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FARM SIZE AND SCALE EFFICIENCY OF SMALL HOLDER TUBER CROP FARMERS IN NORTH CENTRAL, NIGERIA

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ABSTRACT

The empirical study examined the effect of farm size on scale efficiency of small holder tuber crop farmers in North central, Nigeria. Data used for the study were obtained from primary source using a multi-stage sampling technique with structured questionnaires administered to 300 randomly selected tuber crop farmers from the study area. Descriptive statistics such as means, standard deviations and percentages were used to summarize the variables used in the analysis while input– oriented data envelopment analysis (DEA) model was used to empirically determine the total technical, pure technical and scale efficiency with respect to farm size in the study area. The DEA results suggested that gains from improving technical efficiency exist in all farm categories, although they appear to be much higher on large and on medium farms than on small farms among tuber crop farmers in the study. The findings further revealed the mean pure technical efficiency of small, medium and large farms was 0.81, 0.69 and 0.59 respectively while mean scale efficiency of small, medium and large farms was 0.36, 0.40 and 0.50 respectively.

The implication of these findings is that small farmers are fairly efficient in utilizing their resources and any expansion in the use of resources would bring more than proportionate increase in the output. The study therefore recommended that research efforts directed towards the generation of new technology, especially for small farmers, should be encouraged in the study area

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INTRODUCTION

Roots and tubers belong to the class of foods that basically provide energy in the human diet in the form of carbohydrates. According to FAO (1990), yam, cassava and potato of various varieties are the common roots and tubers in Africa. International Food Policy Research Institute (IFPRI) (2010) reported that cereals, roots, and tubers dominated Nigerian crop production, and Nigeria is the world's leading producer of cassava, yams and cowpea. Cassava is commercially processed into *gari*, a staple food in parts of Nigeria, and into *kokonte* in Ghana. According to FAO, (2004), Nigeria is the largest producer of cassava in the world. Its production put at least at 34million metric ton a year. Total area cultivated of the crop (cassava) in 2001 was 3.125 million hectares with an average yield of 10.83metric ton per hectare. Tuber crop sector is almost entirely dominated by small scale resource poor farmers living in the rural areas, with farm holdings of 1-2 hectares, which are usually scattered over a wide area (Daramola, 2004). This shows that the average sizes of farmlands are very small. The production practices of small-scale farmers are synonymous with their production characteristics such as subsistence level of production, low hectare due to tenurial rights, poor access to credit and other production inputs as well as poor managerial ability and enterprise combination based on ecological considerations, available resources, taste and preferences of farm families. These characteristics of the peasant farmers predispose them to low productivity. However, tuber crops 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 efficiency and 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 (Federal Department of Agriculture (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. Hence, the role of increased efficiency and productivity of tuber farms is no longer debatable but a great necessity in order to increase the efficiency of small holder farms in Nigeria, since tuber crops have the potential for bridging the food gap. It is to this end that this study was undertaken with the view to analyze the scale efficiency of tuber crop farmers in relative to their farm size in North central , Nigeria.

Theoretical 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. In economic analysis, much is concerned with the technical and economic efficiencies or resource transformation and allocation (Coelli, 1996). Production efficiency is concerned with the relative performance of the process used in transforming inputs into output. The concept of efficiency goes back to the pioneering work of Farrell (1957) who distinguishes between three types of efficiencies:

- Technical efficiency (TE)
- Allocative or price efficiency (AE), and
- Economic efficiency (EE)

Technical efficiency in production is the physical ratio of product output to the factor input, the greater the ratio, the greater the magnitude of technical efficiency. Allocative efficiency is concerned with choosing optimal sets of inputs. A firm is allocatively efficient when production occurs at a point where the marginal value product is equal to the marginal factor cost. Economic efficiency is a situation where there are both technical and allocative efficiencies.

Estimation of total technical, pure technical and scale efficiencies

Generally, there are two approaches to measure efficiency estimates of a firm i.e. parametric approach and non-parametric approach. Parametric approach involves the use of stochastic frontier analysis (SFA) while non-parametric approach involves the use of data envelopment analysis (DEA). DEA approach was preferred over parametric approach for the estimation of efficiency in this study because it provides means of decomposing total technical efficiency into pure technical and scale efficiency (SE). Technical efficiency scores can be obtained by running a constant returns to scale DEA model or variable returns to scale (VRS) DEA model. Technical efficiency scores obtained from constant returns to scale (CRS) DEA model are called total technical efficiency and from variable returns to scale DEA model as pure technical efficiency. Total technical efficiency of a firm can be decomposed into pure technical and scale efficiency. Pure technical efficiency relates to management practices while scale efficiency relates to the residuals. This would enable better understanding of the nature of technical efficiency of farms and would assess the possibilities for productivity gains by improving the efficiency of farmers in the study area.

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:

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

Subject to :

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

$\alpha_r, \beta_i \geq 0$; 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

Scale efficiency can be obtained residually from CRS and VRS technical efficiency scores as follow:

SE= TECRS/TEVRS

SE= 1 indicates scale efficiency or constant return to scale (CRS) and SE <1 indicates scale inefficiency. Scale inefficiencies arise due to the presence of either increasing returns to scale or decreasing return to scale.

METHODOLOGY

Study Area*:* This study was conducted in the North Central Nigeria. The zone comprises of Benue, Kogi, Kwara, Niger, Nasarawa and Plateau States, including the Federal Capital Territory (FCT), Abuja. The zone occupies a total land area of 296,898 km^2 representing about 32% of the land area of the country. It is located between latitude 6^o 30' to 11^o 20' North and longitude 2^o 30' to 10^o 30' East (Shuaib *et al*, 1997). More than 77% of the people in the region are rural dwellers and are mostly engaged in one form of agricultural activities or the other (Shuaib *et al*, 1997)

According to Tologbonse (2004), the zone has two main seasons' namely dry and wet seasons, with the wet season beginning towards the end of the March and end at the end of October, while the dry season is from November to March. The rainfall per annual ranges from 1000 to 1500mm with the average of 187 to 220 rainy days with average monthly temperature ranges from 21^oC and 37^oC. The vegetation of the zone consists of the forest Savannah Mosaic, Southern Guinea Savannah and the Northern Guinea Savannah. Geographically the zone is characterized by varying landforms such as extensive and swampy feature which are common in the lowland areas which occur in the areas along the valleys of Niger and Benue rivers, deep valleys large hills, mountains and plateaus. The vegetation, soil and weather patterns are favorable for the production of a wide spectrum of agricultural food, industrial and cash crops of various types. The major crops grown in the North Central Nigeria include rice, maize, millet sorghum, yam and cassava.

Sampling technique and sample size

Primary data were collected using multi-stage sampling technique. The first stage involved purposive selection of Niger and Kogi States in the North Central Zone because of the prevalence of root and tuber crops production in these study areas. Cassava and yam were purposely selected for this research work because they are the prevalent tuber crops produced in these study areas as confirmed by IITA, (2004). On a *per capita* basis, North-Central is the highest cassava and yam producing zone at 0.72 and 0.57 tonnes per farmer respectively in 2002 and National *per capita* production of cassava is 0.32 tonne per person with Benue and Kogi

States in the North Central Zone as the largest producers of cassava. This was followed by random selection of 3 Local Government Areas (LGAs) in each State making 6 LGAs altogether. The LGAs selected in Niger State are Shiroro, Lapai and Gurara while Mopamuro, Kabba/Bunu and Ijumu LGAs were selected in Kogi State.The third stage involved a simple random selection of five villages in each LGA and ten yam and cassava farmers in each village to give a total of 300 sampled farmers as respondents 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 (₦).

RESULTS AND DISCUSSION

The summary statistics of the variables for the data envelopment analysis (DEA) for yam and cassava production in the study area are presented in Table 1. They include the sample mean and the standard deviation for each of the variables. The results from Table 1 shows that the mean of 2.79 tons of outputs per annum was obtained from the data analysis with a standard deviation of 2.72 in the study area. Analysis of the inputs also revealed an average farm size of 2.63ha per farmer, an indication that the study covered small scale family managed farm units. The average labour of 138.31 man- day showed that yam and cassava farmers in the study area relied heavily on human labour to do most of the farming operations. The analysis of other input variables showed the mean values of 217.32kg, ₦7,440.13, 1338.94kg and ₦1856.46 for fertilizer, cost of agrochemical, planting materials and capital input cost (depreciation) respectively. All these findings point to the characteristic nature of subsistence farming which dominates agricultural production in Nigeria.

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Table 1: Summary statistics of the variables in data envelopment analysis for yam and cassava in Both Kogi and .Niger States

Variables	Mean	Standard Deviation	Minimum	Maximum
Total Output (ton)	2.79	2.72	0.05	25.60
Total farm size (ha)	2.63	1.74	0.50	10.00
Labour (manday)	138.31	56.28	12.00	287.00
Total Planting Material (kg)	1338.94	2731.35	0.90	24200.00
Agrochemical (₦)	7440.13	8893.97	250.00	54000.00
Total Fertilizer (kg)	217.32	123.43	0.50	1000.00
Capital input (₦)	1856.46	1346.95	350.00	11500.00

Source: Data Analysis, 2012

The total technical, pure technical and scale efficiency scores of tuber crop production in the study area are presented in Table2. Results of study indicate that the mean total technical efficiency of the sample farms is 0.29 implying that the farmers would have to reduce the level of inputs by 71% if they were operating at the frontier. . Decomposition of technical efficiency shows that, on average, the sample farms are more scale efficient than they are technically efficient. The mean pure technical efficiency of the sample farms is 0.74 with a lowest of 0.28 and a highest of 1.0. The mean scale efficiency of the sample farms is 0.39.

Table 2: Summary statistics of efficiency estimates in tuber crop production in the study area.

Efficiency Measures	Mean	Standard Deviation	Minimum	Maximum
CRS Technical Efficiency	0.29	0.24	0.01	1.00
VRS Technical Efficiency	0.74	0.19	0.28	1.00
Scale Efficiency	0.39	0.27	0.02	1.00

Source: Field survey, 2012

In order to investigate the relationship between efficiency estimates and farm size, the sample households were categorized into three groups on the basis of operational holdings of farmers. Farms with less than 2.01hectares were categorized as small farms, those having 2.01 – 4.00 hectares were termed as medium farms and farms having more than 4.00 were called as large

Farms (This classification should not be confused with economic size since all the sample households are smallholder farmers. This classification is only for this study). Results in Table 3 presents mean efficiency estimates for the three farm categories. The results show the overall technical inefficiency ranges from 70% on small farms to 69% on large farms, suggesting that large farms are more technically efficient than small farms. Nevertheless, the decomposition of technical efficiency into pure technical efficiency and scale efficiency reveals that small farms are pure technically more efficient (0.81) than medium (0.69) and large farms (0.74) and high level of technical efficiency observed on large and medium farms is mainly due to scale efficiency.These results are consistent with the findings of Oduol *et al*., (2006) and Javed *et al*., (2011), that small farms are pure technically more efficient than large farms.

Table 3. Estimated mean efficiency measures and proportion of efficient farms

Efficiency	Small		Medium		Large		Total	
Measures	Mean	%	Mean	%	Mean	%	Mean	%
CRS Technical Efficiency	0.30	0.06	0.28	0.04	0.31	0.07	0.29	0.05
VRS Technical Efficiency	0.81	0.26	0.69	0.12	0.59	0.12	0.74	0.19
Scale Efficiency	0.36	0.06	0.40	0.04	0.50	0.07	0.39	0.05

Source: Field survey, 2012

The multiple comparison test for significant differences in mean technical efficiency among the three farm categories, summarised in Table 4, confirms that mean pure technical efficiency is significantly higher on small farms than on large farms. Accordingly, the mean pure technical efficiency results suggest that gains from improving technical efficiency exist in all the farm categories, although they appear to be much higher on large and medium farms than on small farms.

Table 4: Multiple Comparison tests for the differences in mean efficiency estimates among farm categories

Efficiency Measures	Small versus Medium		Small versus Large		Medium versus Large	
	Mean difference	Sig	Mean difference	Sig	Mean difference	Sig
CRS Technical Efficiency	0.017	0.547	-0.009	0.836	-0.027	0.564
VRS Technical Efficiency	0.120	0.000**	0.223	0.000**	0.102	0.004**
Scale Efficiency	-0.036	0.254	-0.140	0.008**	-0.103	0.050*

Note: ** and * denote significance at 0.01 and 0.05 respectively
Source: Field survey, 2012

Table 5 further reveals that the highest share (7.14%) of scale efficient farms lies in the group of large farms. The results also showed that about 94 %, 96% and 93% of small, medium and large farms operated at increasing returns to scale level respectively. This implies that all the farm groups could achieve higher efficiency level by increasing the production scale.

Table 5: Share of farms under CRS (scale efficient), IRS (increasing returns to scale) and DRS (decreasing returns to scale) with farm size groups in tuber crop in the study area.

Farm size	Scale efficient farms	%	Farms under IRS	%	Farms under DRS (%)
Small	9	5.73	148	94.27	-
Medium	4	3.92	98	96.08	-
Large	3	7.14	39	92.86	-

Source: Field survey, 2012

CONCLUSION AND RECOMMENDATIONS

The empirical study examined the effect of farm size on scale efficiency, using an input–oriented data envelopment analysis model. The results suggest that gains from improving technical efficiency exist in all farm categories among tuber crop farmers in North central Nigeria. The mean pure technical efficiency of small, medium and large farms was 0.81, 0.69 and 0.59 respectively while mean scale efficiency of small, medium and large farms was 0.36, 0.40 and 0.50 respectively. Scale inefficiency is found to account for a larger share of technical inefficiency on small farms than on medium and on large farms, suggesting that increasing the scale of operation is necessary if the farmers have to improve technical efficiency. These results revealed that small farm holders were technically more efficient than medium and large farmers. The implication of these findings is that small farmers are fairly efficient in utilizing their resources and any expansion in the use of resources would bring more than proportionate increase in the output. In view of the above findings, it is therefore recommended that research efforts directed towards the generation of new technology, especially for small farmers, should be encouraged in the study area

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