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Full Length Research Paper

Technical efficiency of cocoa farms in Cross River State, Nigeria

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This study was carried out to evaluate the technical efficiency of cocoa farms in Cross River State, Nigeria. Multi stage sampling technique was used to select four local government areas (LGAs) and fifteen cocoa farmers per LGA, to give a total of sixty farmers. The sampled LGAs constitute about 30% of the local government areas in the State. Data collection was carried out with the aid of a structured and pre-tested questionnaire by trained enumerators in 2009. Data collected include socio-economic characteristics of the sampled households, cocoa farm assets, production practices and costs. Farm visits were undertaken and the area of each cocoa field was measured with GPS. Data were analysed using data envelopment analysis (DEA). Results showed that 17.02% of the cocoa farms were technically efficient based on constant return to scale technical efficiency, while 68.09% were technically efficient based on variable return to scale technical efficiency. About 21.28% of the cocoa farms were scale efficient. The DEA output revealed that 17.02% of the sampled cocoa farms were both technically and scale efficient and were hence operating at the most productive scale size. About 57.45% of the cocoa farms were operating at sub-optimal condition. The technically inefficient farms should emulate the operating practices of the most productive farms, so as to improve their performance.

Key words: Cocoa farm, technical efficiency, data envelopment analysis, Nigeria.

INTRODUCTION

Agriculture occupies a prominent place in the economy of Nigeria. The sector accounts for about 35% of the Gross Domestic Product (GDP) and employs about two-third of the labour force (CBN, 1994; Mesike et al., 2009). Up to 1960, tree crops, notably cocoa, oil palm and rubber, have largely led agricultural export in Nigeria, and cocoa still continues in this role. Cocoa is the single agricultural export commodity that has earned foreign exchange more than other crops, offers employment to many people, both directly and indirectly, and serves as an important source of raw materials, and source of revenue to governments of cocoa producing states (Folayan et al., 2006; Nkang et al., 2009). However, the performance of Nigeria's cocoa economy has not been as good, as it was in the past (Mafimisebi et al., 2008). In the international cocoa market, Nigeria's cocoa export now ranks fourth after Cote d'Ivoire, Ghana and Cameroun. Studies have identified different reasons accounting for this decline. The use of a combination of resources on farms affects both the technical and scale efficiencies of production. These invariably affect the crop's productivity and the income generating potentials of farmers (Folayan, 2006). These raises some research questions of concern:

What are the technical and scale efficiencies of cocoa farms in Cross River State? Which is the most technically and scale efficient cocoa farm that could be emulated? At what input level should inefficient farms strive to attain if they are to be technically efficient?

Providing answers to these questions will help to improve the efficiency of cocoa farms for increased production. This paper therefore investigated the technical efficiency of cocoa farms in Cross River State by estimating the technical and scale efficiencies of cocoa farms; determining the optimal cocoa producing farm; and estimating the target input level for efficient production.

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MATERIALS AND METHODS

Study area

The study was conducted among cocoa farmers in Cross River State, Nigeria. The State is located in the south-south of Nigeria, and it is the second largest producer of cocoa in the country (MANR, 2006). . The climate of the state is highly favourable for the agrarian activities of its teeming population who grow crops such as cocoa, oil palm and arable crops like maize and cassava. The vast majority of the population consists of peasant farmers cultivating food and cash crops at a small-scale level. Livestock keeping is a minor occupation of the population of Cross River State dealing on goats, sheep, rabbits and fish farming. Other activities include trading and civil service (MANR, 2006).

Sampling procedure and data collection methods

A multistage sampling technique was used to select respondents for the study. The first stage involved a purposive selection of four local government areas based on the population of cocoa farmers in the States. The second stage involved purposive selection of major cocoa growing communities while the last stage was a simple random selection of fifteen cocoa farmers from a list of cocoa farmers in each community. Data collection was carried out with the aid of a structured and pre-tested questionnaire by trained enumerators. The enumerators used the questionnaire to collect information on socio-economic characteristics of the sampled households, cocoa farm assets, production practices and costs, among others. Farm visits were also carried out to all the cocoa fields of the farmer respondents. The area of each of the cocoa fields was measured with hand-held geographic positioning system (GPS) in order to ascertain the correct areas of the fields.

Data analysis

Descriptive statistics (measures of central tendency and dispersion) were used to analyze variables used in the efficiency analysis. Data envelopment analysis (DEA) was used to obtain efficiency scores for the sampled cocoa farms (Coelli, 1996).

DEA, introduced by Charnes et al. (1978), is a linear programming method for calculating the relative efficiencies of a set of organizations that possess some common functional traits but whose efficiency may vary due to internal differences such as management style. It is an empirical methodology that eliminates the needs for some of the assumptions and limitations of traditional efficiency measurement approaches (Bowlin, 1998). DEA is commonly used to evaluate the efficiency of a number of producers. It is an extreme point method that compares each producer with only the "best" producers. A fundamental assumption behind DEA is that if a given producer A is capable of producing Y (A) unit of output with X (A) inputs, then other producers should be able to do the same if they are to operate efficiently. In the same vein, if producer B is capable of producing Y (B) unit of output with X (B) inputs then other producers should also be capable of the same production schedule.

In this study, DEA was used to assess each cocoa farm by measuring its comparative or relative efficiency with respect to the entire sampled cocoa farms being evaluated, taking into account all input and output factors at the same time rather than one output to one input at a time. It can be used to identify the best performance in the use of resources among a group of similar organizations (Abbott and Doucoulaigos, 2003). Different analysis options are available in DEA. Input minimization (or input orientation) instructs DEA to reduce the inputs as much as possible without dropping the output levels. Alternatively, when focus is on raising performance without increasing the resource base, output maximization (output orientation) could be specified. Under this specification outputs are raised without increasing the inputs. The choice of the appropriate orientation is not as crucial as it is in the econometric estimation of efficiency and, in many instances; the choice of orientation will have only minor influences upon the scores obtained (Coelli, 1996, 1997).

The use of DEA which assesses the efficiency of farms relative to each other will yield a more practical efficiency measure as well as provide information on how efficiency can be improved by inefficient cocoa farms.

Model specification

Mathematical development of DEA can be traced to Charnes and Cooper (1978) who introduced their basic CCR model (Charnes-Cooper-Rhodes model) based on the works of Farrell (1957) and others. Banker et al. (1984) modified this model to account for variable returns to scale conditions, by adding a convexity constraint and introduced their BCC model (Banker-Charnes-Cooper model). A group of similar organizations refers to a set of homogenous units known as decision making units (DMUs). An input-oriented BCC model is given for N decision making units, each producing M outputs by using K different inputs (Coelli et al., 1998):

$$\min_{\Theta,\lambda} \Theta$$

Subject to:

$$-y_i + Y\lambda \geq 0$$
$$\Theta x_i - X\lambda \geq 0$$
$$N1'\lambda = 1$$
$$\lambda \geq 0$$

Where; Θ is a scalar,

$N1'\lambda = 1$ is the convexity constraint,
$N1$ is N x 1 vector of constants,
y_i is output vector of the i^{th} DMU,
x_i is input vector of the i^{th} DMU,
Y represents output matrix,
X represents input matrix.

The value of Θ is the efficiency score for the i-th firm. This linear programming problem must be solved N times, once for each firm in the sample. A value of one (1) indicates that the firm is technically efficient according to the Farrell (1957) definition. According to a strict efficiency definition known as Koopmans (1951) criteria, a firm is only technically efficient if it operates on the frontier and furthermore, all associated slacks are zero. Original DEA specification has been extended in several ways and multi-stage models were developed in order to meet more strict Koopmans criteria, to identify the nearest efficient points, and to make the model invariant to units of measurements. Coelli (1996, 1997) developed such a multi-stage methodology and a computer program which implements a robust multi-stage model among other options.

A ratio of technical efficiency scores obtained from DEA under the constant return to scale (CRS) and variable return to scale (VRS) assumptions measures the scale efficiency (SE). This scale efficiency measure can be interpreted as the ratio of average product of a firm operating at a point to the average product of another firm operating at a point of technically optimal scale. A value of scale efficiency equal to one (1) implies that the farm is scale efficient and a value less than one (< 1) suggests the farm is scale inefficient. A farm operating under decreasing returns to scale conditions means that it is operating under super-optimal

Table 1. Summary statistics for variables used in the efficiency analysis.

Variable		
Age of cocoa farmer (Years)	Mean	48.72 (11.73)
Household size	Mean	7.72 (1.64)
Education (Years)	Mean Standard deviation	8.92 4.57
Ownership status	Owner (%) Sharecropper (%)	85 15
Gender	Male (%) Female (%)	96.67 3.33
Marital status	Married Single	91.67 8.33
Yield per hectare	Mean Standard deviation	588.60 314.72
Farm size	Mean Standard deviation	2.98 2.93
Age of farm (years)	Mean Standard deviation	21.82 13.30
Total cost of labour (₦)	Mean Standard deviation	30,979.49 42,606.59
Total distance from house to farm (km)	Mean Standard deviation	18.54 67.53
Cost of fungicide (₦/ha)	Mean Standard deviation	10, 738.84 18, 400.40
Cost of insecticide (₦/ha)	Mean Standard deviation	5, 017.06 13, 713.08

Figures in parentheses () mean standard deviation. Source: Data analysis (2009).

conditions. On the other hand, a farm operating under increasing returns to scale is operating under sub-optimal conditions (Gul et al., 2009).

One output and four inputs were used in this DEA model. The only output is cocoa beans (kg). The inputs included are: land, that is, total farm size (ha) and the costs of hired labour (₦), fungicide (₦) and pesticide (₦). The software DEAP version 2.1 developed by Coelli (1996) was used to estimate DEA scores. Farms' efficiency scores were calculated under the CRS and VRS assumptions.

RESULTS AND DISCUSSION

The summary statistics of variables used in the efficiency

Table 2. Efficiency scores by CRSTE and VRSTE and scale efficiency.

Efficiency scores	Constant return to scale technical efficiency (CRSTE) (%)	Variable return to scale technical efficiency (VRSTE) (%)	Scale efficiency (%)
0.20-0.29	8.51	2.13	4.26
0.30-0.39	17.02	6.38	8.51
0.40-0.49	19.15	0	19.15
0.50-0.59	12.77	8.51	8.51
0.60-0.69	12.77	4.26	6.38
0.70-0.79	2.13	2.13	8.51
0.80-0.89	4.26	2.13	8.51
0.90-0.99	6.38	6.38	14.89
1.00	17.02	68.09	21.28
Mean	0.591	0.876	0.698

Source: Data analysis (2009).

Table 3. Characteristics of farms with respect to returns to scale.

Variable	No of DMUs	Mean			
		Percent	Yield per ha	Farm size (Ha)	Gross margin (₦)
Super optimal	10	21.28	801.69	4.38	536,420.00
Optimal	10	21.28	744.38	3.68	646,369.00
Sub optimal	27	57.45	397.82	2.25	109,354.52

Source: Data analysis (2009).

analysis is presented in Table 1. The mean age of cocoa farmers in the study area was about forty-nine (49) years. This mean age is about six (6) years lower than the average age of a cocoa farmer in Ondo State as revealed in a study by Amos (2007). About 97% of the respondents were male with a mean household size of about 8. Average number of years of formal education among the respondents was 9 years. The mean cocoa output per hectare was 588.60kg, and farm sizes ranged between 0.2 and 14.6 ha with a mean of 2.98 ha. The mean total cost of hired labour was ₦ 30,979.5. The mean cost of fungicide and insecticide used per hectare were ₦10, 738.84 and ₦ 5, 017.06 respectively, while the mean age of cocoa farm was 21.82 years. The mean distance from the farmers' homestead to the farm was 18.54 km. There were few cases of farms being located at very far distances from the homestead.

Table 2 shows the results of the input oriented DEA analysis of the cocoa farms in Cross River State. It revealed that for constant return to scale technical efficiency (CSRTE) about 17.02% of the sampled cocoa farms were technically efficient while the remaining cocoa farms were technically inefficient. Considering the variable return to scale technical efficiency (VRSTE), 68.09% of the cocoa farms were technically efficient and 21.28% scale efficient. The DEA output further revealed that 17.02% of the farms were both technically and scale efficient. This means that cocoa farms in this category were operating at the most productive scale size (MPSS). For the inefficient farms, the causes of the inefficiency may either be that the farms are not taking advantage of the economies of scale (inappropriate scale) or are inefficient in using their farm inputs (misallocation of resources) Since the mean scale efficiency of the sample farms is relatively high (0.698), it could be concluded that inefficiencies are mostly due to improper input use and some level of inappropriate scale.

Table 3 depicts the characteristics of optimal, sub-optimal and super optimal cocoa farms. Majority (57.45%) of the cocoa farms operated under the sub-optimal condition, and super optimum cocoa farms had the highest yield per hectare of about ₦801.7 with the least farm size (4.4 ha).

Table 4 indicates that for cocoa farms 4, 30 and 40 to be efficient, they should emulate the operating practices of farm 3 which is an efficient peer operating at the most productive scale size. This is because farm 3 had the highest peer weight among all the peers in any of the cases. Hence, it is the most suitable farm whose operating practices should be studied by the inefficient farms. For farms 19, 21, 32, 36 and 44 to be efficient, they should emulate the operating practices of farm 35 which is an efficient peer operating at the most productive scale size. Farm 17 should be copied by farms 41 and 22 in order to become efficient. For farms 25, 28, 29, 31, 37, 39 and 43 to become efficient they must emulate the

Table 4. Efficient peers for inefficient farms.

Inefficient farms	Efficient peers	Peer weights	Most suitable efficient peer
4	20	0.03	3
	23	0.36	
	3	0.61	
19	17	0.13	35
	35	0.87	
21	20	0.30	35
	23	0.30	
	35	0.40	
22	17	0.67	17
	20	0.04	
	23	0.29	
25	47	0.71	47
	3	0.09	
	35	0.20	
27	23	0.11	20
	3	0.18	
	20	0.40	
	47	0.31	
28	47	0.82	47
	3	0.18	
29	47	0.76	47
	45	0.10	
	23	0.15	
30	35	0.00	3
	3	0.94	
	47	0.04	
	20	0.02	
31	45	0.17	47
	47	0.42	
	23	0.41	
32	3	0.10	35
	35	0.90	
36	35	0.54	35
	47	0.46	
37	47	0.66	47
	3	0.14	
	35	0.20	
38	1	0.20	20
	20	0.50	
	3	0.30	

Table 4. Contd.

39	3 47	0.09 0.91	47
40	20 3 35 47	0.35 0.38 0.23 0.04	3
41	17 35	0.69 0.31	17
42	47 45 23	0.08 0.56 0.36	45
43	9 35 47	0.04 0.19 0.78	47
44	47 3 35	0.25 0.06 0.70	35

Source: Data analysis (2009).

Table 5. Input slacks and number of farms using excess inputs.

Input	Number of farms	Mean slack	Mean input used
Farm size	19	0.489	3.5
Cost of hired labour (₦)	30	7092.437	26,540.00
Cost of fungicide(N)	26	3831.179	12,865.38
Cost of insecticide(N)	25	3943.585	11,916.00

Source: Data analysis (2009).

operations of farm 47. Farm 20 should be copied by farms 27 and 38, if they are to be efficient. Finally, for farm 42 to be efficient, it can emulate the operational processes of farm 45. The mean input slacks and excess input used are given in Table 5. Since a slack indicates excess of an input, a farm can reduce its expenditure on an input by the amount of slack without reducing its output. The results show that there are opportunities for some of the farms to reduce their expenditures without reducing their outputs. Farm size displayed a mean slack of 0.5 ha among 19 inefficient farms, 30 inefficient farms spent an excess of ₦7092.437 on hired labour, 26 farms spent an excess of ₦3831.18 on fungicide while 25 cocoa farms spent an excess of ₦3943.58 on insecticides. This inefficient spending and over-use of resources may be due to inadequate knowledge of appropriate production practices and non-reliance on prescriptions by extension agents.

CONCLUSIONS AND RECOMMENDATIONS

This study set assessed the technical efficiency of cocoa farms in Cross River State. Technical efficiencies were computed using 2008/2009 cocoa production data from sampled farmers in Cross River State. An input oriented DEA approach was used to generate technical efficiency estimated using DEAP software (Coelli, 1996).

The estimated mean technical efficiency (TE) was 88% which implies that there is a 12% scope for increasing cocoa production by using the existing technology. However, TE ranges between 20 to 100% among the cocoa producers in the sampled area.

Excesses in input utilization were observed in respect of farm size, cost of hired labour, cost of fungicide and cost of insecticide. All these excesses adversely affect technical efficiencies of cocoa farming. Inefficiencies indicate a wrong combination of these inputs. Thus, cocoa producers in the study area must be educated about the use and appropriate combination of these inputs in order to improve their efficiency.

This implies that farmer training programs should be available to all farmers in order to improve their knowledge and hence ensure appropriate combination of inputs. The inefficient farms should be encouraged to emulate the operating practices of the most productive farms so as to improve their productivity.

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