2014-07-01

Profitability and efficiency of cassava production at the farm-level in Delta State, Nigeria

Awerije, BO

http://hdl.handle.net/10026.1/3995

10.5836/ijam/2014-04-04
International Journal of Agricultural Management
International Farm Management Association and Institute of Agricultural Management

Second revised version incorporating all comments of three referees and the editor

Profitability and efficiency of cassava production at the farm-level in Delta State, Nigeria[1]

Brodrick O. Awerije

School of Geography, Earth and Environmental Sciences, University of Plymouth, Drake Circus, Plymouth, PL4 8AA, United Kingdom, E-mail: brodrick.awerije@plymouth.ac.uk

Sanzidur Rahman

School of Geography, Earth and Environmental Sciences, University of Plymouth, Drake Circus, Plymouth, PL4 8AA, United Kingdom, Phone: +44-1752-585911, Fax: +44-1752-584710, E-mail: srahman@plymouth.ac.uk

Address for correspondence

Dr. Sanzidur Rahman
Associate Professor in Rural Development
School of Geography, Earth and Environmental Sciences
University of Plymouth
Drake Circus
Plymouth, PL4 8AA
Phone: +44-1752-585911
Fax: +44-1752-584710
E-mail: srahman@plymouth.ac.uk

April 2014

---

[1] The paper was extracted from the first author's PhD thesis submitted at the School of Geography, Earth and Environmental Sciences, University of Plymouth, UK in 2014. The data required for this project was generously funded by the Seale-Hayne Educational Trust, UK. The authors gratefully acknowledge the comments of three anonymous reviewers and the editor for constructive and critical comments that have substantially improved this paper. All caveats remain with the authors.

Profitability and efficiency of cassava production at the farm-level in Delta State, Nigeria

ABSTRACT

The present study examines profitability, technical, cost and allocative efficiencies of cassava production by applying Data Envelopment Analysis (DEA) of 315 farmers from three regions of Delta State, Nigeria. Results revealed that cassava production was profitable (overall profit margin 1.93), with significant differences across regions as well as farm size categories. Mean levels of technical, cost and allocative efficiencies are low estimated at 40%, 29% and 73% respectively, also with significant differences across regions as well as farm size categories. The implication is that cassava production can be increased substantially by reallocation of resources to optimal levels, given input and output prices. The results also confirmed inverse size-productivity and size-efficiency relationships in cassava production, i.e., the marginal farms are the most productive, profitable, and efficient. Subsistence pressure significantly reduces technical and cost efficiency. Extension contact significantly improves allocative efficiency whereas it reduces technical and cost efficiency. There is no gender difference in performance implying both men and women performs equally well. Farmers located in Delta South and Delta North are technically efficient relative to Delta Central. However, farmers located in Delta North are allocatively inefficient. Investment in extension services to make it more effective and improvements in infrastructure are suggested as policy options.

Key words: Profitability analysis, technical, cost and allocative efficiency, DEA, cassava production, Delta state, Nigeria.

1. Introduction

The agricultural sector in Nigeria is the major employer which employs nearly 70% of the country's labour force (Abolagba *et al.,* 2010; Ismaila *et al.,* 2010; Abolaji *et al.,* 2007). The sector is characterised by small scale traditional farming methods with very low levels of mechanization and modern technologies leading to low levels of productivity (Abang *et al*., 2000). The growth in the agricultural sector has been slow, growing at an annual rate of 3.7% to 6.5% during the period 2001-2012, which is about half of the GDP growth rates (Eboh *et al.,* 2012; CBN, 2011; Samuel *et al.,* 2010).

Cassava is an important crop that has great potential to support agricultural growth in Nigeria because of its wide range of use spanning from consumption to industrial use. Africa produces 40–50% of the world cassava output (FAO, 2005; Nang'ayo *et al.,* 2007) and Nigeria and Ghana are the leading producers (Ayoade and Adeola, 2009; Knipscheer *et al*., 2007; Nweke, 2004). In addition, recent studies have shown cassava to be a promising crop for international trade. Indeed, demand for cassava derivatives such as starch, gari (a type of processed cassava), tapioca, etc. were doubled over the last two decades (Nweke 2004).

However, the average yield level of cassava in Nigeria is low estimated at 14.7 mt/ha (Nang'ayo *et al*., 2007) as compared with 19 mt/ha in Indonesia, which is also a tropical country where production is similarly constrained by low level of input use, high variability in commodity prices, and lack of adequate infrastructure (Sugino and Mayrowani, 2009). To a large extent, the influence of these constraints could be reduced by changes in the use of modern inputs (e.g., fertilizers and pesticides), changes in tenancy policy, and the use of embodied technologies (Oyewo, 2011).

An important factor that affects productivity in developing country agriculture is farm operation size. The debate on size-productivity relationship is mixed in the literature. An inverse relationship between farm size and productivity is prominent in areas where farming practice is labour intensive because, for the large farms, high level of labour costs deters them to use hired labour to optimal levels (Niroula and Thapa, 2005). However, with increased use of modern technology and inputs, the inverse size-productivity relationship has been weakened in recent times (Ram *et al*., 1999 cited in Niroula and Thapa, 2005). Nigerian farming is characterized by small scale and labour intensive farming but large farmers are also featured to some extent. For example, Apata *et al*. (2011) noted that three percent of farm holdings are owned by large farmers with an average farm size of 13.51 ha. Therefore, it is important to test the size-productivity relationship in Nigeria using recent evidence, which this study is set to examine.

According to Ogunsumi *et al*., (2010), past success of the Agricultural Development Projects (ADP) in Nigeria were based on the availability of right technology, free access to inputs, adequate market and other infrastructural provisions. Nnadi *et al*. (2013) also noted importance of extension services in providing information on modern technologies and management of farm resources. However, with the withdrawal of World Bank funding, the quality of extension officers' training and their performance in supporting subsequent ADPs are on the decline (Chukwuemeka and Nzewi, 2011; Adebayo and Idowu, 2000). Nevertheless, the role of extension services cannot be undermined in the pursuit of improving productivity and efficiency in agriculture.

A number of studies looked into production efficiency of cassava in different states of Nigeria (e.g., Oladeebo and Oluwaranti, 2012; Raphael, 2008; Udoh and Etim, 2007; Ogundari and Ojo, 2007). All of these studies applied parametric approach, i.e., Stochastic Production Frontier approach with relatively smaller sample size ranging from 100–200 farmers. It is well known that although parametric approach has certain advantage of accommodating statistical noise, it requires assumption of the nature of production technology and behaviour of the market if cost and allocative efficiencies are to be analysed as well (e.g., Ogundari and Ojo, 2007). Furthermore, all of these studies used the restricted Cobb-Douglas specification of the production technology (without investigating alternative specifications) which imposes unitary elasticity of substitution as well as no interaction amongst inputs and may not represent the true form of underlying technological relationship. On the other hand, the non-parametric approach, i.e., the Data Envelopment Analysis (DEA), does not require any assumption of the production technology or the behaviour of the markets, but all noise and statistical errors are included as inefficiency. Another potential limitation of DEA is the failure to rank the most efficient Decision Making Units (DMUs) leading to possibility of some inefficient DMUs appearing as better overall performers. However, such weakness is unlikely to override the advantage of DEA, particularly, if these DMUs are very few in numbers in relation to total sample size.

Ogundari and Ojo (2007) estimated technical efficiency (TE), allocative efficiency (AE), and cost efficiency (CE) levels of 90%, 89% and 91% for cassava production in Nigeria. Similarly, Oladeebo and Oluwaranti (2012), Raphael (2008) and Udoh and Etim (2007) reported TE levels of 74–79% for cassava production in Nigeria. However, none of these studies examined the size-productivity and/or size-efficiency relationships in cassava production which may be an important limiting factor in assessing potential to improve farmers' performance.

Given this backdrop, the objectives of this study are: (a) to determine profitability of cassava production by farm size categories, (b) to estimate technical, allocative and cost efficiency of cassava production by farm size categories, and (c) to analyse the socio-economic determinants of technical, allocative and cost efficiency of cassava production.

The contribution of this research to the existing literature are three fold: (a) the study specifically tested the role farm operation size on the aforementioned objectives in order to test the size-productivity and size-efficiency relationship with respect to cassava production in Nigeria, which was not addressed in the previous studies; (b) use of the non-parametric DEA approach to estimate all three measures of efficiency simultaneously which then provides information on the potential to improve productivity of cassava without resorting to additional use of resources given existing levels of input prices; and (c) use of the fractional regression model to analyse the socio-economic determinants of observed efficiency levels.

2. Methodology

In order to examine profitability of cassava production, the standard gross margin analysis is used where costs of all family supplied inputs were imputed with market prices. Next, to estimate technical, allocative and cost efficiency of cassava production, DEA method is applied. And finally, to identify the determinants of DEA efficiency scores, a fractional regression model is estimated in the second stage. The details of the methods used are presented below preceded by a description of the study area, sampling procedure and the data.

2.1 Study area, sampling procedure and the data

Data used for the study were drawn from the three geopolitical zones of the Delta state of Nigeria which is situated at the South-southern (Niger Delta) part of Nigeria. These are, North, Central and South Delta. The Atlantic Ocean forms southern boundary of the state with a coastline of 160 kilometres. The state has two agro-ecological zones: riverine and upland; and consist of three vegetation types which include mangrove salt swamp areas (mainly in Delta South), rainforest areas (in Delta Central) and upland areas (in Delta North). The annual rainfall varies from 2,665 mm at the coast to 1,905 mm in the inner areas, with average temperature range from 30°C to 34°C. The major food crops grown in Delta state are cassava (leading producer), yam, plantain, maize, and vegetables (MANR, 2006).

Delta state was selected as the case study area due to a number of reasons. Cassava grows best in areas where annual rainfall is about 1,000–2,500 mm and is well distributed, as in Delta state. It can tolerate drought and may even survive 4-6 months of dry weather, provided that such dry weather does not occur too soon after planting. Because of its drought tolerant nature, cassava can grow in areas with as little as 600 mm annual rainfall (Erhabor *et* *al.*, 2007). Cassava does require some period of dry weather during maturity before harvesting. Delta state has the ideal climatic and soil conditions for the cultivation of cassava and it is a very important crop in the state because of its use as a staple food.

Farm sampling was based on the cell structure developed by the Agricultural Developmental Programme. First, nine local government areas (LGAs) of the total 25 LGAs in the state were selected randomly. Then three cells per LGA were chosen randomly. Next, 105 cassava growers from each LGA were selected using a stratified random sampling procedure with cassava farm operation size as the strata. The cut-off points for farm size followed the nationally defined categories (Apata *et al.*, 2011). These are: marginal farms – upto 1.00 ha; small farms – 1.01 to 2.00 ha; medium farms – 2.01 to 10.00 ha and large farms – >10.01 ha. This provided a total of 315 cassava farmers as the sample for the study.

For primary data collection, a structured questionnaire was administered containing both open and closed type questions. A team of two research assistants were trained by one of the authors and all three members were involved in collecting primary data using face to face interview method. Demographic and socio-economic information from each of the farm households included information such as age of the farmer, years of farming experience, number of household members, number of working adult household members, level of education (completed year of schooling) of the head of household, cassava farm operation size, contact with extension services and training received over the past one year, and gender of the household head. Input-output data included information on the quantities of cassava output, family and hired labour, fertilizers, pesticides, and seeds used. Also, information on all input and output prices were collected from each farm household based on memory recall of the farmers. The survey was conducted during September to December, 2008.

2.2 Profitability analysis of cassava

Profitability analysis includes calculation of detailed costs of production and return from cassava on a per hectare basis. The total cost (TC) is composed of total variable costs (TVC) and total fixed costs (TFC). TVC includes costs of human labour (both family supplied and hired labour, wherein the cost of family supplied labour is estimated by imputing market wage rate), seed, chemical fertilizers, and pesticides. The cost of tractor use (i.e., for ploughing, harrowing, followed by ridging) is counted as the additional hired labour cost attached to these operations because rental charges of only the tractor cannot be isolated. The tractor services are undertaken as contract based on ha of land to be tilled. TFC includes land rent (if owned land is used then the imputed value of market rate of land rent is applied). Although some other capital may have been used, e.g., buildings and farm implements, but the farmers could not recall the actual cost in order to derive a satisfactory depreciation costs involved for these items, and hence not included. The total revenue (TR) is computed by multiplying the cassava output with the current market price of cassava. The elements are computed as follows:

Total Revenue (TR) = Total cassava output * Cassava price

Gross Margin (GM) = Total Revenue (TR) – Total Variable Cost (TVC)

Total Cost TC = TVC + Total Fixed Cost (TFC)

Profit (P) = TR – TC

Profit margin = TR/TC

2.3 DEA approach to analyse technical, cost and allocative efficiency

Data Envelopment Analysis (DEA), a non-parametric approach, has been widely applied to measure relative efficiency of decision making units (DMUs) engaged in the production of goods and services (Kao and Hwang, 2008; Charnes *et al*., 1978). An advantage of DEA is its capacity to analyze multiple output–multiple input production technologies without assuming any functional form or behaviour of the DMUs or markets. The analysis provides DMU specific relative efficiency measures in comparison to its most efficient peers so that one can identify what factors are responsible for inefficient performance of DMUs.

Technical efficiency relates to the degree to which a farmer produces the maximum feasible output from a given bundle of inputs, or uses the minimum feasible amount of inputs to produce a given level of output. These two definitions of technical efficiency lead to what are known as output-oriented and input-oriented efficiency measures, respectively (Coelli *et al.*, 2002). These two measures of technical efficiency will coincide when the technology exhibits constant returns to scale, but are likely to differ otherwise.

In this study, the input-oriented efficiency measures were used because these lead to a natural decomposition of cost efficiency into its technical and allocative components (Coelli *et al.*, 2002). Since most of the sampled farmers have very small areas of land, the technology is unlikely to be significantly affected by non-constant returns to scale.

Allocative efficiency refers to a producer's ability to maximise profit given technical efficiency. It refers to a producer's ability to utilise the inputs in optimal proportions, given observed input prices, in order to produce at minimum possible cost. A producer may be technically efficient but allocatively inefficient (Hazarika and Alwang, 2003). Cost efficiency, also known as economic efficiency, results from both technical efficiency and allocative efficiency. Therefore, cost efficiency refers to a producer's ability to produce the maximum possible output from a given quantity of inputs at the lowest possible cost.

The DEA production frontier is constructed using linear programming techniques, which give a piece-wise linear frontier that 'envelopes' the observed input and output data. Technologies produced in this way possess the standard properties of convexity and strong disposability, which are discussed in Färe *et al.*, (1994). Although such linearity assumption in crop production is criticised as being too simplistic, the use of DEA is quite extensive in analysing performance of DMUs because of its inherent advantages. Also, with low levels of modern input use in small scale cassava production, the decreasing returns to increased investment in modern inputs is less likely to be a critical factor.

The DEA model is used to simultaneously construct the production frontier and obtain the technical efficiency measures. Following Coelli *et al*., (2002) the general model for data on K inputs and M outputs for each of the N farms is presented. For the ith farm, input and output data are represented by the column vectors x_i and y_i, respectively. The K×N input matrix, X, and the M×N output matrix, Y, represent the data for all N farms in the sample.

The DEA model used for calculation of technical efficiency (TE) is:

$$
\begin{aligned}
&\mathrm{Min}_{\theta,\lambda}\ \theta,\\
&\text{Subject to}\quad -y_i + Y\lambda \geq 0,\\
&\qquad\qquad\quad \theta x_i - X\lambda \geq 0,\\
&\qquad\qquad\quad N1'\lambda = 1\\
&\qquad\qquad\quad \lambda \geq 0, \qquad\qquad (1)
\end{aligned}
$$

where θ is a scalar, N1 is an N×1 vector of ones, and λ is an N×1 vector of constants. The value of θ obtained is the technical efficiency score for the ith farm. It will satisfy: $\theta \leq 1$, with a value of 1 indicating a point on the frontier and hence a technically efficient farm, according to the Farrell (1957) definition. Note that the linear programming problem must be solved N times, to obtain a value of θ for each farm in the sample.

The cost and allocative efficiencies are obtained by solving the following additional cost minimisation DEA problem:

$$
\begin{aligned}
&\min_{\lambda, x_i^*}\ w_i' x_i^*,\\
&\text{st}\quad -y_i + Y\lambda \geq 0,\\
&\qquad x_i^* - X\lambda \geq 0,\\
&\qquad N1'\lambda = 1
\end{aligned}
$$

$$\lambda \geq 0, \qquad (2)$$

where w_i is a vector of input prices for the i^{th} farm and x_i^* (which is calculated by the model) is the cost-minimising vector of input quantities for the i^{th} farm, given input prices w_i and the output levels y_i. The total cost efficiency (CE) of the i^{th} farm is calculated as

$$CE = w_i'x_i^*/\ w_i'x_i.$$

That is, CE is the ratio of minimum cost to observed cost for the i^{th} farm. The allocative efficiency (AE) is then calculated residually by

$$AE = CE/TE.$$

2.4 Determinants of efficiency: a fractional logit model

Since the DEA efficiency scores are bounded and typically lie between $0 < \theta \leq 1$, the application of standard regression model is not suitable as mentioned earlier in the introduction section. Therefore, the study adopted a fractional regression model introduced by Papke and Wooldridge (2008) which keeps the predicted values of the conditional mean of the fractional response in the unit interval. Ramalho *et al.* (2011) noted that if large proportion of the fractional data (i.e., efficiency scores) strictly lie above the 0 threshold but do not reach the upper boundary of 1, then a one-part analysis of the data is sufficient[2]. Therefore, a single step fractional logit model is applied in this study which was also adopted by Gelan and Muriithi (2012).

In simple terms, the one-part analysis involves only those observations with $y = \in (0, 1)$ for which a conditional mean or a parametric model is employed by assuming a particular distribution of the fractional variable (Ramalho *et al.*, 2011). The conditional mean of the dependent variable (i.e., efficiency scores θ) is given by (Ramalho *et al.*, 2011)

---

[2] See Ramalho *et al.* (2010) for detailed discussion of two-part and one-part analysis of fractional response models.

$$E(y|x) = G(x\theta) \qquad (3)$$

where G(.) is the known linear function satisfying $0 \leq G(.) \leq 1$. The study assumes $G(.)$ to be a logistic distribution function defined as:

$$G(x\theta) = \frac{e^{x\theta}}{1+e^{x\theta}} \qquad (4)$$

The derivative with respect to the index $x\ \theta$ is given by:

$$g(x\theta) = \partial G(x\theta)/\partial x\theta \qquad (5)$$

and the link function $h(\mu)$ is given by (Ramalho *et al.*, 2011):

$$h(\mu) = ln\frac{\mu}{1-\mu} \qquad (6)$$

The link function $h(\mu)$ is a widely used concept in the Generalised Linear Model (GLM) literature, and is defined as the function that relates the linear predictor $x\theta$ to the conditional expected value (Ramalho *et al.*, 2011):

$$\mu = E(y|x), \text{ i.e. } h(\mu) = x\theta \qquad (7)$$

The quasi-maximum likelihood estimation (QMLE) procedure was applied to obtain robust estimators of the conditional mean parameters developed above by using STATA Version 10 software (STATA Corp, 2010).

The following farm-specific socio-economic characteristics were used as regressors to identify the determinants of technical, cost and allocative efficiencies. These are farmers' experience in years (V_1), subsistence pressure (V_2), educational level of the head of the household (V_3), farm size (V_4), a set of dummy variables to identify the following: main occupation is farming (V_5), extension contact (V_6), training received (V_7), credit receipt (V_8), gender (V_9), Delta North (V_{10}), and Delta South (V_{11}). Choice of these variables are based on existing literature and justification thereof (e.g., Gelan and Murithi, 2012; Aye and Mungatana, 2011; and Coelli *et al.*, 2002).

3. Results

The summary statistics of the sample farms are presented in Table 1. The average farm size is 2.05 ha with similar share of marginal, small and medium/large farms[3]; average level of completed schooling is 6.92 years; average farming experience is 16 years; 35% of farmers had extension contact in the past one year and only 10% received any training.

3.1 Profitability of producing cassava

Table 2 presents the results of the profitability analysis of cassava production classified by farm size categories as well as regions. The major cost element is the labour cost (62% of total). Seed cost accounts for 20.9% of total cost. The cost of fertilizers, land rent and pesticides account for 8.8%, 7.5%, and 0.8%, respectively. The overall gross margin per hectare is Naira 58,609 (~ USD 293.05).

Anyaegbunam *et al.*, (2010) noted that labour cost varies between 70-90% of total cost and is a critical constraint in smallholder farming which is reflected in this study as well. It should be noted that about half of the labour cost is imputed family labour cost with market wages. This is the closest approximate to cost family labour used in the production process although a well-functioning hired labour market may not be available in all the survey villages in order to reflect true opportunity cost of family labour. The medium/large farms incur significantly higher levels of hired labour, fertilizers and pesticides costs as compared to marginal farms, yet derive significantly lower level of productivity and profitability, which is quite puzzling.

Cassava production is profitable across all farm size categories and regions with significant differences amongst them based on ANOVA analysis. The overall profit margin is 1.93. Table 2 clearly shows an inverse size-productivity relationship with marginal farms being the most productive as well as profitable followed by small farms. Geography does

---

[3] There is only one farm with cultivated land >10 ha. Therefore, the medium and large farms are grouped as one category.

matter. Both productivity as well as profitability is lowest in Delta North, which may be due to variations in the regional characteristics and agro-ecology.

3.2 Technical, cost and allocative efficiency of cassava production

Results of efficiency estimates using DEA are presented in Table 3 classified by farm size categories and by regions. The overall mean levels of TE, AE and CE are 40%, 73% and 29% respectively, with significant difference across regions as well as farm size categories. The implication is that there is substantial scope to boost cassava production by reallocating resources to optimal levels, given input prices. As with the case of productivity, a clear inverse size-efficiency relationship is observed with marginal farms scoring highest levels of TE, AE and CE. The last row of Table 3 presents the percentage of DMUs defining the frontier, where higher share of marginal farms are defining the frontier. It is somewhat surprising to see that no small farms are on the frontier. Although, some of the medium/large farms are defining the frontier, their share is relatively small and, therefore, is not of any concern. Therefore, based on the results from Table 2 and Table 3, it can be safely concluded that the classic inverse size-productivity as well as size-efficiency relationship exist in cassava production in these sample farms of Delta State, Nigeria.

Among the regions, farms located in Delta South, which is a coastal region, performed better than the other two regions. These efficiency measures presented in Table 3 are quite low compared to those reported for cassava production in Nigeria, where TE were in the range of 74–79% (e.g., Oladeebo and Oluwaranti, 2012; Raphael, 2008; Udoh and Etim, 2007; Ogundari and Ojo, 2007). However, as mentioned earlier, their estimates are based on restrictive Cobb-Douglas stochastic frontier models with relatively small sample sizes, which may be a source of difference.

4. Determinants of technical, cost and allocative efficiency of cassava production

Table 4 presents the parameter estimates of the fractional logit model with robust standard error obtained by applying Quasi-Maximum Likelihood Estimation (QMLE) procedure. A total of 12 variables representing farm-specific socio-economic factors were used to identify the determinants of observed technical, cost and allocative efficiencies of cassava production. The model diagnostics revealed that these variables jointly explain variation in farm-specific efficiency levels quite satisfactorily. A total of 13 coefficients out of 36 in three models (excluding the intercept) were significant at the 10% level at least, implying that these factors exert differential effect on the observed measures of efficiency.

Table 4 clearly shows that marginal farms are more efficient relative to small and medium/large farms which econometrically confirm the inverse size-efficiency relationship observed in Table 3. Subsistence pressure significantly negatively affects technical and cost efficiency. The interpretation is that higher dependency ratio increases inefficiency. In other words, large families with fewer working adults are relatively inefficient because labour available from the family may not have the requisite experience in farming.

Extension contact significantly improves allocative efficiency. However, extension contact also significantly reduces technical and cost efficiency. The implication is that farmers who have extension advice are using the inputs in the correct combination (i.e., improving allocative efficiency) but perhaps using too much of them and not achieving the expected yield (hence technical efficiency is lower). And because the farmers are using too much of the inputs, their cost efficiency is low. Aye and Mungatana (2011) also reported negative significant influence of extension contact on technical efficiency and positive influence on cost efficiency in maize production in Nigeria. They concluded that extension services in Nigeria in general have not been effective, especially after the withdrawal of the World Bank funding from the Agricultural Development Project, which is the main agency responsible for extension services (Aye and Mungatana, 2011). Table 4 also shows that training significantly negatively influence technical and cost efficiency. The reasons may be that the type of training which the farmers received are either not relevant or not specifically on cassava production and only 10% of the farmers have actually received any type of training in the sample. It is disappointing to see no influence of education or experience on efficiency. Gender does not pose any limitation on performance, implying that both male and female farmers perform equally well, which is very encouraging, particularly when 59% are female.

Location of farmers has an important effect on performance. Farmers located in the Delta North and Delta South are technically inefficient as compared with farmers in Delta Central. However, farmers in Delta North are allocatively inefficient. The reasons for such differences may lie with respect to differences in the regional features (e.g., soil conditions, topography, weather, and other unknown factors) and market conditions (e.g., input prices, timely availability, market infrastructure, market competition, *etc*.).

5. Conclusions and policy implications

The present study examined the level of profitability as well as technical, cost and allocative efficiency of cassava production as well as determinants of efficiency using a sample of 315 farmers from three regions of Delta State, Nigeria. Specifically, the study tested the hypothesis of inverse size-productivity and size-efficiency relationships in cassava production.

Results confirmed that Nigerian agriculture is still dominated by marginal and small farms accounting for 68% of the total sample which is very close to the national estimate of 70% reported by Apata *et al.* (2011). Cassava production is profitable across all farm size categories as well as regions. The overall profit margin is 1.93 and the average levels of TE, AE, and CE are 40%, 73%, and 29%, respectively, implying that cassava production can be boosted substantially by reallocation of resources to optimal levels, given input prices. The results also confirmed that cassava production in the Delta State, Nigeria demonstrated inverse size-productivity as well as size-efficiency relationships. The smallest scale farms, i.e., the marginal farms are the most productive, profitable and efficient followed by small farms. In other words, the cassava farming system in Nigeria conforms to the characteristics of regions with inverse size-productivity relationship as outlined by Niroula and Thapa (2005), i.e., dominant labour cost and low levels of modern input use (e.g., fertilizers, pesticides, and modern seeds). Extension contact significantly improves allocative efficiency whereas it reduces technical and cost efficiency. Subsistence pressure significantly reduces technical and cost efficiency. Farmers located in Delta North and Delta South regions are technically efficient relative to Delta Central (the effect of which is subsumed in the constant term). And farmers located in Delta North are allocatively inefficient relative to Delta Central.

The agricultural extension services in Nigeria needs to be revitalized so that it not only supports allocative efficiency but contributes to improving technical and cost efficiency of cassava production for all categories of farmers because mean efficiency levels are still very low across the board. This would require investment in developing capacity of the extension workers on new and improved technologies as well as dissemination strategies so that they can effectively serve to benefit the farmers. Also, measures are needed to target farmers located in Delta Central and Delta North to support them to overcome low level of inefficiency relative to Delta South. This may take the form of providing infrastructural and marketing support to bring them at par with the facilities and opportunities available for farmers in Delta South. Although the policy options are challenging, effective implementation of these measures will increase production of cassava that could contribute positively to agricultural growth in Delta State, Nigeria.

References

Abang, S.O., Ekpe, E.E. and Usani, W.W. (2000). Technical and allocative efficiency of small scale cassava farmers in five selected Local Government Areas of Cross Rivers State. *Global Journal of Food and Applied Sciences*, **1**: 37-47. DOI: http://dx.doi.org/10.4314%2Fgjpas.v7i1.16202

Abolagba, E.O., Onyekwere, N.C., Agbonkpolar, B.N. and Umar, H.U. (2010). Determinants of Agricultural Export. *Journal of Human Ecology,* **29**: 181-84.

Abolaji, D.D., Sinyanbola, W.O., Afolabi, O.O. and Oduola, I.A. (2007). Capacity innovations in cassava production, harvesting and processing in Nigeria.

Adebayo, K. and Idowu, I.A. (2000). The aftermath of the World Bank counterpart funding for the Ogun State Agricultural Development Programme (ADP) in Nigeria. *Journal of Sustainable Agriculture*, **17**: 79-98. DOI: 10.1300/J064v17n02_09

Anyaegbunam, H., Okoye,, B., Asumugha, G., Ogbonna, M., Madu, T., Nwakor, N. and Ejechi, M. (2010). Labour productivity among small-holder cassava farmers in South East agro ecological zone, Nigeria. *African Journal of Agricultural Research,* **5**: 2882-2885.

Apata, T.G., Folayan, A., Apata, O.M. and Akinlua, J. (2011). The economic role of Nigeria's subsistence agriculture in the transition process: implications for rural development. Paper presented at the 85th Agricultural Economics, UK conference at Warwick University during 18-20 April, 2011.

Aye, G.C. and Mungatana, E.D. (2011). Technological innovation and efficiency in the Nigerian maize sector: Parametric stochastic and non-parametric distance function approaches. *Agrekon: Agricultural Economics Research, Policy and Practice in Southern Africa*, **50**: 1-24. DOI: 10.1080/03031853.2011.617870

Ayoade, A.R. and Adeola, R. G. (2009). Constraints to domestic industrialization of cassava in Osun State Nigeria. *Ozean Journal of social sciences*, **2**: 1-5.

CBN, (2011). *Chapter Six: Real Sector Development*. Nigeria: Central Bank of Nigeria.

Charnes, A., Cooper, W. W. and Rhodes, E. (1978). Measuring the Efficiency of Decision Making Units. *European Journal of Operational Research*, **2:** 429-444. @ http://www.utdallas.edu/~ryoung/phdseminar/CCR1978.pdf

Chukwuemeka, E. and Nzewi, H.N. (2011). An empirical study of World Bank agricultural development programme in Nigeria. *American Journal of Social and Management Sciences*, **2**: 176-187.

Coelli, T.J., Rahman, S. and Thirtle, C. (2002). Technical, allocative, cost and scale efficiencies in Bangladesh rice cultivation: a non-parametric approach. *Journal of Agricultural Economics*, **53:** 607-626. DOI:10.1111/j.1477-9552.2002.tb00040.x

Eboh, E., Oduh, M.A. and Ejah, E. (2012). Drivers and sustainability of agriculture growth in Nigeria. *African Institute for Applied Economics* (AIAE) Research Paper 8.

Erhabor, P. O, Azaiki, S.S. and Ingawa, S.A. (2007). *Cassava the White Gold*. First edition. Benin City, Nigeria: Initiative publications Company, 2007.

FAO (2005). A Review of Cassava in Africa with Country Cases Studies on Nigeria, Ghana, United Republic of Tanzania, Uganda and Benin. Proceedings of the Validation Forum on the Global Cassava Development strategy, Volume 2. International Fund for Agricultural Development and Food and Agricultural Organisation of the United Nations, Rome.

Färe, R., Grosskopf, S. and Lovell, C.A.K. (1994). Production Frontiers. Cambridge: Cambridge University Press.

Farrell, M.J. (1957). The Measurement of Productive Efficiency. *Journal of the Royal Statistical Society* Series A, CXX (Part 3): 253-290. @ http://www.aae.wisc.edu/aae741/Ref/Farrell%201957.pdf

Gelan, A. and Muriithi, B.W. (2012). Measuring and explaining technical efficiency of dairy farms: a case study of smallholder farms in east Africa. *Agrekon: Agricultural Economics Research, Policy and Practice in Southern Africa*, **51**: 53-74. DOI: 10.1080/03031853.2012.695140

Hazarika, G. and Alwang, J. (2003). Access to credit, plot size, and cost inefficiency among smallholder tobacco cultivators in Malawi. *Agricultural Economics*, **29**: 99-109. DOI:10.1016/S0169-5150(03)00020-3

Ismaila, U., Gana, A.S., Tswanya N.M. and Dogara, D. (2010). Cereal Production in Nigeria: Problems, Constraints and Opportunity for Betterment. *African Journal of Agricultural Research.* **5**: 1341-1350. DOI: 10.5897/AJAR09.407

Kao, C. and Hwang, S.N. (2008). Efficiency decomposition in two-stage data envelopment analysis: An application to non-life insurance companies in Taiwan. *European Journal of Operational Research*, **185**: 418–429. DOI: 10.1016/j.ejor.2006.11.041

Knipscheer, H., Ezedinma, C., Kormawa, P., Asumugha, G., Mankinde, K., Okechukwu. R. and Dixon, A. (2007). Opportunities in the Industrial Cassava Market in Nigeria. *International Institute for Tropical Agriculture (IITA).*

MANR (2006). Ministry of Agriculture and Natural Resources, Delta State, Nigeria. Agricultural Development Policy Report.

Nang'ayo, F., Odera, G., Muchiri, N., Ali, Z. and Werehire, P. (2007). *A Strategy for Industrialization of Cassava in Africa*. Proceedings of a Small Group Meeting, 14-28 November 2005, Ibadan, Nigeria. African Agricultural Technology Foundation, Kenya. @ http://aatf-africa.org/userfiles/CassavaProceedings.pdf

Niroula, G.S. and Thapa, G.B. (2005). Impacts and causes of land fragmentation, and lessons learned from land consolidation in South Asia. *Land Use Policy*, **22**: 358-372. doi:10.1016/j.landusepol.2004.10.001

Nnadi, F.N., Chikaire, J., Echetama, J.A., Ihenacho, R.A. and Utazi, C.O. (2013). Assessment of agricultural extension strategies for poverty alleviation in Imo State, Nigeria. Net *Journal of Agricultural Science*, **1**: 17-23.

Nweke, F. (2004). *New challenges in the cassava transformation in Nigeria and Ghana. .* IFPRI, Washington, D. C.

Ogundari, K. and Ojo, S.O. (2007). An Examination of Technical, Economic and Allocative Efficiency of Small Farms: The Case Study of Cassava Farmers in Osun State of Nigeria. *Bulgarian Journal of Agriculture,* **13**: 185-195.

Ogunsumi, L.O., Farinde, A. J. and Alonge, G.C. (2010). Comparative Analysis of Extension Services of Agricultural Development Programme in Edo and Osun States, Nigeria. *American Journal of Social and Management Sciences,* **1**: 186-190.

Oladeebo, J.O. and Oluwaranti, A.S. (2012). Profit Efficiency among Cassava Producers: Empirical Evidence from South Western Nigeria. *Journal of Agricultural Economics and Development,* **1**: 46-52.

Oyewo, I.O. (2011). Technical Efficiency of Maize Production in Oyo State. *Journal of economics and International Finance* **3**: 211-16.

Papke, L.E. and Wooldridge, J.M. (2008). *Panel data methods for fractional response variables with an application to test pass rates*. Journal of Econometrics, **145**: 121-133. DOI:10.1016/j.jeconom.2008.05.009

Ramalho, E.A., Ramalho, J.J.S. and Henriques, P.D. (2010). Fractional regression models for second stage DEA efficiency analysis. CEFAGE-UE Working Paper 2010/01.

Available @ editorialexpress.com/cgi-in/conference/download.cgi?db_nameCEF 2010&paper _id=90 (accessed 06 June 2013).

Ramalho, E.A., Ramalho, J.J.S. and Murteira, J.M.R. (2011). Alternative estimating and testing empirical strategies for fractional regression model. *Journal of Economic Surveys.* **25**:19–68. DOI: 10.1111/j.1467-6419.2009.00602.x

Raphael, I.O. (2008) Technical Efficiency of Cassava Farmers in South Eastern Nigeria: Stochastic Approach. *Agricultural Journal,* **3**: 152-56.

Samuel, B., Adam, K., Malisa, L. and McBride, L. (2010). *Monitoring Agricultural Development Process and Performances: A Comparative Analysis*: Regional Strategic Analysis Knowledge Support System (RESAKSS).

STATA Corp. (2010). STATA Version 10. Stata Press Publications, College Station, Texas, USA.

Sugino, T. and Mayrowani, H. (2009). The determinants of cassava productivity and price under the farmers' collaboration with emerging cassava processors: A case study in East Lampung, Indonesia. *Journal of Development and Agricultural Economics,* **1**: 114-20.

Udoh, E.I. and Etim, N-A. (2007). Application of Stochastic Production Frontier in the Estimation of Technical Efficiency of Cassava Based Farms in Akwa Ibom State, Nigeria. *Agricultural Journal,* **2**: 731-35.

Table 1. Definition, measurement and summary statistics of the variables

Variables	**Definition**	**Mean**	**Standard deviation**
Cassava root tuber	Kg/ha of cassava root tuber produced	12137.35	11498.98
Inputs			
Farm size	Area under cassava production in hectare	2.05	1.71
Fertilizer	Kg of all fertilizers	94.63	175.14
Labour	Person days	212.77	160.90
Seed	Kg	67.59	48.19
Pesticide	Litre of active ingredients	0.70	2.45
Prices			
Land rent	Naira per hectare	4382.54	760.60
Fertilizer price	Naira per kg	142.82	14.21
Wage rate	Naira per day	579.88	110.43
Seed price	Naira per kg	297.40	58.53
Pesticide price	Naira per litre	1614.66	161.84
Socio-economic factors			
Education	Completed years of schooling	6.92	4.98
Subsistence pressure	Number of family members/working adult	1.52	1.17
Experience	Years engaged in farming	16.11	11.63
Delta North	Dummy (1 if Central, 0 otherwise)	0.33	--
Delta South	Dummy (1 if South, 0 otherwise)	0.33	--
Delta North	Dummy (1 if South, 0 otherwise)	0.33	--
Main occupation	Dummy (1 if farmer, 0 otherwise)	0.84	--
Extension contact	Dummy (1 if had extension contact in the past one year, 0 otherwise)	0.35	--
Credit received	Dummy (1 if had received credit, 0 otherwise)	0.29	--
Training received	Dummy (1 if had received training, 0 otherwise)	0.10	--
Marginal farms	Dummy (1 if cultivated area upto 1.00 ha, 0 otherwise)	0.33	
Small farms	Dummy (1 if cultivated area between 1.01 – 2.00 ha, 0 otherwise)	0.35	--
Medium/large farms	Dummy (1 if cultivated area >2.01 ha, 0 otherwise)	0.32	--
Gender	Dummy (1 if male, 0 otherwise)	0.41	--

Note: Exchange Rate: GBP1.00 = Naira 200.00.

Table 2: Profitability of cassava production per hectare (N) by farm size and region.

Variables	**Region**				**Farm Sizes Category**		**Overall**
	Delta Central	**Delta South**	**Delta North**	**Marginal**	**Small**	**Medium/Large**	
Cassava root tuber (kg)	6874.38	7283.25	5904.56	8571.56	6351.83	5100.34	6687.39
Cassava output price (N)	16.73	17.29	16.48	17.00	17.02	16.45	16.83
Total revenue/ha(N)	115008.4	125927.4	97307.15	145716.60	108095.48	83900.59	112560.53
Imputed family labour cost	19693.25	19729.24	14348.68	18146.20	18326.62	17245.12	17923.72
Hired Labour cost	14793.06	16015.89	23767.11	17321.92	16951.94	20473.41	18192.02
Total labour cost	34567.77	35621.43	37829.19	35445.67	35179.94	37506.08	36006.13
Fertilizer cost	5366.32	3818.83	6237.75	2564.42	5598.04	7313.22	5140.97
Pesticide cost	411.11	295.04	648.75	431.01	321.73	617.27	451.63
Seeds cost	11931.19	15662.74	9133.24	17225.25	10375.58	9132.36	12242.39
Total Variable Cost/ha (N)	52276.40	55398.03	53848.92	55666.36	51475.30	54568.92	53950.73
Imputed land rental cost	2887.05	3781.67	2131.96	3540.86	3164.68	2045.43	2933.56
Rented land rental cost	1741.50	479.76	2385.47	843.26	1438.92	2362.87	1535.57
Total Fixed cost	4614.29	4271.43	4261.90	4413.46	4360.36	4375.00	4382.54
Gross Margin	62732.00	70529.37	43458.23	90050.24	56620.18	29331.67	58609.81
Profit	58117.72	66257.94	39196.32	85636.78	52259.82	24956.67	54227.27
Profit Margin	2.02	2.11	1.67	2.43	1.94	1.42	1.93

Note: Exchange Rate: GBP1.00 = Naira 200.00.

Significant difference exists across regions for all variables except fertilizer and pesticide costs (based on One-Way ANOVA analysis).

Significant difference exists across farm size categories for all variables except imputed family labour cost and Total Fixed Cost (based on One-Way ANOVA analysis).

Source: Computed from Field Survey, 2008

Table 3. Technical, cost and allocative efficiency of cassava production by region and by farm size.

Regions	**Delta Central**			**Delta South**			**Delta North**			**Overall**		
	TE	**AE**	**CE**	**TE**	**AE**	**CE**	**TE**	**AE**	**CE**	**TE**	**AE**	**CE**
Mean	0.37	0.75	0.28	0.43	0.78	0.32	0.39	0.66	0.26	0.40	0.73	0.29
Std Deviation	0.14	0.12	0.13	0.23	0.18	0.17	0.21	0.18	0.18	0.20	0.17	0.16
Minimum	0.15	0.47	0.12	0.19	0.26	0.15	0.08	0.12	0.06	0.08	0.12	0.06
Maximum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
p-value for regional differences (ANOVA)										0.057	0.000	0.011
Farm size categories	**Marginal (upto 1.00 ha)**			**Small (1.01 – 2.00 ha)**			**Medium/Large >2.01)**			**Overall**		
Mean	0.50	0.82	0.40	0.34	0.71	0.23	0.36	0.67	0.24	0.40	0.73	0.29
Std Deviation	0.21	0.16	0.17	0.12	0.13	0.06	0.21	0.15	0.19	0.20	0.16	0.17
Minimum	0.24	0.12	0.08	0.17	0.39	0.11	0.08	0.14	0.06	0.08	0.12	0.06
Maximum	1.00	1.00	1.00	0.74	0.99	0.41	1.00	1.00	1.00	1.00	1.00	1.00
p-value for farm size differences (ANOVA)										0.000	0.000	0.000
% of farmers defining the frontier by farm size	7.69	3.84	3.84	--	--	--	6.00	3.00	3.00	4.44	2.22	2.22

Source: Computed from Field Survey, 2008

Table 4. Determinants of technical, cost and allocative efficiencies in cassava production (fractional logit model with robust standard errors)

Variables	**Technical efficiency**	**Allocative efficiency**	**Cost efficiency**
Constant	-0.6669***	1.0949***	-1.0215***
Delta North§	0.2715**	-0.3581***	0.0816
Delta South§	0.2401**	-0.1234	0.0788
Education	0.0027	-0.0063	0.0026
Main occupation§	0.1597	-0.2004*	0.0396
Subsistence pressure	-0.0689**	0.0148	-0.0542***
Experience	-0.0034	-0.0022	-0.0048
Extension contact§	-0.5565***	0.5866***	-0.2148*
Training received§	-0.2608**	0.0593	-0.2150**
Credit received§	-0.0883	-0.0334	-0.1832
Marginal farms§	0.6925***	0.5834***	0.7839***
Small farms§	0.1361	-0.1117	0.0192
Gender§	0.1117	-0.0005	0.0797
Model diagnostic			
Pseudo log likelihood	-143.68	-124.75	-129.74
AIC	0.9948	0.8745	0.9063
BIC	-1693.73	-1705.04	-1705.33
Number of observations	315	315	315

Note: *** = significant at 1 percent level ($p<0.01$)
** = significant at 5 percent level ($p<0.05$)
* = significant at105 percent level ($p<0.10$)
§ = dummy variables.