MEASUREMENT OF SCALE EFFICIENCY IN GINGER FARMS IN KACHIA LOCAL GOVERNMENT AREA OF KADUNA STATE, NIGERIA: NON-PARAMETRIC MODEL APPROACH

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Abstract
The study was carried out to measure scale efficiency among ginger farmers in Kachia Local Government Area of Kaduna State. A two stage sampling techniques was used to select 99 ginger farmers from whom the data for the study were collected. Data were analyzed using Data Envelopment Analysis (DEA) and descriptive statistics. Results show that the mean values of overall TE, Pure TE and scale efficiency were 0.718, 0.804 and 0.898 respectively. Only 14 % the farms were operating on the optimal scale. While about 86% of the farms were experiencing scale inefficiency (sub-optimal scale), consisting of 47% of the farms revealing increasing return to scale and 38% exhibiting decreasing returns to scale. Therefore, it is recommended that for realization of optimal production scale in the study area, farmers operating at inefficient production scale should be encouraged to either increase farm size to address scale inefficiency from IRS, or decrease farm size to remedy scale inefficiency due to DRS.

Keywords: Ginger farms, scale efficiency and DEA

Introduction
Ginger (*Zingiber officinale*) is herbaceous perennial crop grown vegetative for its spicy underground rhizomes across many climates in the world. It requires a good soil tilled for production of well-shaped rhizomes (NAERLS, 2004). Consumption of ginger helps in preventing stomach ulcers, reduce muscle pain and soreness. It also helps in reducing nausea and vomiting, which mostly affects pregnant women and chemotherapy (Lete and Allue, 2016). The five major ginger producing countries across the globe are India, China, Nepal, Indonesia and Nigeria. Figure 1 shows that in 2014, India is the highest ginger producer in the world with total output of about 655,000 MT, followed by China with 451,000 MT. Nepal, followed China with 276,000 MT, while, Indonesia closely followed Nepal with 266,000 MT. Figure 1 also shows that Nigerian ginger production is the least in terms five major global producers with 58,000 MT.

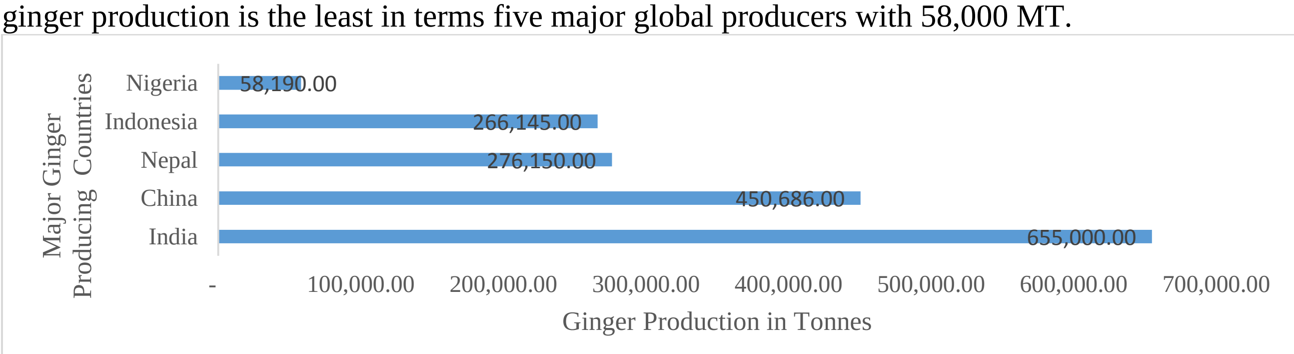

Figure 1: The Five Major Ginger Producing Countries in the World
Source: Data Retrieved from FAOSTAT (2017)

In Nigeria, for two and half decades, ginger production has increased steadily from 42,000 tonnes in 1990 to about 497, 000 tonnes in 2013; an increase of about 92% (Figure 2). However, there was a sharp reduction in the national output of about 83% in 2014 compare with the preceding year. Figure 2 also shows income from ginger production in the country increased steadily from ₦500 million in 1990 to ₦60 billion in 2013 (100 % increase). But, in 2014, the national income from ginger production witnessed significant reduction of about 88% when compare to 2013 earning.

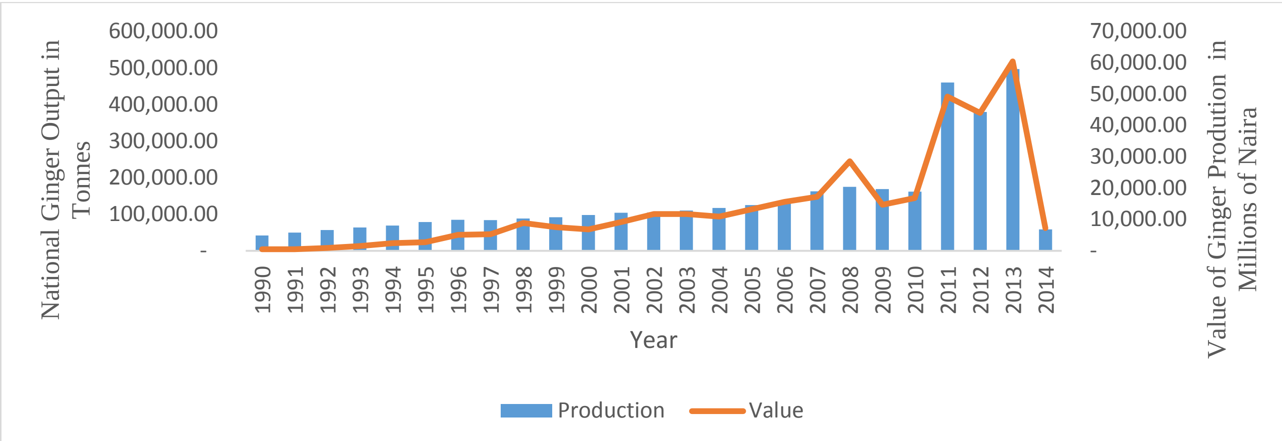

Figure 2: Trends in National Output and Value of Ginger in Nigeria
Source: Data Retrieved from FAOSTAT (2017)

Cultivation of ginger started around Kachia, Kwoi, Jaba, Kafanchan and Kagarko areas of Southern Kaduna State and around the neighbouring parts of Plateau State (Kaduna State Agricultural Development Project, KADP, 2000). In recent times, ginger cultivation has been introduced into South Eastern and South Western Geographical Zones of Nigeria. According to the United Nations Food and Agriculture Organization (FAO, 2004), there are two major varieties of ginger grown in Nigeria which differ in the colour of their rhizomes namely, the reddish and yellow varieties. The yellow variety appears to be widely planted than the reddish variety. In southern Kaduna where ginger is extensively grown in Nigeria, beds are preferred for rain fed ginger production while planting on ridges is recommended for irrigated ginger. The two common methods for the efficiency measurement are parametric method, which comprises of the Stochastic Frontier Approach (SFA), the Thick Frontier Approach (TFA) and the Distribution Free Approach (DFA), and Nonparametric methods, which involves Data Envelopment Analysis (DEA) and the Free Disposal Hull (FDH). All these methods are used to determine technical, scale and economic efficiencies of the decision making unit (DMU) or farm. A non-parametric approach considers a frontier that is not related to any functional form: the isoquant is estimated by the ratio outputs/inputs of each DMU. It is generally of a deterministic type. According to Coelli (1995), DEA approach has two main advantages in estimating efficiency. First, it does not require the assumption of a functional form to specify the relationship between inputs and outputs. Second, it does not require the distributional assumption of the inefficiency term. Indeed, DEA is an illustrative example of non-parametric approach, which comprises two models namely, Constant Return to Scale (CRS) and Variable Return to Scale (VRS). Coelli *et al.*, (2005) observed that the difference between technical efficiency ratio obtained from the two types (CRS and VRS) is a good measure of scale efficiency of the farm. In order to obtain scale efficiency, Coelli *et al.*, (2005) suggest performing on the same database, both DEA-CRS and DEA-VRS types. If for a given farm, there is a difference in efficiency ratios measured by these two types of DEA, it then indicates that the firm is not operating at an optimal scale. Therefore, scale inefficiency is obtained by the difference between CRS technical inefficiency and VRS technical inefficiency. This approach allows separation of the concept of technical efficiency into pure technical efficiency and scale technical efficiency. Pure technical efficiency reflects the way in which production unit resources are managed while scale efficiency or scale technical efficiency determines whether production unit operates at an optimal scale or not. The optimal implies best situation that can achieve the production by increasing proportionally the quantity of all its factors, or operating at a point where the production frontier exhibits CRS. Previous research studies on the efficiency measurement in ginger farms mainly focus on technical efficiency namely, Mailumo *et al.,* (2014); Folorunso and Adenuga (2013) and Ayodele and Sambo (2014). However in the present study, effort is made to go beyond technical efficiency by focusing more on scale efficiency of ginger farmers in the study area. The result of the study will avail the opportunity of ascertain the scale of operation of ginger farmers: whether operating at increasing return to scale or decreasing return to scale, or optimal level (constant return to scale). Hence, the objective of present study is to estimate scale efficiency of the ginger farms using Data Envelopment Analysis (DEA).

Methodology

The study was conducted in Kachia Local Government of Area of Southern part of Kaduna State. The climate is predominantly tropical with two distinct seasons (dry and wet seasons). Ginger is the major cash crop grown in the area with Jaban kogo, Yarbung 1 and Sabon sarki communities as major producing villages in the Local Government Area. A two stage sampling techniques was used to collect the sample of ginger farming households: the first stage involved a purposive selection of the three major ginger producing communities namely: Jaban kogo, Yarbung 1 and Sabon Sarki in the Local Government Area. In the second stage, a list of ginger farming households from each village was used as sample frame from which 33 ginger farming households were randomly selected from each of the three villages. This give a total of 99 ginger farmers used as sample size for the study. The list of the farmers was obtained from Samaru Zone of Kaduna State Agricultural Development Program. Primary data were collected through structured questionnaire administered on ginger farmers. Data collected included ginger output and farming inputs namely, farm area, fertilizer, seed, agrochemical and labour. Data Envelopment Analysis (DEA): Following Coelli *et al*., (2002) and applied by Alboghdady (2014), assumed that there are data on a single output (Y=1, ginger) for each of N farms (N=1,2,…,99) and K inputs (K=1,2,…,5) denoting farm size (Ha), seed (Kg), fertilizer (Kg), agrochemical (Litres) and labour (Man-day). For ith farm, inputs and output data were represented by the column vectors k_i and y_i. The data for all N farms are represented by $K \times N$ input matrix, k, and $Y \times N$ output matrix, y. Hence, the Constant Return to Scale (CRS) input oriented DEA model for the ith farm is specified as follows:

$Min_{\varphi i,i}\varphi_i$,

Subject to $Y\lambda - yi \geq 0$

$k_i\varphi_i - K\lambda \geq 0,\ \lambda > 0$ ……………………………………………………………….1

Where,

Where φ is a scalar and λ is a $N \times 1$ vector of constant. The linear programming problem for constant return to scale (CRS) can be easily modified to obtain variable return to scale (VRS) by adding the convexity constraint: $N1'\lambda = 1$ so as to minimize the following equation:

$Min_{\varphi i,i}\varphi_i$,

Subject to $\lambda - yi \geq 0$,

$k_i\varphi_i - K\lambda \geq 0$…………………………………………………………………….. (2)

$N1'\lambda = 1\ \lambda > 0$, where $N1$ is a $N \times 1$ vectors of ones. In this study, both constant return to scale (CRS) and variable return to scale (VRS) DEA models were applied. According to Coelli *et al*., (2005), the input technical efficiency (TE) score gets a value $0 \leq \varphi \leq 1$.

Scale Efficiency: Exploiting on the relationship between CRS-DEA and VRS-DEA scores, Alboghdady (2014) and Tipi *et al.*, (2009) computed the scale efficiency (SE) score for i^{th} farm as follows:

$$TE_{iCRS} = TE_{iVRS} \times SE_i \ldots\ldots\ldots\ldots (3)$$

$$SE_i = {TE_{iCRS}}/{TE_{iVRS}} \ldots\ldots\ldots\ldots (4)$$

Where, SE=1 indicates a scale efficient i^{th} farm that is operating at an optimal scale or a point of CRS. SE<1 indicates scale inefficiency.

It should be noted that Scale inefficiency arises as a result of existence of either Increasing Returns to Scale (IRS) or Decreasing Returns to Scale (DRS). This may be determined for i^{th} farm by imposing restriction on $N1'\lambda = 1$ in equation (2) above as $N1'\lambda \leq 1$.This results in non-increasing returns to scale (NIRS). According to Coelli (1996), if the non-increasing return to scale technical efficiency (TE) score is equal to the VRS score, it implies that decreasing returns to scale (DRS) exist for i^{th} farm. However, if the non-increasing returns to scale TE score is unequal to the VRS TE score, it implies increasing return to scale (IRS) exists for the i^{th} farm

Results and Discussion

The descriptive statistics of all the variables deployed for analyses are presented in Table 1. The output of ginger varied widely from the minimum of 2,100 Kg to the maximum of 54,600 Kg. The mean of output in the study was 23,076 Kg. The variability of the ginger output among the farmers was 59% as measured by coefficient of variation (CV). The farm size devoted to the cultivation of ginger is largely small, ranged between 0.1ha to 4 ha, while the mean of farm size was about 1.4 ha and coefficient of variation was 62%. This shows high variability of farm size from the average value. The ginger seed used also has wide variability among famers with the minimum value of 360Kg and maximum of 12,600 Kg. The mean of ginger seed was 4,800 Kg, with 62 % coefficient of variation. The mean of fertilizer and other agrochemical utilized in the cultivation of ginger were 642 Kg and 8.03 litres respectively. Table 1 also shows labour utilization in ginger production; which ranged between 15 man-day to 644 man-day. The mean of labour was 213-manday with 61% coefficient of variation

Table 1: Descriptive statistics of variables used in the models

Variable	Unit	Minimum	Maximum	Mean	Std. Deviation	CV
output	Kilogram	2100.00	54600.00	23076.97	13726.07	59
Farm Size	Hectare	0.10	4.00	1.39	0.86	62
Seed	Kilogram	360.00	12600.00	4800.00	2974.53	62
Fertilizer	Kilogram	50.00	4500.00	642.68	665.27	100
Agrochemical	Litre	1.00	25.00	8.03	5.85	73
Labour	Man-hour	15.00	644.00	213.43	129.52	61

Source: Estimated data collected through Field survey (2017)

The efficiency scores generated through input-oriented DEA approach is presented in Table 2. By decomposition of the technical efficiency scores obtained from CRS-DEA, that is overall Technical Efficiency (inefficiency) scores, two other components resulted namely, Pure Efficiency (inefficiency) scores obtained from VRS-DEA and Scale Efficiency scores, which is the ratio of the former. Table 2 shows that the mean values of overall TE, Pure TE and scale efficiency were 0.718, 0.804 and 0.898 respectively. The mean of overall TE implies that ginger farmers in the study area could still obtain the current average output of ginger by reducing the size of inputs combination by 28% on the average. Based on the pure technical efficiency scores, the ginger farmers could still obtain their output level by reducing the size of inputs combination by 20% on the average. Table 2 also shows that ginger production is characterized by scale inefficiency of about 10% on the average.

Table 2: Statistics of three different types of efficiency scores

Type of Efficiency Score	Minimum	Maximum	Mean	Std. Deviation	CV
Overall Technical Efficiency (CRS)	0.10	1.00	0.718	0.170	24
Pure Technical Efficiency (VRS)	0.30	1.00	0.804	0.172	21
Scale Efficiency	0.33	1.00	0.898	0.137	15

Frequency of the ginger farms showing different levels of return to scale is presented in Figure 3. Return to scale, which connote level of scale efficiency, indicates whether any efficiency can be obtained by improving the size of the operation. Figure 3 shows that only 14 farms were operating on the optimal scale. This represents about 14 % of total ginger farms in the area. This group of farmers, would suffer losses in efficiency by changing their scale of production. A total of 47 farms (representing 47 %) were revealing increasing return to scale. This implies that 47% of the ginger farms in the area were operating at sub-optimal level. This group of farmers can realize optimal production/farm scale by increasing the size of their farms. Figure 3 also shows that 38 farms (that is 38 % of the total farms in the area) were revealing decreasing returns to scale. For optimal production scale, the size of the farms in this category has to be reduced

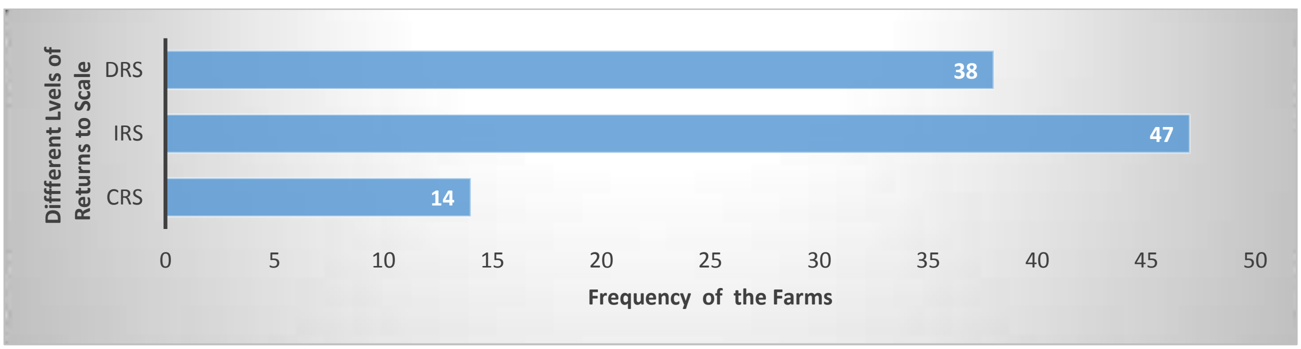

Figure 3: Frequency of Farms based on three Levels of Returns to Scale

Conclusion

Only 14 % of the farms in the study area were operating at optimal production scale. Scale inefficiency in ginger farms were partly due to increasing return to scale exhibited by 47 % of the farms and decreasing return to scale revealed by 38% of the farms in the study area. Therefore, it is recommended that for realization of optimal production scale in the study area, farmers operating at inefficient production scale should be encouraged to either increase farm size to address scale inefficiency from IRS, or decreasing the farm size to remedy scale inefficiency due to DRS.

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