MARGINAL PRODUCTIVITY OF SMALL SCALE YAM AND CASSAVA FARMERS IN KOGI STATE, NIGERIA: DATA ENVELOPMENT ANALYSIS AS A COMPLEMENT.

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ABSTRACT

The study examined marginal productivity analysis of small scale of yam and cassava farmers in Kogi State, Nigeria. Data used for the study were obtained from primary source using a multi-stage sampling technique with structured questionnaires administered to 150 randomly selected yam and cassava farmers from three Local Government Areas of the State. Descriptive statistics, data envelopment analysis and Cobb- Douglas production function were used to analyze the data. The DEA result on the overall technical efficiency of the farmers showed that 40% of the sampled yam and cassava farmers in the study area were operating at frontier and optimum level of production with mean technical efficiency of 1.00. This implies that 60% of the yam and cassava farmers in the study area can still improve on their level of efficiency through better utilization of available resources, given the current state of technology. The results of the Cobb-Douglas analysis of factors affecting the output of yam and cassava farmers showed that labour, planting materials, fertilizer and capital inputs positively and significantly affected the output of the yam and cassava farmers in the study area. The study further revealed that yam and cassava farms in the study area operated under increasing returns to scale. This result of marginal productivity analysis further showed that relatively efficient farms were more marginally productive in resource utilization. It is therefore recommended that yam and cassava farmers in the study area should form cooperative societies so as to enable them have access to productive inputs that will enable them expand. Also, since using a single equation model for production function produces a bias parameter estimates as confirmed from the study, farms should therefore be decomposed into efficient and inefficient ones before production function estimation is done.

Keywords: Marginal productivity, DEA, yam and cassava production

INTRODUCTION

Yam and cassava belong to the class of foods that basically provide energy in the human diet in the form of carbohydrates. These crops refer to plants that store edible material in subterranean root, corm or tuber (FAO, 1990). Yam and cassava are important, not only as food crops but even more as major sources of income for rural households. Their use in some industries as livestock feed is well known but is gradually increasing. They have become prominent in the industrial sector of the economy. Cassava food products followed by yams are the most important staples of rural and urban households in Nigeria both in terms of food and cash income generation (Chukwuji *et al*., (2007). Famine rarely occurs in a community where cassava is widely grown, because in some places they are harvested continuously through out the year, thus tidying farmers over hungry seasons after other crops have been planted but are not yet mature (IITA, 1990, Nweke, 1997 and Kathundu and Chiwona-Karltun, 2001). Cassava appeals to low income households because it offers the cheapest source of food calories. Compared with grains, fresh and dried cassava roots are very cheap sources of calories.

Agricultural production in Nigeria according to Oladele *et al*., (2008) is largely in the hand of peasants' farmers and the characteristics of these peasant farmers predispose them to low productivity. However, yam and cassava farms just like the other crop farms in Nigeria are the small-scale types which are characterized by very low productivity. The crucial issue in the Nigerian agriculture is that of low productivity. The problem of declining crop productivity in Nigeria is important. Despite all human and material resources devoted to agriculture, the productive efficiency for most crops still fall under 60 percent (FDA, 1995). Farmers output must therefore be expanded with existing levels of conventional inputs and technology. More than ever, farmers will have to produce more efficiently. Expected increases in the demand for yam and cassava occasioned by population growth and declining per-capita incomes will require continued increase in yam and cassava farms productivity. Ogundari and Ojo (2006) concluded that the profit of the cassava farmers in Nigeria could be increased by 19% through improved efficiency, which is positively related with education and extension services. Hence, the role of increased efficiency and productivity of yam and cassava farms is no longer debatable but a great necessity in order to increase the efficiency of small holder farms in Nigeria, since cassava and yam have the potential for bridging the food gap. It is to this end that this study was undertaken with the view to analyze the marginal productivity of small scale yam and cassava farmers in Kogi State, Nigeria.

Analytical Framework

The terms productivity and efficiency are often used interchangeably but these are not precisely the same things. Productivity is an absolute concept and is measured by the ratio of outputs to inputs while efficiency is a relative concept and is measured by comparing the actual ratio of outputs to inputs with the optimal ratio of outputs to inputs. Productivity could be measured in terms of marginal physical product (MPP) in which case, the interest is in the addition to total product resulting exclusively from a unit increase in the use of that input i.e., total factor productivity (TFP) growth, which is measured using the frontier and non-frontier approaches. Parametric approaches have been extensively used to estimate input-output relationships in a firm or in an industry in order to study the efficiency of resource allocation. The most celebrated of them is the Cobb-Douglas production function. The Cobb-Douglas function has been widely used in the early stages of empirical applications of production theory. However, this particular form has been unduly restrictive (Theodoridis *et al.,* 2006). To render a model operational and to limit the restrictive properties imposed on the production process, the translog production function is chosen very often and tested against the restricted Cobb-Douglas functional form. The estimation of translog functions has been extensively used for the flexibility it provides. When a single equation model is estimated by using the Cobb-Douglas production function or a more flexible one like translog production function, one of the basic assumptions is that all farms are operating at technically efficient level. However, not all farms are technically efficient.

Production is possible with a variety of factor proportions and production technologies. Where there are several production techniques, it is possible that the partial production elasticities (the estimated parameters of the function) will differ significantly among the different techniques. Consequently, valuable information has been lost. A common method used to assess these differences is dividing the sample into groups on the basis of some predetermined criteria. It is the alternative of categorizing the sample of farms by different production techniques. The same concept is also applied in this paper. However, in this study relative technical efficiency is the classification criterion using Data Envelopment Analysis (DEA).

The key construct of a DEA model is the envelopment surface and the efficient projection path to the envelopment surface (Charnes *et al*., 1978). The envelopment surface will differ depending on the scale assumptions that underline the model. The efficiency projection path to the envelopment/surface will differ depending on if the model is output-oriented or input oriented. The choice of model depends upon optimization production process characterizing the firm. Input oriented DEA determines how much the mix for a firm would have to change to achieve the output level that coincides with the best practice frontier. Output-oriented DEA is used to determine a firm's potential output given its inputs mix if operated as efficiently as firms along the best practice frontier. For this study input-oriented DEA was used to determine how much input mix the farmers would have to change to achieve the output level that coincides with the best practice frontier. For this study, technical efficiency was used to estimate the resource productivity of the farmers in the study area. Measurement of technical efficiency is important because it is a success indicator of performance measure by which production units are evaluated (Ajibefun, 2008).

DEA is a relative measure of efficiency where the general problem is given as:

$$\text{Max TE} = \frac{\sum_{r=1}^{s} \alpha_r Y_{ro}}{\sum_{r=1}^{m} \beta_i X_{i0}} = \frac{q}{q^*} \qquad (1)$$

Subject to :

$$\frac{\sum_{r=1}^{s} \alpha_r Y_{rj}}{\sum_{r=1}^{m} \beta_i X_{ij}} \leq 1,\ j = 1, \ldots\ldots, n \qquad (2)$$

$\alpha_r, \beta_i \geq 0$; r = 1, -----, s; i = 1, …., m

Where X_{ij} and Y_{ij} respectively are quantities of the i^{th} input and *rth* output of the j^{th} firm and α_r, $\beta_i \geq 0$ are the variable weights to be determined by the solution to this problem.

METHODOLOGY

Study Area: This study was carried out in Kogi State. The State lies between latitudes $6^0 33'$N and $8^0\ 44'$N and longitude $5^0\ 40'$E and $7^0\ 49'$E with an average maximum temperature of 33.2^0C and an average minimum temperature of 22.8^0C. The State has two distinct weathers; dry season which lasts from November to February and rain season that last from March to October. Annual rainfall ranges from 1016mm to 1524mm. The vegetation of the State consists of mixed leguminous (guinea) woodland to forest savannah. The State is blessed with suitable ecological and climatic conditions. It is therefore, possible to produce various agricultural products like palm produce, yam, cassava, millet, rice, cowpea, cocoa, coffee and cashew (Wikipedia, 2012).

Sampling technique and sample size

The data mainly from primary sources were collected using a multi-stage sampling technique. The first stage involved the random selection of 3 Local Government Areas (LGAs) in the State which include Mopamuro, Kabba/Bunu and Ijumu LGAs. The second stage involved a simple random selection of five villages in each LGA and ten yam and cassava farmers in each village totalling 150 farmers sampled for this study.

Method of data collection

A limited cost-route approach method was used in data collection for this study. The data were collected with the use of structured questionnaire designed in line with the objectives of the study. Data collected included total output produced per annum in tonnes, while the inputs included the size of farm land in hectare, quantity of seeds as planting materials in kg; quantity of fertilizer used in kg; quantity of herbicides used in litres and total labour in man-days which include family and hired labour utilised pre and post planting operations and harvesting; prices of yam and cassava in naira; total production cost per year; average wage rate per man days of labour, price per kg of planting materials, average price of agrochemicals, average price of fertilizer and average price of farm tools. Also, data collected include the farmer's socio-economic variables such as farmer's age, years of schooling, household size, number of contact with extension agents, accessibility to credit etc.

Empirical Model specification

The output variable used for estimating efficiency scores was total farm output (tons) (Y). Total farm output included outputs of yam and cassava in tons which were aggregated using wheat grain equivalent table. The inputs used included farm size (ha), labour (man-day), planting materials (kg) agrochemical (herbicides and pesticides) (₦), fertilizer (kg) and capital Input (₦). The aim of this study is not just to estimate the efficiency score of the decision making units (DMUs), but to classify the respondents into efficient and inefficient farmers, and also to determine the marginal productivity of the farmers. Based on this, a non-parametric analysis (DEA) was used to classify the farmers to categories. The ordinary least square regression analysis (Cobb-Douglas production function) was further applied to determine the factors affecting the output of each category of the farmers and their marginal productivity.

RESULTS AND DISCUSSION

The summary DEA result on the classification of the farmers into efficient and inefficient farmers is shown in Table 1. The result shows that 40% of the sampled yam and cassava farmers in the study area were operating at frontier and optimum level of production with mean technical efficiency of 1.00. This shows that 60% of the farmers in the study area can still improve on their level of efficiency through better utilization of available resources, given the current state of technology.

Table1: DEA Summary results

Models	Sample (Number of farms)	Percentage	Mean Technical Efficiency
Model I	150	100.0	0.8707
Model II	90	60.0	0.8698
Model III	60	40.0	1.0000

Source: Data Analysis, 2013

Production analysis: The results of production analysis of the factors affecting output of the efficient and inefficient yam and cassava farmers are presented in Table 2. The size of the coefficients of multiple determinations suggests that the major part of the interfarm variation in output is explained by the observed inputs (0.4189 in the first case, 0.5807 in the second case and 0.6371 in the third case). The results showed that labour, planting materials, fertilizer and capital inputs positively and significantly affected the output of the yam and cassava farmers in the study area. This implies that a unit increase in each of these variables will lead to increase in the yam and cassava output in the study area. Under perfect competition, the sum of Cobb-Douglas regression coefficients measures returns to scale (Theodoridis *et al.*, 2006). In the result, in the three cases the sum of regression coefficients is greater than one (1.3358 in the first case, 1.6575 in the second case and 1.1714 in the third case). This means that the farms operated under increasing returns to scale. This is an expected result since there are *a priori* theoretical reasons to believe that variable returns to scale will prevail.

Table 2: Factors affecting output of the yam and cassava efficient and inefficient farmers in Kogi State using Cobb-Douglas production function

	All farms (N = 150)	Inefficient farms (N = 90)	Efficient farms (N = 60)
Variables	Coefficients & T values	Coefficients & T values	Coefficients & T values
Constant	-6.8545 (-6.2714)***	-9.7106 (-8.9676)***	-8.6387 (-6.1327)***
Farm Size (ha)	-0.0536 (-0.6582)	-0.1553 (-2.1043)**	0.1041 (1.1048)
Labour (manday)	0.7908 (8.2785)***	1.0490 (8.9253)***	0.7898 (6.5065)***
Planting material (kg)	0.1257 (3.4027)***	0.1795 (4.2777)***	0.0934 2.5725***
Agrochemical (₦)	0.0430 (0.6361)	0.0911 (1.4579)	0.1731 (1.7993)*
Fertilizer (kg)	0.1586 (1.7201)**	0.0621 (0.5990)**	0.2348 2.7946***
Capital Inputs	0.2714 (2.7036)***	0.4311 (4.2923)***	0.3662 (3.2596)***
R^2	0.4189	0.5807	0.6371
Adjusted R^2	0.3945	0.5504	0.5960
F-Ratio	17.18***	19.16***	15.51***
Return to scale (RTS)	1.3358	1.6575	1.1714

Numbers in parenthesis are t values
*** = Significant at 1% level of probability, ** = Significant at 5% level of probability * = Significant at 10% level of probability.
Source: Field Data Analysis, 2013

Marginal productivities of the inputs

The sample means of the variables, and the marginal productivities of the production inputs are presented in Table 3. The sample means of the independent variables were computed for 1000kg of output for a comparison between the different cases. The result shows that farms that were relatively efficient (farms in third model) utilized inputs in a more productive sense than inefficient farms in the model II. In model III all inputs, apart from planting material (which is considered negligible), decreased in order to produce the same level of output meaning that fewer inputs are demanded for the production of the same output, thereby releasing resources for other economic activities.

The marginal products of the production inputs in the models came out in the expected way i.e. for decreasing inputs the marginal products increased and vice versa. This result shows that efficient farms in model III were more marginally productive in resource utilization. This also shows that estimating production functions without separating the farms to efficient and inefficient farms bias the parameter values obtained from such production function. This was also confirmed by Doran, (1985), Sharma, (1983) and Theodoridis *et al., (*2006).

Table 3. Marginal products of production factors used

Sample Means	Model I (n = 150)	Model II (n = 90)	Model III (n = 60)
Output (kg)	1000.00	1000.00	1000.00
Farm Size (ha)	2.42	3.64	2.10
Labour (manday)	135.91	173.84	130.64
Planting material (kg)	2080.81	2167.73	2245.79
Agrochemical (₦)	8978.13	10568.88	6657.21
Fertilizer (kg)	253.35	258.43	245.93
Capital Inputs	2520.36	2833.18	2355.76
Marginal Products			
Farm Size (ha)	22.17	42.71	49.61
Labour (manday)	5.82	6.03	6.05
Planting material (kg)	0.06	0.08	0.04
Agrochemical (₦)	0.00	0.01	0.03
Fertilizer (kg)	0.63	0.24	0.95
Capital Inputs	0.11	0.15	0.16

Source: Data Analysis, 2013

CONCLUSION AND RECOMMENDATIONS

The empirical study is on marginal productivity of small scale yam and cassava farmers in Kogi State, Nigeria. . The DEA result on the classification of the farmers into efficient and inefficient farmers showed that that 40% of the sampled yam and cassava farmers in the study area were operating at frontier and optimum level of production with mean technical efficiency of 1.00. This shows that 60% of the farmers in the study area can still improve on their level of efficiency through better utilization of available resources, given the current state of technology. The results of the Cobb-Douglas analysis of factors affecting the output of yam and cassava farmers showed that labour, planting materials, fertilizer and capital inputs positively and significantly affected the output of the yam and cassava farmers in the study area. The findings also indicated that yam and cassava farms in the study area operated under increasing returns to scale. This result of marginal productivity analysis further showed that relatively efficient farms in model III were more marginally productive in resource utilization. In view of the findings, it therefore recommended that yam and cassava farmers in the study area should form cooperative societies so as to enable them have access to productive inputs that will enable them expand. Also, since using a single equation model for production function produces a bias parameter estimates as confirmed earlier, it is therefore recommended that farms should be separated into efficient and inefficient ones before production function estimation is done

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