# SCALE EFFICIENCY OF COCOA PRODUCTION IN CROSS RIVER STATE, NIGERIA

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**Abstract:** The paper analyzed the scale efficiency of cocoa production in Cross River State of Nigeria. The data were collected from 180 cocoa farmers using structured questionnaire and personal interview. Data Envelopment Analysis (DEA) model, using the input orientation technique was employed as the analytical tool. The findings reveal that 37 farms, i.e. Decision Making Units (DMUs) representing 20% exhibited full scale efficiency operating under constant returns to scale, 64 Farms (DMUs) 37% operated under decreasing returns to scale and 79 farms (DMUs) 43% operated under increasing returns to scale. It is recommended that government should provide cocoa inputs at subsidized rate to improve the efficiency of the farms production. Also, extension agents are used to educate the farmers on improved technologies to enhance the utilization of inputs for increase scale efficiency.

**Keywords:** Cocoa production, scale efficiency, data envelopment analysis

## 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 government of cocoa producing states (Folayan *et al*., 2006; Nkang *et al.,* 2009). However, the performance of Nigerians cocoa economy has not been as good, as it was in the past (Mafimisebi *et al.,* 2008). Most important producers of cocoa include; Brazil, Dominican Republic, Ecuador, Colombia, Cameron, Code D' Ivoire, Ghana, Nigeria, Indonesia and Malaysia. In the international cocoa market, Nigerian's cocoa export now ranks fourth after Cote d'ivoire, Ghana and Cameroon. Studies have identified different reasons accounting for this decline. The use of a combination of resources on farm affects both the technical and scale efficiency of production. These invariably affect the crop's productivity and the income generating potentials of farmers (Folayan, 2006). Cocoa tree grows wildly in tropical forest within latitude $20^{o}$ of the equator. Cocoa is the main ingredient of chocolate which makes it one of the most important things in the world.

Cocoa tree gives cocoa pods, cocoa pods gives cocoa beans and from cocoa beans we get chocolate and many other cocoa products. A researcher at the cocoa research institute of Ghana has advocated the daily consumption of natural cocoa product without additives such as sugar and milk, saying this reduces the potency of the cocoa. (African World Issued Discussion Forum, 2011). Even though Cocoa diet reduces the risk of heart diseases and stroke, the use of additives interfere with the flow of antioxidants, substance that prevent damage of the body's cell. Daily intake of natural cocoa drink helps to reduce persistent cough, asthmatic attacks and overcome erectile dysfunctions and other forms of sexual weakness. Cocoa is the natural source of dietary magnesium which research have shown to be effective in treating diabetes, epilepsy, sleeplessness, menstrual pain, migraine and arthritis. For external usage, non edible cocoa benefits include; treating lip sore, nipple sore of breastfeeding woman, burns and rashes, skin irritation and hemorrhoids. Timothy (2011) reported that apart from chocolate, cocoa bean has a variety of other common uses, many of which are industrial in nature and not visible to the end users. This is due to one of cocoa's remarkable qualities. Its oil is solid at room temperature, but melt at body temperature. Other uses include; dietary pharmaceutical, make-ups and soap as well as scar removal.

Consequently, efficiency improvement becomes a significant factor in increasing productivity. Scale efficiency refers to the potential productivity gain from achieving optimum size of a firm or the reduction in the unit cost available to a firm when producing at a higher output volume. Scale efficiency of production is when a farmer produces at a reduction in average cost (cost per unit) associated with increasing the scale of production for a single product type. Several techniques are available in literature to conduct the performance analysis of cocoa production. Mostly, ratio analysis is used, but there are some short comings associated with these techniques (Yeh, 1996). Non-parametric (Data Envelopment Analysis DEA) approach for assessing scale efficiency of cocoa production in Central Senatorial District of Cross River State, Nigeria, is the crux of the project.

In recent years, emphasis has been on the measures to bring about improvement in the production and utilization of cocoa and its derivatives. The price of cocoa products has been increasing, but the rate of production increase has not been matching its demand, as well as efficient utilization of inputs in the production process. The agricultural problem in Nigeria therefore centers on efficiency with which farmers use resources on their farms. Scale efficiency in cocoa production therefore will be used to determine what a cocoa farmer will be expecting from say one hectare of his cocoa farm with less input, how efficient is the cocoa farm, whether constant return to scale, decreasing return to scale or increasing return to scale are guaranteed. It also bothers on how various factors that explain the farm efficiency could be harnessed so as to improve the crop production in the study area and the country at large.

All efforts from various government and non-Governmental bodies to increase production have not yielded results. Farmers output could be expanded with existing levels of conventional input and technology so that farmers will produce more efficiently with less of inputs. In other words, produce maximum output from a given level of input. It will therefore, be necessary to examine the production of unit resources used in cocoa production, as this will help to highlight those areas or variables that could be better managed to improve the productivity of cocoa in the study area. The main objective of this study is to determine the scale efficiency of cocoa production in Central Senatorial District of Cross River State.

***Research hypotheses***

$H_{O1}$ : Cocoa farmers in the study area are not scaled efficient in the use of productive resources.

$H_{O2}$ : Factors inputs in cocoa production are not marginally productive in the study area.

***Theoretical framework***

Scale efficiency refers to the potential productivity gain from achieving optimum size of a firm or the reduction in unit cost available to a firm when producing at a higher output volume (Encyclopedia of Small Business, 2002). According to (Brada and King, 1994) scale efficiency is the extent to which an organization alters its size towards optimal scale (which is defined as the region in which there are constant return to scale in the relationship between output and input).

DEA has competitors such as the stochastic frontier method which is extremely popular. But in this study DEA has been chosen in preference to the stochastic frontier methods for several reasons. First, it facilitate the partition of total technical efficiency into pure technical efficiency and scale efficiency, as well as identifying farms that operate under decreasing or increasing returns to scale. Total technical efficiency is estimated assuming that the farms have constant returns to scale (CRS). When estimating efficiency under variable returns to scale (VRS), the terms pure technical efficiency is used. Pure technical inefficiency is assumed to be a result of the farmer's management behavior rather than farm size (Brummer, 2001). The residual ratio between CRS efficiency and VRS efficiency is called scale efficiency, and can be used to identify optimally sized farms. Whether farms with sub optimal size operate under decreasing or increasing returns to scale can also be determined (Coelli *et al.*, 1998),

Drummond and John, (2004) reported that in the long-run, all factors of production are variable. Suppose the manager of a particular production process increased the quantity of each input used by 50%, what will happen to output if output also increased by 50%? Then we will say that the firm exhibit constant return to scale (or size). If output increased more or less than 50%, we will say that firm has increasing or decreasing return to scale respectively. If increasing return to scale exists in a particular production process, then we would logically expect to see larger firms pushing smaller ones out of the business since the large could produce more outputs per bundle of inputs than the smaller firms. In economics, the ratio of output per unit of input is called efficiency, so industries (collection of firms) that have production process with increasing returns to scale would likely have a few large, efficient firms rather than many smaller, less efficient ones. If returns to scale are constant, then large firms and small firms are equally efficient and could be expected to happily co-exist (Pouliquen, 2001).

Economic studies have found that, with the exception of very small farm, United State. agriculture is characterized by constant returns to scale. This explains two phenomena that can be observed. First, it explains the apparently peaceful co-existence of quite large and relatively modest farms in the US without any stamped "Corporate farming" or "Industrialization".

In Nigeria, especially Cross River State, both large Government Cocoa farms co-exist with industrial small cocoa farm holdings. It is the scale of production with respect to this varying farm sizes that is brought to fore in this research.

**Materials and Methods**

This study was conducted in three purposively selected Local Government Areas in Central Senatorial District of Cross River State, Nigeria. They include: Ikom, Boki and Etung Local Government Areas. Ikom has a total population of 162,383 people (NPC, 2006) with a land size of 1,861,926 square kilometers; bounded on the North by Ogoja, on the North – East by Boki, on the east by Etung and South by Obubra Local Government Area. It has Eleven (11) council wards. Boki with the population of about 300,000 people, has a contiguous territory border with the republic of Cameroon; Boki bears a national and international reputation for being a major commercial centre were forest and internationally quoted agricultural commodities such as cocoa, coffee, timber, palm products etc. are sourced and supplied for international consumption. It covers a total land mass of 920 square kilometers. Boki Local Government Area is bounded in the west by Ogoja, North by Obudu, South by Ikom while in the East; it is bounded by the Republic of Cameroon with Boje as its headquarters. (http://www.tripadvisor.com, 2011).

Etung Local Government Area has a total land mass of 833, 07 Square Kilometers and a population of 80.196 people (NPC, 2006) census. The postal code of the area is 551 (according to Post – Offices -with map of LGA NIPOST, 2009). It shares an international boundary with the republic of Cameroon to the East. It is bounded in the North by Ikom, in the South by Obubra and Akamkpa Local Government Area. There are two distinct climatic seasons in these areas; rainy season from March to October and dry season November to February.

The study area is situated in the rain forest belt, which promotes the growth of cash crops such as cocoa, oil palm, plantain, orange, banana, guava etc. Food crops commonly grown by the inhabitants include; Rice, Yam, Cassava, Potato, Maize, Vegetables, Cucumber, etc. (MOFINEWS, 2009; Obeten, 2011; Ibang, 2011). The main occupation of the people is farming, with over sixty percent of the inhabitants cultivating crops and rearing of animals like goats, sheep, pigs, and poultry (birds). Apart from farming, the people of the area also engage in agro-based activities, a good number of people are involved in civil service, marketing of agricultural products, and other forms of non-farming activities

Primary source was the major method of data collection for this study. The data was collected through the use of questionnaires and interviews. These were designed to capture the objectives of the study. A total of 180 questionnaires were distributed to selected cocoa farmers in the study area, 60 in each Local Government Area. Personal interviews and field observations were also conducted, so as to ensure that the information provided

by the respondents reflects the true position of the farming activities in the cocoa sub-sector in the area.

Multiple-stage procedure was adopted for the study. In the first stage, three Local Government Areas was purposively selected namely; Ikom, Boki and Etung Local Government Areas. Selection of these 3 LGA's was done on the basis that they are the highest producers of cocoa in the State. In the second stage, a random sampling technique was adopted where four (4) council wards were selected from each of the three L. G. A`s which gives total of twelve (12) council wards. In the third stage, 15 cocoa farmers each were randomly selected from list of the farmers in each of the 12 council wards, to give a total sample size of 180 respondents.

***Model specification***

For the purpose of this study, Data Envelopment Analysis (DEA) tool was employed.

***Linear programming technique***

For the $i^{th}$ farm, the estimated input-orientated efficiency score θi, under constant returns to scale was given by solving the following linear programming model.

Min $\theta_i$ ……..1

$\lambda$, $\theta_i$ ……..2

Subject to $y_i + Y\lambda \geq 0$…… 3

$\theta_i x_i - x\lambda \geq 0$ ……4

$\lambda \geq 0$, (non-negativity property ) ……5

**Where:** X and Y are matrices of the inputs and outputs respectively, of all observed (N) farms; $x_i$ and $y_i$, are the input and output vectors of the ith farm respectively, $\lambda$ as a N x 1 vector of constants; $\theta_i$ is the technical efficiency of the ith farm, bounded by O and 1, with a value of 1 indicating a technically efficient firm.

The variables' return to scale (VRS) DEA model was obtained by adding the constraint N1'$\lambda$ = 1, where N1 is a N x 1 vector ones. This is a convexity constraint ensuring that a firm is benchmarked against firms of a similar size. Scale efficiency was obtained as the ratio of the constant return to scale (CRS) efficiency measure (total technical efficient) to the VRS measure (pure technical efficiency). DEA under decreasing returns to scale (DRS) was obtained by adding the constraint N1'$\lambda \leq 1$. If the two scores are different, then ith farm operates under increasing returns to scale (IRS).

**Where:** $\lambda$ = lamda; X = inputs; $\theta_i$ = technical efficiency; VRS = variable return to scale; and CRS = constant returns to scale.

VRS is obtained by:

VRS = N1 $\lambda$ = 1 …… 6

**Where:** N1 = N x 1 = ith farm

Scale efficiency is obtained as a ratio of the CRS to VRS

$$Scale\ efficiency = \frac{CRS}{VRS} \quad .....7$$

**Where:** VRS = variable return to scale; CRS = constant returns to scale.

***The variables for consideration in calculating scale efficiency are:***

$x_1$ = Cost of cocoa chemicals (₦)

$x_2$ = Cost of labour (₦)

$x_3$ = Cost of harvesting (₦)

$x_4$ = Cost of clearing the farm (₦)

$x_5$ = Cost of Pruning (₦)

$x_6$ = Cost of working capital (₦)

$x_7$ = Drying cost (₦)

$x_8$ = Transportation cost (₦)

Y = Output (Kg)

**Results and Discussion**

***Socio-economic characteristics of cocoa farmers in Cross River State***

Table 1 reveals that, of the 180 respondents sampled for the study, the majority of the farmers in the study area were between the age brackets of 31 – 40 representing 37.8%, while very few farmers falls between the age bracket of 60 and above. The above analysis shows that cocoa production is practiced by adults who are in their prime age. The economic implication is that, more cocoa can be produced to meet the world demand since young and energetic people are actively involved in cocoa production. Further analysis revealed that 96.1% of the respondents were male, while 3.9% were females. This shows that cocoa farms in the study area are mostly owned by the men who are the head of the family.

The study revealed that 10% of the respondents had no formal education, 11.1% had only primary education; those that attended junior secondary school were 15.6% (Table 1); those that attended senior secondary school were 38.9%, while those who attended tertiary school represent 24.4%. These show that more than 85% of the farmers had formal education and can read and write. This implies that, the farmers can easily adopt new innovations and improved technologies in the area as increased education permit early adoption of innovations (Agbogo *et al* 2011). It also shows that households with size ranges of 1-5; 6-10; and 11-15 represent 45%, 47.8%, and 6.12%, respectively of the entire respondents under survey. Household is important as it provides family labour needed in the farm. The study reveals that the number of married respondents is 108, representing 60.0%; while those for single, separated as well as widows/widowers are 60, 6 and 4, representing 33.3%, 3.3% and 2.2%, respectively. The economic implication is that cocoa production in the study area does not depend on the marital status of the farmers only. Also, the study further reveals that, farmers with farming experience between 6 years and 10years as well as 11 years and 15 years are more, representing 58% and 18%, respectively. This shows that the farmers in the study area have more than five years of experience in cocoa farming, and has been engaged in the practice for a very long time and had acquired much experience.

The distribution of respondents according to the number of hectares cultivated show that, respondents with farm sizes of 1 – 5 hectares account for 81.1%,while those with 6 – 10 hectares account for 11.11%; those with 11 hectares and above and less than 1 hectare account for 4.4 and 3.3%, respectively (Table 1). 5 hectares and above of cocoa farm is a big farm and most of the farmers have up to five hectares and above. This implies that, the farmers in the study area are large producers of cocoa. Also, farm ownership status reveals that 55 respondents, representing 30.6% of the farmers planted cocoa on their farms personally, just as 16 of them representing 8.9% bought their farm lands. Again, 50 represented 27.8% of the farms hired their farm lands, while 59 respondents representing 32.8% of the farmers inherited their cocoa farms. This is an indication that most of the respondents inherited their farm lands and have been carrying out indigenous farming practices as laid down by their parent.

**Table 1: Distribution of respondents according to socio-economic characteristics**

| Age (years) | Frequency | Percentage |
|---|---|---|

| | | |
|---|---|---|
| 20 – 25 | 3 | 1,6 |
| 26 – 30 | 20 | 16.1 |
| 31 – 35 | 30 | 16.7 |
| 36 – 40 | 38 | 21.1 |
| 41 – 45 | 25 | 13.3 |
| 46 – 50 | 27 | 15.0 |
| 51 – 55 | 17 | 9.4 |
| 56 – 60 | 5 | 2.7 |
| 61 – 70 | 6 | 3.3 |
| **Total** | **180** | **100** |
| **Sex** | | |
| Male | 173 | 96.1 |
| Female | 7 | 3.9 |
| **Total** | **180** | **100** |
| **Level of Educational Att.** | | |
| No formal education | 18 | 10.0 |
| Primary school | 20 | 11.1 |
| Junior secondary school | 28 | 15.6 |
| Senior secondary school | 70 | 38.9 |
| Tertiary school | 44 | 24.4 |
| **Total** | **180** | **100** |
| **Household size** | | |
| 1 – 5 | 82 | 45.5 |
| 6 – 10 | 86 | 47.8 |
| 11 and above | 12 | 6.7 |
| **Total** | **180** | **100** |
| **Marital Status** | | |
| Married | 108 | 60.0 |
| Single | 60 | 33.3 |
| Separated | 6 | 3.3 |
| Widow/widower | 4 | 2.2 |
| **Total** | **180** | **100** |
| **Farming experiences (years)** | | |
| 1 – 5 | 27 | 15.0 |
| 6 – 10 | 58 | 32.2 |
| 11 – 15 | 34 | 18.9 |
| 16 – 20 | 23 | 12.8 |
| 21 – 25 | 17 | 9.4 |
| 26 – 30 | 16 | 8.9 |
| 31 – and above | 5 | 2.8 |
| **Total** | **180** | **100** |
| **Farm Size (ha)** | | |
| Less than one | 6 | 3.33 |
| 1 – 5 | 146 | 81.11 |
| 6 – 10 | 20 | 11.11 |
| 11 – and above | 8 | 4.44 |
| **Total** | **180** | **100** |
| **Ownership status** | | |
| Planted personally | 55 | 30.6 |
| Bought for life | 16 | 8.9 |
| Inherited | 59 | 32.8 |
| Hired | 50 | 27.8 |
| **Total** | **180** | **100** |

**Source:** Field Survey (2012)

***Scale efficiency of the respondents***

The study revealed that 79 cocoa farms representing 43.% exhibited increasing return to scale with a mean scale efficiency of 0.916. Fig. 1 illustrates the efficiency ratio of the farms. The Graph (Fig. 1) depict increasing return to scale , showing that farms in this category becomes smaller and smaller in spaces between their isoquant as one moves to higher levels of output, implying that inefficiency gap in their level of production is narrowed and more output is realized with lesser inputs. The Graph (Fig. 2) depict decreasing return to scale, showing that firms in this category gets wider and wider in the spaces between their isoquant as one move to higher level of output. This also implies greater inefficiency level of production i.e. the more inputs ploughed into the farms the less output realized.

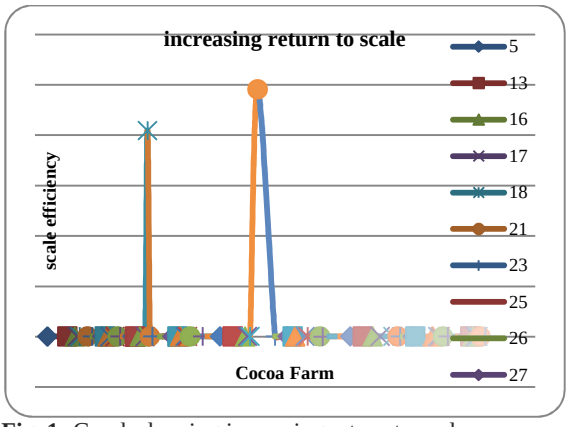



**Fig. 1:** Graph showing increasing return to scale

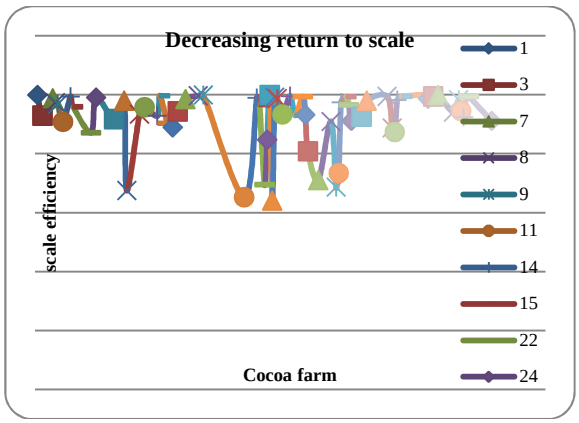



**Fig. 2:** Graph showing decreasing return to scale

Table 2 reveals that 64 representing 35.6% cocoa farms are operating under decreasing return to scale, the table shows the inefficiency gaps of the various decision making units (DMU), with average of 0.926, scale efficiency.

The Graph (Fig. 3), depict constant a return to scale, showing that firms under this category, their output increases in the proportion with the input the ratio of efficiency is equal to 1. This implies that farmers have fully employed their factors of production and there are both technically and allocatively efficient in their farm production decision making operation. Table 2 illustrates the average cost of cocoa production in Cross River State. The result shows that, the average total cost of production in the study area was ₦2533671, the gross margin (GM) which was derived by subtracting the average total cost (ATC) from the average total revenue (ATR) was ₦2524382.32. Expressed mathematically as: Total cost (TC) = ₦752383; Average total cost (ATC) = ₦9288.68; Average total revenue (ATR) = ₦2533671; Gross Margin (GM) = ATR – ATC GM = ₦2533671 – ₦9288.68; GM = ₦ 2524382.32

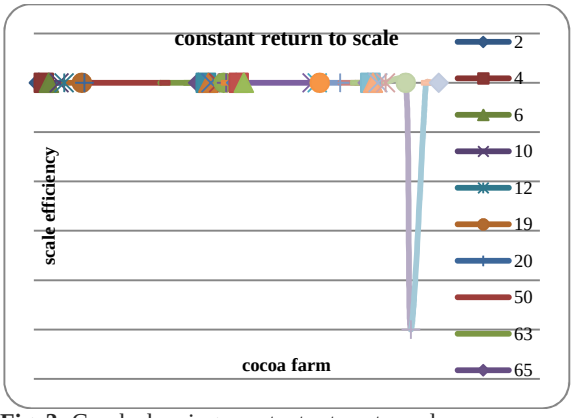



**Fig. 3:** Graph showing constant return to scale

**Table 2: Average cost of cocoa production per hectare in Cross River State**

| S/N | Items | Average cost (₦) |
|---|---|---|
| 1 | Cost of labour | 274636.00 |
| 2 | Clearing cost | 13661.00 |
| 3 | Pruning cost | 54011.50 |
| 4 | Cost of working capital | 78807.40 |
| 5 | Chemical cost | 69464.80 |
| 6 | Harvesting cost | 68890.20 |
| 7 | Drying cost | 2500.00 |
| 8 | Marketing cost | 24329.50 |
| 9 | Transport cost | 43125.60 |
| | **Total cost** | **₦752,383.00** |

***Scale efficiency***

The technical efficiency of cocoa production in Cross River State was measured using input orientation measures, with $X_1$ to $X_9$ (cost of labour, clearing cost, pruning cost, cost of working capital, cost of chemicals, harvesting cost, drying cost marketing and transportation cost) as the inputs to produce a single output (Y) the cocoa bean under the assumption of constant returns to scale. In the study area 37 firms were fully technically efficient of the 180 farmers representing 20.6% (Table 4). The distance between zero and one is the technical inefficient gap of a firm. From the study, it is revealed that 79.4% of the firms are technically inefficient.

***Source: Computed from DEA software***

The study reveals that the mean technical inefficiency is 0.661, the mean technical efficiency of the farms is 1.000, the mean of inefficiency gap is 0.328, the mean allocative efficiency is 0.593, and the mean total economic efficiency is 0.334, respectively; this implies that cocoa farmers in the study area can only cover 33% of the total cost of production. Economically, the farmers are 67% less efficient in the resource allocation. It is important to note that, the allocative efficiency (AE) of the farm represent the reduction in production costs that would occur if production were to occur at the allocatively (and technically) efficient point. The product of technical and allocative efficiency provides the overall economic efficiency. In the study area, it is revealed that the average allocative efficiency of cocoa farmers is 0.999.

***Measurement of scale efficiencies***

The scale efficiency for the cocoa farmers in Cross River State revealed that 64 farms out of 180 farmers representing 35.6% are operating under decreasing return to scale. Also, the study revealed that 79 farms representing 43.8% are operating under increasing return to scale. Additionally, 37 farms representing 20.6% exhibited constant return to scale. Summarily, the scale efficiency study of the cocoa farmers can be seen in the Table 3.

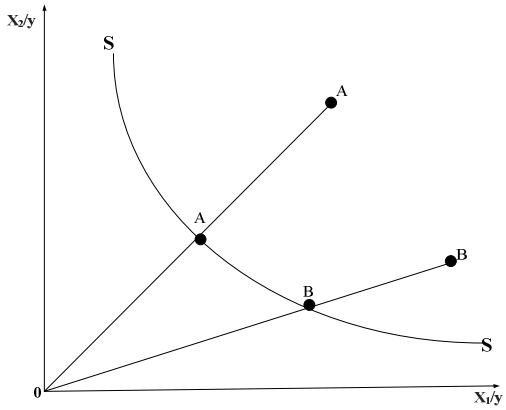
**Table 3: Showing summary of farms scale efficient index**

| S/N | No. of farm | % Scale efficiency |
|---|---|---|
| 1 | 64 | 35.6 |
| 2 | 79 | 43.8 |
| 3 | 37 | 20.6 |
| **Total** | **180** | **100** |

***Efficiency measurement and input slacks***

The piecewise linear form of the non-parametric frontier in DEA can cause a few difficulties in efficiency measurement. The problem arises because of the sections of the piecewise linear frontier which run parallel to the axis which do not occur in most parametric functions.

The Farrel (1957) measure of technical efficiency gives the efficiency of a firm A and B as OA'/OA and OB'/OB, respectively. The points OA and OB are the firms technical efficiency, OA' and OB' are the level of input that the firm is expected to reduce to achieve the same level of output. This is known as input slack in the literature. Once one considers a case involving more inputs and/or multiple outputs, the diagrams are no longer a simple matter.




**Source:** Centre for Efficiency and Productivity Analysis (CEPA) Working Paper (1986).

**Fig. 4:** Showing efficiency measurement and input slacks

Mathematically, the i-$^{th}$ firm output slacks will be equal to zero only if $Y_{\Lambda}$-y; = 0, while the input slacks will be equal to zero only if $\Theta_{x1-x\Lambda}$ = 0 (for the given optimal values of $\Theta$ and $\Lambda$). From the DEA results of the cocoa farmers in Cross River State, all the farms slack input were equal to zero emphasizing the authenticity of their various levels of technical efficiency.

**Conclusion**

Cocoa production is the major practice and has been the main stay of the economy of the people in the study area. Due to the increase demand of cocoa products, there is need for increased introduction of improved technologies that will tackle the constraints faced by the producers of cocoa beans in order to enhance the productivity and efficiency. This will go a long way to alleviating the problems of inefficiency and low yield. It is therefore concluded that 80% of the farmers in the study area operate below full scale efficiency.

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