central European Agriculture 7 (2): 337-342.

Leibenstein, H. (1996): "Allocative efficiency vs. X-efficiency". American Economic Review, 56(3): 392-415.

Lovell, C.A.K., (1993): Production frontiers and productive efficiency, in the measurement of productive efficiency techniques and applications, edited by Harold O. Fried, C.A. Knox Lovell, shelton S. Schmidt. New York, Oxford University Press, pp. 3-67.

Lund, P.J. and Hill, P.G. (1979): "Farm Size, Efficiency and Economies of Size". Journal of Agricultural Economics. 30(2): 145-147.

Njeru, J.(2004): Factors Influecing Technical Efficiency in Wheat Production in Kenya. New Research Proposal submitted to African Economic Reseach Consortium.

Thanda Kyi and Mathias Von Oppen (1998): An Economic Analysis of Rice Farmers at Delta Region in Myanmar. IRRI.

acs77_40