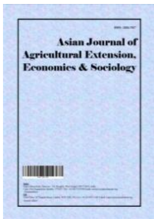

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Data Envelopment Analysis Approach to Estimating Economic and Scale Efficiency in Processing Cassava into Gari in Ankpa Local Area, Kogi State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author EOH designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors EES and BA managed the literature searches, participated in data collection and processing. All authors read and approved the final manuscript.

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ABSTRACT

This study examined the economic and scale efficiency in processing cassava into gari in Ankpa Local Government, Kogi State. Data were collected from 120 cassava processors through a multistage sampling technique in 2019 using questionnaire as the instrument for data collection. Data collected were analyzed through the use of Data Envelopment Analysis (DEA), ordinary Least squares regression analysis and simple descriptive statistics. The result of the study revealed that about 8.33% and 63.33% achieved full technical efficiency (TE = 1) under the CRS and VRS respectively while 12.50% achieved both full allocative and economic efficiency. About 8.33% achieved full scale efficiency. These efficiency scores revealed the presence of considerable level of inefficiency and room for improvement in order to become fully efficient. The returns to scale analysis revealed that majority of cassava processors (about 90%) are operating under increasing returns scale implying that most of the firms in the sample are too small and therefore would benefit

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from an increase in scale. The OLS result showed that household size, experience and education are the most important and significant factors affecting both technical and economic efficiency of the processors in the study area. We recommend that processors should be encouraged to form and join viable cooperatives where they can access credit, information, training and processing facilities in order to improve their efficiency.

Keywords: Gari; data envelopment analysis; efficiency; returns to scale.

1. INTRODUCTION

Nigeria is predominantly an agricultural society as over 70 percent of the population are engaged in agriculture [1]. However, the country rely heavily on petroleum as the sector provides for 95% of Nigeria's foreign exchange earnings and 80% of its budgetary revenues [2]. With the dwindling oil fortunes in the international market, there is a major policy shift towards the diversification of the economy. An example of this is the launching of Presidential Initiative on Increased Cassava Production and Export Programme in (2002) where cassava export is estimated to generate 5.4 billion dollars annually for five years [3]. The goal is the promotion of cassava as a viable foreign exchange earner and the development of the production system to sustain the national demand [4]. This is as a result of the realization that cassava has the potential to increase farm incomes, reduce rural and urban poverty and help close the food gap [5]. Nigeria is the leading world cassava producer with an estimated annual output of 34 million tones with Benue and Kogi in the North-central the highest cassava producing states [6].

Fresh cassava roots are bulky and highly perishable. They cannot be stored for long because they rot within 3 – 4 days after harvest as they contain about 70 percent moisture [7]. Processing of cassava provides a means of producing shelf stable products (thereby reducing losses), adding value at a local rural level and reducing the bulk to be marketed [3]. Processing also eliminate or reduce the level of Hydrogen Cyanide in cassava and improve the palatability of the products. [8] pointed out that as urban population expand, the demand for more convenience and shelf-stable foods increases. Gari is the major processed, consumed and marketed form of cassava [9]. According to [10], gari has a long shelf-life, a year or more as long as it is not exposed to moisture, it is therefore attractive to urban consumers. Gari appeals mainly to low income households because it offers the cheapest source of food calories compared to grains. Thus, processing of cassava into gari reduces post-harvest losses of cassava, creates form, place and time utilities and incentives to actors in the value chain.

The traditional pealing and grating methods of cassava into main products such as gari, among others are grossly inefficient with low turnover, and sometimes injurious to health. By implication, poor processing technology results in quality deterioration, storage losses and health hazards. The post-harvest losses has been estimated to be about 50 percent for root and tuber crops [8] due to glut and transportation problems in rural areas. This means that producers and processors are not maximizing the benefit of their output. Improving processors' efficiency would increase their income and provide food security for households. Studies on cassava processing into gari in Nigeria reported that it is technically efficient [9]. However, quantitative empirical study on economic and scale efficiency of processing cassava into gari using data envelopment analysis is scarce. It is against this backdrop that this study examined economic and scale efficiency of processing cassava into gari in Ankpa Local Government Area, Kogi State.

2. MATERIALS AND METHODS

This study was conducted in Ankpa Local Government Area. Ankpa LGA is one of the 21 Local Government Areas in Kogi State, Nigeria. Its headquarters are in the town of Ankpa on the A 233 highway in the west of the area at 7°22'14" 7°37'31"E. The total land area is 1,200km^2 and a population of 267,353 at the 2006 census [11]. The population has increased to 359,300 in 2016. The LGA has 3 districts areas and 13 wards and many villages under the districts. The predominant occupation of people are farming and trading with a small percentage of people in civil service. The LGA cultivates a number of crops among which are cassava, tomato, okra, maize and Oil palm.The area is rich in minerals resources with coal as the most common.

A multi-stage sampling technique was employed in selecting respondents for the study. All the three (3) districts in the local government area were considered in the selection of data for the study. The districts are Ankpa, Enjema and Ojoku. In stage one (1), one (1) council ward was purposively selected from each of the districts based on their level of cassava processing activities. In stage two (2), two (2) communities were randomly selected from each thus giving a total of six (6) communities. In stage three (3), twenty respondents were randomly selected from each community making a total of one hundred and twenty (120) respondents for the study. Structured questionnaire was administered to the selected gari processors coupled with interview method to take care of respondents without formal education. The study used the two-stage technique to data envelopment analysis (DEA) to analyze the data.

2.1 Data Envelopment Analysis Approach to Efficiency Measurement

This study utilized the Data Envelopment Analysis (DEA) approach to efficiency measurement to examine economic efficiency of gari processors in the study area. DEA was developed by [12], and it is a non-parametric, deterministic procedure for evaluating the frontier and employs the best-practice frontier [13]. Unlike the Stochastic Frontier Approach (SFA), DEA uses linear programming methods to construct a piecewise frontier of the data. Since it is nonparametric, DEA does not require any assumptions to be made about the functional form or distribution type. It is thus less sensitive to misspecification relative to SFA. However, the deterministic nature of DEA means all deviations from the frontier are attributed to inefficiency.

2.1.1 Technical Efficiency (TE)

In using the DEA model, the technical efficiency (TE) score of a given processor (firm) n is obtained by solving the following input-oriented linear programming (LP) problem:

$$TE_n = \min \theta_n \quad (1)$$

Subject to

$$\sum_{i=1}^{1} \lambda_i x_{ij} - \theta_n x_{nj} \leq 0 \quad (2)$$

$$\sum_{i=1}^{1} \lambda_i y_{ik} - y_{nk} \geq 0 \quad (3)$$

$$\sum_{i}^{1} \lambda_i = 1 \quad (4)$$

$$\lambda_i \geq 0 \quad (5)$$

Where:

i= one to I processors (firms); j = one to J inputs; k = one to K outputs; x_{ij} = the amount of input j used byfirm i; ; x_{nj}= amount of input j used by firm n; y_{ik} = amount of output k produced by firm i ; y_{nk} = amount of output k produced by firm n ; λ_i = non-negative weights for I firms; θ_n = a scalar ≤ 1 that defines the TE of firm n. If θ_n= 1 , it means the firm is technically efficient and if the value is less than one ,it indicates a technically inefficient firm with the level of technical inefficiency equal to 1 - TE_n [14].

Equation (2) is the input constraint specified for every input j. The constraint stipulates that the input used by the firm n , weighted by its efficiency must exceed or be equal to a weighted combination of all inputs used by the other firms. The output constraint formulated for every output $k$is represented by Equation (3). This stipulates that for every output obtained by firm n must be lower than or equal to the weighted combination of outputs obtained by other firms. Equation (4) sets the sum of all weights given to other firms equal to 1 and ensures that TE_n is calculated under the assumption of Variable returns to scale (VRS) [14]. Equation (1) to (5) is the formulation proposed by [15] to calculate pure technical efficiency (TE_n = TE_{VRSn}). When Equation (4) is omitted, constant returns to scale (CRS) is assumed, and the model reflects the formulation proposed by [12] to calculate the overall technical efficiency ((TE_n= TE_{CRSn}).

2.1.2 Economic efficiency

Economic efficiency (EE) is also referred to as cost efficiency and is calculated as the ratio of the minimum feasible costs and the actually observed costs for a decision-making unit [16]. If a decision-making unit is both technically and allocatively efficient, then it is said to be economically efficient. The EE score for a given firm *n* is obtained by solving the following input-oriented DEA model to obtain the minimum cost:

$$MC_n = min \lambda_i x_{nj}^{*} \sum_{j=1}^{J} p_{nj}\, x_{nj}^{*} \quad (6)$$

Subject to:

$$\sum_{i=1}^{j} \lambda_i\, x_{ij} - x_{nj}^{*} \leq 0 \quad (7)$$

$$\sum_{i=1}^{I} \lambda_i\, y_{ik} - y_{nk} \geq 0 \quad (8)$$

$$\sum_{i=1}^{I} \lambda_i = 1 \qquad (9)$$

$$\lambda_i \geq 0 \qquad (10)$$

Where:

MC_n= the minimum total cost for firm$n$; p_{nj} = the price for input j for firm n ; x_{nj}^* = the cost minimizing level of input j for firm n given its input price and output levels; all other variables are as previously defined. The constraint $\sum_{i=1}^{I} \lambda_i = 1$ ensures that the total minimum costs for the field are calculated under VRS assumption [17,18]. The economic efficiency for each firm n can then be calculated using Equation (11).

$$EE_n = \frac{\sum_{j=1}^{J} p_{nj} x_{nj}^*}{\sum_{j=1}^{J} p_{nj} x_{nj}} \qquad (11)$$

Where:

The numerator is the minimum total cost obtained for firm n based on equation (6) to (10) and the denominator is the actual total cost observed for firm$n$. When EE_n =1, the firm is economically efficient and EE_n< 1 means the firm is economically inefficient.

EE for each firm can also be estimated as a product of technical efficiency and allocative efficiency

$$EE_n = TE_n \mathrm{X} AE_n \quad [16]. \qquad (12)$$

2.1.3 Allocative efficiency

Thus, the allocative efficiency (AE) score for firm n can be estimated given both TE and EE for the firm using the following relationship:

$$AE_n = \frac{EE_n}{TE_n} \qquad (13)$$

Where:

EE_n = economic efficiency calculated for firm n using Equation 11 and TE_n = technical efficiency calculated for firm $n$using Equation 1 to 5. When the value of AE_n = 1, the firm is allocatively efficient and an AE_n< 1 means it is allocatively inefficient.

2.1.4 Scale efficiency and returns to scale

As stated earlier, CRS can be estimated by omitting the constraint $\sum_{i=1}^{I} \lambda_i = 1$ in the estimation of TE and EE. Imposing CRS and VRS in the estimation of TE allows for the computation of scale efficiency. The scale efficiency (SE_n) for a firm n is estimated as follows:

$$SE_n = \frac{TE_{CRS_n}}{TE_{VRS_n}} \qquad (14)$$

Where:

TE_{CRS_n} = technical efficiency of a firm n under constant returns to scale and TE_{VRS_n}= technical efficiency under variable returns to scale. When SE_n = 1, it means the firm is operating at an optimal scale and when SE_n< 1, the firm is scale inefficient. Scale inefficiency arises as a result of the presence of increasing returns to scale (IRS) or decreasing returns to scale (DRS). The estimate obtained from equation (14) can indicate if the firm is scale- inefficient but does not provide information whether the inefficiency is as a result of IRS or DRS. Increasing or decreasing returns to scale may be determined for each firm by estimating the TE model in equation (1) and replacing the constraint $\sum_{i=1}^{I} \lambda_i = 1$ with$\sum_{i=1}^{I} \lambda_i \leq 1$. The outcome is TE calculated under non-increasing returns to scale (TE_{NIRSn}). If TE_{NIRSn}= TE_{VRSn}, the firm exhibits DRS(larger than optimal scale) ; if $TE_{NIRSn} \neq TE_{VRSn}$, the firm operates IRS (sub-optimal scale) [19]. The Technical, allocative, cost and scale efficiency were estimated using the computer program DEAP version 2.1 developed by [20].

2.2 Ordinary Least Squares (OLS) Multiple Regression Analysis

The ordinary least squares (OLS) regression was used to examine the factors affecting technical and economic efficiency of gari processors in the second stage. [21] pointed out that this method is quite popular in agricultural research. The use of Tobit regression has been widely criticized for producing inconsistent estimates and contextually inappropriate since the TE scores are fractions and not generated by censoring procedure [22]. The OLS regression technique is considered an appropriate method to use in this situation and is believed to produce better results [22]; it is a stable estimator and its computation is easy [23]. Also, [24] believed that the OLS regression provides a statistically consistent estimator of the coefficients under more general assumptions. The OLS method have been used in several DEA studies (See [25,26]; among others).

The OLS regression is specified as follows:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + + \beta_6 X_6 + \varepsilon$$

Where:

Y = TE or EE scores; α = constant; $\beta_1 \ldots \beta_5$ = parameters to be estimated; X_1 = age (years); X_2 = household size (number); X_3 = processing experience(years) ; X_4 = cooperative membership (yes=1; 0 otherwise); X_5 = Access to credit (yes=1; 0 otherwise) ; X_6 = education(years of formal education); ε = error term.

3. RESULTS AND DISCUSSION

3.1 Technical, Allocative, Economic and Scale Efficiency Score of Gari Processors

The summary of technical, allocative and economic efficiency indexes of gari processors is presented in Table 1. The technical efficiency scores were presented under constant returns to scale and variable returns to scale. The mean TE_{CRS} (overall) is 0.83, a minimum of 0.65 and a maximum of 1 while the mean TE_{VRS} (pure) is 0.91, a minimum of 0.67 and a maximum of 1. Over half of the processors have TE of 0.83 or higher under CRS and achieve full technical efficiency (TE=1) under VRS. Some of the processors did not utilize their resources in the most efficient manner, thus did not obtain the maximum output. The inefficient processors can still increase their TE by about 17% under CRS and 9% under the VRS. The result of TE obtained in this study is higher when compared to what is reported in other studies. Using the stochastic frontier production function [7] obtained a mean TE of 0.82 and 0.53 for local and modern method of processing gari respectively while [9] reported a mean TE of 0.65.

The mean allocative efficiency score for gari processors in the study area is 0.88 with a range of 0.71 – 1.0. The median AE score mirrored the mean. Given this AE level, some processors are not using inputs in a cost-minimizing level given the prices of inputs they face and that on average cost may be reduced by 12% to attain the level of the best allocative efficient processor.

The mean economic efficiency of the gari processors is 0.80 with a range of 0.63 – 1.The range is similar to the mean. This result indicates that some processors are economically inefficient on average and that the total cost of processing cassava into gari can be reduced by about 20% to attain the same level of output.

The scale efficiency as presented in Table 1 revealed a mean of 0.91 and a median of 0.92. The range is 0.75 – 1. This scale efficiency score indicates that most processors operates close to optimal scale size. Thus the TE can be improved by 9% by adapting the scale of their firms.

Further analysis of returns to scale as shown in Table 2 revealed that about 90% of the processors operate at an increasing returns to scale (sub-optimal scale), indicating that most of the firms in the sample are too small and therefore these firms would benefit from an increase in scale. The number of processors that operated at constant returns to scale (optimal size) were 10 (8.33%) while only 2 (1.67%) operated at decreasing returns to scale (i.e. operated above optimal size). In order to be

Table 1. Summary of technical, allocative and economic efficiency indexes of gari processors

Class	TECRS		TEVRS		Allo Eff.		Eco. Eff.		Scale Eff.	
	Freq.	Perc.	Freq.	Perc.	Freq.	Perc.	Freq.	Perc.	Freq	Perc.
1	10	8.33	76	63.33	15	12.50	15	12.50	10	8.33
0.90 - 0.99	44	36.67	0	0.00	20	16.67	19	15.83	74	61.67
0.80 - 0.89	24	20.00	7	5.83	78	65.00	35	29.17	33	27.50
0.70 - 0.79	29	24.17	36	30.00	7	5.83	12	10.00	3	2.50
0.60 - 0.69	13	10.83	1	0.83	0	0.00	39	32.50	0	0.00
Total	120	100.00	120	100.00	120	100.00	120	100.00	120	100.00
Mean	0.83		0.91		0.88		0.80		0.91	
Median	0.83		1		0.88		0.80		0.92	
Std.Dev.	0.11		0.12		0.07		0.12		0.05	
Min	0.65		0.67		0.71		0.63		0.75	
Max	1		1		1		1		1	

efficient most firms should operate at large scale. This can be achieved by encouraging processors to form cooperatives in order to enjoy economics of scale.

Table 2. Returns to scale summary statistics of gari processors

Class. of scale Eff.*	Frequency	Percentage
CRS	10	8.33
IRS	108	90.00
DRS	2	1.67
Total	120	100.00

** CRS: Constant Returns to Scale; IRS: Increasing Returns to Scale;DRS: Decreasing Returns to Scale*

3.2 Factors Affecting Gari Processors' Efficiency

We used a two-step approach following [20] using OLS regression to examine factors affecting gari processors' efficiency. The results are presented in Tables 4 and 5. The summary statistics of socioeconomic characteristics of gari processors are presented in Table 3.

Tables 4 and 5 revealed that household size, experience in cassava processing and education are important and significant factors affecting technical efficiency while household size and education are the significant factors affecting economic efficiency of gari processors in the study area. While household size, experience in cassava processing, membership of cooperative society and education are positively related technical efficiency, age and access to credit are negatively related to it. Household size, experience, access to credit and education are positively related to economic efficiency while age and membership of cooperative society are negatively related to it.

Household size increases processors' technical and economic efficiency. [5] reported that the manual pealing of cassava roots and frying/toasting of gari is tasking and labour-intensive. Depending on the age composition of the households, an increase in household size means more family labour would be available for cassava processing. Chukwuji et al. [9] reported that large household size increases gari processors’ technical efficiency because they are under pressure to provide for the household needs of calorie and to produce marketable surpluses in order to generate needed cash income for the family.

Table 3. Descriptive statistics of socioeconomic variables of gari processors (N=120)

Variable	Unit	Mean	Minimum	Maximum
Age	Year	45	19	66
Household Size	Number	7	1	15
Experience	Year	17	1	35
Education	Years of Formal Education	7	6	18
Coop. Membership	1=yes; 0= No			
Access to Credit	1=yes; 0= No			

Source: Field Survey (2019)

Table 4. OLS estimates of factors affecting technical efficiency of gari processors

Variable	Coef.	Std. Err.	T-Stat.	P-Value
Constant	1.178	0.054	21.970	0.00***
Age	-0.001	0.001	-1.020	0.31
Household Size	0.014	0.005	3.010	0.003***
Experience	0.004	0.002	2.030	0.045**
Coop. Membership	0.058	0.099	0.580	0.56
Access to Credit	-0.044	0.100	-0.440	0.66
Education	0.007	0.003	2.110	0.04**
Model				
F-Stat.(6,113)	8.92			
Prob.> F	0.00			
R-Squarred	0.3213			
Adj. R-Squarred	0.2853			
No. of Observ.	120			

***P = .05 ***P = .01*

Source: Field Survey (2019) and STATA 12

Table 5. OLS estimates of factors affecting economic efficiency of gari processors

Variable	Coef.	Std. Err.	T-Stat.	P-Value
Constant	1.045	0.058	18.09	0.00***
Age	-0.001	0.001	-0.86	0.39
Household Size	0.012	0.005	2.28	0.02**
Experience	0.003	0.002	1.54	0.13
Coop. Membership	-0.100	0.107	-0.94	0.35
Access to Credit	0.125	0.107	1.16	0.25
Education	0.010	0.004	2.68	0.01***
Model				
F-Stat.(6,113)	6.92			
Prob.> F	0.00			
R-Squarred	0.2688			
Adj R-Squarred	0.2300			
No. of Observ.	120			

***P = .05 ***P = .01*

Source: Field Survey (2019) and STATA 12

Experience in cassava processing increases processors' efficiency as this enables them to avoid previous mistakes and adapt to economic changes. Similar findings were reported by [7]; that experience in cassava processing, among other factors led to increase in TE for processors using local method.

Education is also positively related to both technical and economic efficiency of gari processors. The level of education could have serious implications on their ability to access information, adopt new technologies and even access or procure credit from formal financial institutions. Chukwuji et al. [9] reported that education encourages adoption of better management systems by producers and promotes the consciousness to maximize the full benefit of resource use, while [27] found that education brings about choice of better input combinations and use of existing inputs.

An increase in processors' age beyond the mean of 45 years reduces both their technical and economic efficiency. This means that older processors are less efficient than their young counterparts. This can be attributed to the fact that older processors are less willing to take risks and adopt new technologies. Chukwuji et al. [9] has reported similar findings; that age has positive effect on technical inefficiency of processors, indicating that the older ones are less efficient than the younger ones.

Membership of processors cooperative society increases TE but surprisingly reduces economic efficiency. Membership of a cooperative enables processors access credit and inputs are lower costs, share market information and receive training concerning their productive activities. Chukwuji et al. [9] reported that the training cooperative give to their members with respect to better management practices tend to encourage more efficient use of resources. Similarly, [9] noted that that members of cooperative societies are able to adopt better techniques of production than non– members because of the greater awareness created and encouragement given to their members.

Access to credit is negatively related to TE and positively related to EE. Credit will enable processors acquire the necessary inputs and finance their processing activities. From the result obtained majority of gari processors did not have access to credit which may have accounted for the negative relationship with economic efficiency.

4. CONCLUSION

This study used the input-oriented DEA to estimate the technical, allocative and economic efficiency of 120 gari processors in Ankpa local government, Kogi state. The OLS regression was used to examine the factors affecting technical and economic efficiency of the processors. The objective was to address lack of empirical studies on efficiency performance using the DEA and the factors affecting it in the study area. The result revealed that about 8.33% and 63.33% achieved full technical efficiency (TE=1) under the CRS and VRS respectively while 12.50% achieved both full allocative and economic efficiency. About 8.33% achieved full scale efficiency. These efficiency scores reveal the presence of considerable level of inefficiency and room for improvement in order to become fully efficient. the returns to scale analysis revealed that majority (about 90%) are operating under increasing returns scale implying that most of the firms in the sample are too small and therefore would benefit from an increase in scale. household size, experience and education are most important and significant factors affecting both technical and economic efficiency of the processors in the study area.

Based on the results of this study the following recommendations are made:

1. Gari processors should be encouraged to form and join viable cooperative associations that can be used as a driver for acquiring loans for members at affordable interest rates. Members of these cooperatives should also be encouraged to pool resources together to acquire processing facilities. This will reduce cost of cassava processing.
2. Considerable efforts should be geared towards improving educational level of processors. In this case, government and Non-governmental organizations through extension agents, can teach processors modern techniques in gari processing. They are also very important in creating awareness and dissemination of improved cassava processing technologies Adult education programmes can also be put in place to enhance their ability to read and write. Such education and information dissemination can be done in their local languages.
3. Formal lending institutions and government micro credit schemes should be encouraged to advance loans and credit to processors at low interest rates. This will enable them acquire the necessary processing facilities. Private and non-governmental organizations should also be encouraged to establish processing centers close to them to ease cost of transportation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Adegun IK, Ajimotokan HA, Akinlosoye AA, Babarinde MS. Development of a cassava processing plant for producing improved stone-free Garri. Journal of Agricultural Technology. 2011;7(5):1193-98.
2. Globaledge; 2018.
Accessed 15 June 2020
Available:https://globaledge.msu.edu/countries/nigeria/economy
3. Phillips T, Taylor DS, Sanni L, Akoroda M. A Cassava Industrial Revolution in Nigeria. The potential for a new industrial crop. IFAD/FAO, Rome. 2004;43.
4. Sanni LO, Onadipe OO, Ilona P, Mussagy MD, Abass A, Dixon AGO. Successes and challenges of Cassava enterprise in West Africa: A case study of Nigeria, Benin and Sierra Leone. International Institute of Tropical Agriculture, Ibadan. Nigeria. 2009; 9-11.
5. IFAD (International Fund for Agricultural Development) and FAO (Food and Agriculture Organization of the United Nations). A review of cassava in Africa with country case studies on Nigeria, Ghana, the United Republic of Tanzania, Uganda and Benin. Proceedings of the Validation Forum on the Global Cassava Development Strategy. 2005;2:66.
6. Nigeria's Cassava Industry. Statistical Handbook. International Institute for Tropical Agriculture (IITA); 2004.
7. Ehinmowo OO, Ojo SO. Analysis of technical efficiency of cassava processing methods among small scale processors in South – West, Nigeria. American Journal of Rural Development. 2014;2(2):20-23.
8. Processing of cassava into gari and high quality Cassava flour in West Africa. USAID / CORAF / SONGHAI TRAINING MANUAL (DRAFT); 2010.
9. Chukwuji CO, Inini OE, Ike PC. Determinants of technical efficiency in gari processing in Delta State Nigeria. Journal of Central European Agriculture. 2007; 8(3):327-36.
10. Nweke FI. New challenges in Cassava Transformation in Nigeria and Ghana. Paper presented at the Inn WENT, IFPRI, NEPAD and CTA conference on Success in Africa Agriculture. Pretoria; December 1-3; 2003.
11. NPC (National Population Commission). Population Census of the Federal Republic of Nigeria; Draft Report; 2006.
12. Charnes A, Cooper WW, Rhodes E. Measuring the efficiency of decision making units. European Journal of Operational Research. 1978;2:429–44.

13. Bates JM, Baines D, Whynes DK. Measuring the efficiency of prescribing by general analysis. Journal of Operational Research Society. 1996;47(12):1443–51.
14. Coelli TJ. Recent developments in frontier modelling and efficiency measurement. Australian Journal of Agricultural and Resource Economics. 1995;39(3):219-45.
15. Banker RD, Charnes A, Cooper WW. Some models for estimating technical and scale inefficiencies in Data Envelopment Analysis. Management Science. 1984;30: 1078–92.
16. Farrell MJ. The measurement of productive efficiency. Journal of the Royal Statistical Society. Series A (General). 1957;120(3): 253-90.
17. Fletschner DK, Zepeda L. Efficiency of small landholders in Eastern Paraguay. Journal of Agricultural and Resource Economics. 2002;27:554–72.
18. Wu S, Prato T. Cost efficiency and scope economies of crop and livestock farms in Missouri. Journal of Agricultural and Applied Economics. 2006;38:539–53.
19. Coelli T, Rahman S, Thirtle C. Technical, allocative, cost and scale efficiencies in Bangladesh rice cultivation: A Non-parametric Approach. Journal of Agricultural Economics. 2002;53(3):607-26.
20. Coelli TJ. A Guide to DEAP version 2.1: A Data Envelopment Analysis (computer) Program. Armidale, Australia: Centre for Efficiency and Productivity Analysis, University of New England; 1996.
21. Liu JS, Lu LY, Lu, WM, Lin BJ. A survey of DEA applications. Omega. 2013;41:893-902.
22. Banker RD, Natarajan R. Evaluating contextual variables affecting productivity using data envelopment analysis. Operational Resources. 2008;56(1):48-58.
23. McDonald, J. Using least squares and Tobit in second stage DEA efficiency analyses. European Journal of Operational Resource. 2009;197:792-98.
24. Johnson AL, Kuosmanen T. One-stage and two-stage DEA estimation of the effects of contextual variables. European Journal of Operational Research. 2012; 220:559-70.
25. Umar M, Zainalabidin M, Mad NS, Juwaidah S, Abdullahi I. Application of data envelopment analysis for technical efficiency of smallholder pearl millet farmers in Kano State, Nigeria. Bulgarian Journal of Agricultural Science. 2018; 24(2):213–22.
26. Le TL, Pai PL, Ke CP, Rebecca HC. Technical and cost efficiency estimates of rice production in Vietnam: A two-stage data envelopment analysis. The Journal of Animal and Plant Sciences. 2019;29(1): 299-305.
27. Ahzar RA. Education and technical efficiency during the Green Revolution in Pakistan. Economic Development and Cultural Change. 1991;39(3):651–65.

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