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Estimation of Technical Efficiency for Rice Farms in Kebbi State: A Data Envelopment Analysis (DEA) Approach

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Abstract:*This paper estimates the technical efficiency of rice farms in Kebbi State utilizing Data Envelopment Analysis and Tobit regression. Primary data were collected using structured questionnaires from a sample of 231 rice producers surveyed in 2016 production season. The finding reveals that the mean technical efficiency estimates was 65.6 percent. This implies that 34.4 percent of potential output is lost due to technical inefficiency. The average input slacks for seeds, fertilizer, agrochemicals and labour were found to be 0.103, 0.838, 0.071 and 0.170 individually. This implies excess used of these inputs by their respective quantities. The output slack was found to be zero, meaning that no excess output was recorded. Education, extension contact and planting technology were the factors that significantly decreased the technical inefficiency of the farmers in the research area. The study concluded that most of the rice farmers in the investigation area are producing below the best possible output and have the opportunity to increase their output by 34.4 percent simply by using the technology of the best practice farm.*

Key words:*Technical efficiency, DEA, Tobit regression, Input and output slacks*

Contribution/Originality:*Wastefulness is the issue in Nigerian rice production. Efficient utilization of scarce resources is the best way to encourage farmers in order to achieve high yield. This paper to study the production efficiency among rice farmers in Kebbi State Nigeria, employing a data envelopment analysis model.*

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I. Introduction

Rice is an important crop and strategic commodity for food security in Nigeria. It has turned into an important food in Nigeria where by each family unit comprising does possessing material wealth and the wretched consume a large quantity [1]. The importance of rice in the Nigerian economy made different government administration to set up research centres, implement various agricultural policies and programs to address the problems of inefficiency and market challenges in the agricultural sector and rice to be specific. However, smallholder farmers accounting for about 80% of country's total farmers population [2] are still surrounded with many problems such as low harvest yield, restricted opportunity to get credit and other services from agricultural experts, poor processing and storage facilities and lack of perfect information about the market condition prompting high transaction costs related with input and output market engagement [3, 4].

Rice is produced in basically all the agro-natural zones in Nigeria [5] mostly by smallholder farmers who are confined to the rural areas where they depend on farming as their main source of income. In spite of the abundant agro-natural zones in Nigeria, in 2015 available records shows that Nigeria supply only 2.3 million tons of rice out of 6.3 million tons needed for consumption [6]. This implies that, Nigeria is only 36.5% self-sufficient in rice production. The pressure coming from the need for rice compare to the quantity of the commodity available for use is shown in the continuous increase in the costs of the goods thus has relative large implication for food security and financial improvement of the Nigerian economy.

The challenges of the agricultural sector and rice sub-sector to be specific prompted the government and development organizations to renew their efforts by forming farmer groups as one of the basic ways in the execution of farming and value chain enhancement plans in developing nations. Farmer groups can increase rural community enhancement, reduce the level of poverty in the community, increase efficiency and food security through their job in encouraging successful and productive smallholder involvement in agricultural food value chains [7]. Thus, In 2015 Nigerian government launched the Anchor Borrowers Programme to diversify its economy. The aim of the programme is to organize farmers into groups, providefinancial connection between the farmers and Agro-processor with the intention to increase the production of rice and some targeted commodities. Substantial agribusiness organization and non-governmental organizations keep on supplementing the efforts of the government by setting up successful vertical coordination mechanism (for instance, contracting) with farmer groups [3, 8]. Under these connections, the programme provide subsidize farm inputs both in cash and kind to farmers, technical support service amid the cultivating period and ready market for the farmers to dispose their produce at harvest. These efforts of the government could additionally be complemented with detail investigation of the factors affecting productivity of the rice cultivars. Knowing the causes and extend of technical inefficiency would suggest how potential output could be increase or potential expenses could be diminished.Additionally efficiency analysis decides the under use or over use of factor inputs.

Existing literature concerning farm efficiency in Nigeria have been focused on estimation of efficiency by utilizing parametric method. However, the use of deterministic approach (DEA) is still not much. The benefits of the approach are; the technique does not require the specification of production function thus, the likelihood of incorrect functional form is avoided. It can also be utilized to many outputs and many inputs [9, 10]. Thus, this investigation intends to estimate the technical efficiency of rice farms in Kebbi State using DEA method and identify the factors influencing technical inefficiency of the farmers in the investigation area.

The remaining part of the study is organized according to section 2, 3, and 4 respectively. Section 2 covered methodology which include: study area, data collection, sampling techniques, data analysis and theoretical framework, section 3 covered results and discussion while section 4 focuses on conclusions.

II. Methodology

2.1. Study Area

The research was carry out in Kebbi State, Nigeria. Kebbi State lies between latitude 11^0 30'N Longitude 4^0 15'E on the equator and has a total area of 36,229 square kilometres out of which 12,600 square kilometres is under agriculture [11]. The State is characterized with distinct wet and dry season. Wet season start from April and end October, while dry season last for the remaining part of the year. The yearly precipitation vary from 600mm to 875mm and on average 650mm amid the period 1997 to 2014 [12].Kebbi State comprised of twenty one Local Government Area (LGA) and four Agricultural Development Zones (Figure 1)[11]. It is endowed with water bodies such as River Niger, Rima River and river Ka. These rivers are sources of water for irrigation and fishing. The climate, soil and vegetation allow for the cultivation of staple crops like rice, millet, guinea corn, maize, wheat, beans, soya bean, groundnut and vegetables among others. The source of income for people living in Kebbi State depend greatly on farming.

2.2 Data Collection

This investigation used cross sectional data from an aggregate of 231 rice farms randomly sampled from Kebbi State. The data for the study was sourced from the survey conducted for the period of 2016 farming season. The data covered relevant variables including output and inputs variables as well as farm specific variables.

2.3. Sampling Techniques

Kebbi State has 21 Local Government Area with four agricultural zones [11]. Rice farmers are in cooperatives with the least of five and highest of twenty persons per cooperative in all the four zones. The list of all the cooperatives was collected from Kebbi State Agricultural Development Authority. In arriving at the representative sample from the list, cluster random sampling approach was employed to select the respondents from the four zone as follows: zone i(Birnin Kebbi) 68, zone ii (Argungu) 44, zone iii (Suru) 95 and zone iv (Zuru) 24, totalling 231 respondents.

Figure 1: Map of Kebbi State indicating the twenty one local government area of the State

2.4. Data Analysis

This research employed output oriented DEA as outlined by Coelli and Battese [13] and adopted by Yusuf and Malomo [14]. The methodology estimate how much input mix the farmer would have to change to achieve the output level that corresponds with the best practice frontier. After generating technical efficiency scores of every sampled farm by using Data Envelopment Analysis (DEA) model, following Lim [15],Tobitregression was used to estimate the factors influencing technical inefficiency of the farmers.

2.5. Theoretical Framework

Data Envelopment Analysis (DEA) is a linear scheduling technique of estimating efficiency. In this method, efficiency of a particular firm is contrasted with the ''best practice firm,'' meaning comparing with a firm that is hundred percent efficient.Farrell [16] was the first to estimate productive efficiency of a firm that is below hundred percent. The advantage of this method is that one overcomes the inconveniences of specifying production technology hence the likelihood of incorrect functional form is evaded. Also the method give room to suggest on the quantity of input to be use and output to be produce. There two efficiency measures in DEA, which is input-oriented efficiency and output-oriented efficiency. According to Coelli[9] DEA builds a piece-wise linear surface by utilizing least inputs of rice farms, if input-oriented efficiency examination is applied. Then again, if output-oriented efficiency examination is applied, a piece-wise linear surface is developed by focusing on the maximum outputs of rice farms. DEA can either be Constant Return to Scale (CRS) or Variable Return to Scale (VRS). CRS infers that a degree of change in inputs will corresponds to the same degree of change in output while VRS suggests a degree of change in inputs will corresponds to a more than a degree of change in output (IRS) or less than a degree of change in outputs (DRS).Rice farmers in the study area were found to experience variations in agricultural production occasioned by factors, for example, financial constraints, fluctuating inputs prices, inconsistent labour supply, pest and disease and so forth. Since there is no justification to expect that CRS exists in the cultivation of the rice at the farm level, the use of VRS was assumed appropriate in order to account for these variations. Technical efficiency was estimated based on output orientation where household produces the best possible output given a level of inputs and determines the greatest proportional increase in output produced with input level held fixed.

This study follows Yusuf and Malomo [14] methodology, the overall approach is specified as:

$$MaxTE = \frac{\sum_{r}^{s} D_r Y_{r0}}{\sum_{r=1}^{m} T_i X_{i0}} = \frac{K}{K^*} \quad (1)$$

Subject to:

$$\frac{\sum_{r=1}^{s} D_r Y_{rj}}{\sum_{r=1}^{m} T_i X_{ij}} \leq 1 \quad (2)$$

j = 1,….n; $D_r, T_i \geq 0$ for any r, i; r = 1,…..s; i = 1,…..m and X_{ij} and Y_{rj} individually are the amounts of the i-th input and r-th output of the j-th farm. T_i and D_r are input and output weights individually. As the relative magnitudes of the input and output amounts is maximized it would be limited to be no greater than one. The variables in the Data Envelopment model are described upon below:

Y_{rj} = Quantity of rice output obtained by j-th farmer measured in Kilogram per hectare (Kg/ha).

X_{ij} = Input quantity: seed in Kilogram per hectare (kg/ha), fertilizer in kilogram per hectare (Kg/ha), agrochemicals in litre per hectare (Lt/ha) and labour in man day per hectare (Man days/ha). All the Decision Making Units (DMUs) with a score of 1 were regarded as being technically efficient (fully or 100% efficient), while all other DMUs with scores of less than 1 or 100% were rated as being technically inefficient.After generating the technical efficiency of every sampled farm by using DEA method, Tobit regression was used to estimate the factors influencing technical inefficiency. Following [15],Tobit regression model for this study is specified as follows:

$$U_j = \beta_0 + \beta_1 Sex_j + \beta_2 Hhs_j + \beta_3 Edu_j + \beta_4 Exp_j + \beta_5 Ext_j + \beta_6 Lanown_j + \beta_7 Lct_j + \beta_8 Plt_j + \beta_9 Hvt_j + \varepsilon_j \quad (3)$$

Where U_j implies technical inefficiency of farm j, obtained by subtracting technical efficiency score of farm j from 1 (TE = 1-TI) before running Tobit regression. $\beta_{0,}\beta_i$ Are estimated parameters of inefficiency factors, ε_j represent an error term of j farm which is presumed to be independent and normally distributed. The factors included in the technical inefficiency model are presented in Table 1.

2.5.1 Depictions of the factors and their likely signs in the inefficiency model

Sex: This factor was captured as 1 and 0. Number 1 represent female while male was captured as 0. Studies on this variable varies, result could either be positive or negative. Positive result implies increase in inefficiency and vice versa.

Household size: Household size was captured in numbers. It refers to the total number of individual who live and feed in the house. It is expected to have positive effect on inefficiency. Substantial household size having financial wastefulness is conceivable looking at the estimation of farm products that could have been disposed of to the purchaser however are eat in by the family. Also, in a circumstance where the household size is substantial and just a little bit of farm labour is obtained from it, then the inefficiency effects are likely to be greater.

Education: Education was captured as number of years spent in formal schooling. Studies have demonstrated that agriculturists with high level of formal training have greater tendency and capacity to receive new innovation and development. Education is likely to have negative effects on technical inefficiency [9].

Farming Experience: Farming experience is the number of years over which the farmer had been engaged in farming. Studies on farming experience have given mixed results. Coelli and Battese [9]revealed that the age of the farmers which is directly corresponded with cultivating knowledge of the farmer could have a positive or negative effects on efficiency. They infers that older farmers are to have had more cultivating knowledge and hence less inefficiency. But it is also possible that older cultivators could be traditional and resistant to change and therefore show less ability to embrace new practices hence more inefficiency.

Extension contact: Extension specialist are likely to give advisory services and preparing of farmers to enhance their efficiency. The variable was captured as number of contact and training the extension agent had with the farmers and is likely to have negative effects on technical inefficiency.

Land ownership: land ownership was measured as dummy variable, 1 assigned to own land and 0 assigned to hired land. This could have either positive or negative effects on efficiency. Direct relationship with efficiency is in line with the assumption that longer years of leasing encourage farmers to work harder to meet their contractual obligations [9]. A negative relationship was reported byGiannakas [17].

Land cultivation method: Land cultivation method was measured as 1 and 0. Number 1 was given to farmers who use manual tillageduring land preparation and 0 was given to farmers that use machine. It is expected that land preparation with machine should have negative effects on technical inefficiency. This is because machine minimize waste of time and the harrow allows deep tillage of the soil which improves soil aeration and subsequently yield.

Planting method: Planting method was recorded as dummy variable. Broadcasting wascaptured as 1 while transplanting 0. Transplanting method is likely to have negative effects on technical inefficiency because the method ensure that only viable plants are transferred to the farm with the right spacing, so that each plants has an equal chance of survival. In broadcasting method a lot of seeds are wasted. More seeds may fall into one space and will have to compete for nutrients resulting in a relatively lower yield.

Harvesting method: Dummy variable was used to represents harvesting method. 1 was assigned to farmers who use manual harvesting while 0 was given to those who harvested with combine harvester. Those with combine harvester are expected to be more efficient than those that harvested manually.

Table 1. Depiction of the factors in the inefficiency model

Factor	Parameter	Measurement
Sex	β_1	Female=1, male=0
Household size	β_2	Numbers of people living in the house
Education	β_3	Years in school Primary=6yrs, secondary 12yrs, colleges15yrs, university16yrs, others specify……….
Farming experience	β_4	Years in rice cultivation
Extension contact	β_5	Number of contact with extension agent
Land ownership	β_6	Own land=1, hired land=0
Land cultivation method	β_7	Manual=1,Use machine=0
Planting method	β_8	Broadcasting=1,Transplanting=0
Harvesting method	β_9	Manual=1, use machine=0

Source: Field survey data, 2016.

III. Results And Discussion

3.1. Estimates of Technical Efficiency.

Table 2 reveals that the average technical efficiency is just about0.656. This implies that on the average farmers produced only 65.6 percent of the best possible output for a given input levels for the period of production under analysis, thus they are 34.4 percent below the best possible output at a given technology. The results simply means that the farmers in the study area have the opportunity to increase their output in the short run simply by adopting a technology of the best practice of the best farm. The maximum estimated technical efficiency was found to be 1 that is hundred percent and the minimum was 0.104 that is ten point four percent.On top of the table, 11.3percent of the sampled farmers were technically efficient meaning that their production activities is at hundred percent. This group of farmers have achieved their frontier output. Furthermore, 17 percent of the sampled farmers have average technical efficiency greater than 90 percent, about 11.7 percent have a mean technical efficiency greater than 80 or equal to 90 percent and 13.5 percent have a mean technical efficiency greater than 70 or equal to 80 percent. Similarly, 8.1 percent of the sampled farmers have a mean technical efficiency greater than 60 or equal to 70 percent, 11.3percent of the farmers average technical efficiency was found to be greater than 50 or equal to 60 percent, while 27.1 percent of the sampledfarmers operating on mean technical efficiency greater than 10 or equal to 50 percent were those who were badly affected by different factors such as technical production problems, socio-economic problems and environmental problems. The result of this study agrees with the findingsof Ismail *et.al*. [18] and Cobanoglu [19].

Table 2. Distribution of technical efficiency scores among the respondents

Efficiency Scores	Frequency	Percentage
1.00	25	11.3
>0.90<1	38	17.0
>0.80≤0.90	26	11.7
>0.70≤0.80	30	13.5
>0.60≤0.70	18	8.1
>0.50≤0.60	25	11.3
>0.40≤0.50	17	7.7
>0.10≤0.40	43	19.4
Total	222	100
Mean	**0.656**	
Minimum	0.104	
Maximum	1.000	
Standard Deviation	0.272	

Source: Field survey data, 2016.

3.1.1. Output and Input Slacks. Slack issues advanced when it is unsure whether a farm is on efficient point on the frontier. Input slack which is generally named as input excess is the surplus quantity of any input that can be removed and yet produce a similar quantity of output. Estimates of the DEA technique usually generate: radial Farrell technical efficiency scores and radial slacks to give an exact piece of information of a DEA investigation. Table 3 revealed slack factors acquired from the DEA estimates of the farmers.

Result in Table 3 shows that, the values of output are all zeros, implying that no excess output was found. This by implication means that the output were not optimized. On the average seed, fertilizer, agrochemicals and labour had slacks of 0.103, 0.838, 0.071 and 0.170 individually. These suggested that the inputs could be diminished by those quantities and yet produce a similar output level. It likewise shows that these inputs were not efficiently utilized in the production process. Then again, the farms were being wasteful in their input utilization by the said quantities.

Table 3. Output and Inputs Slacks

Output/Inputs Variables	**Slack**
Output (Rice grains kilogram per hectare)	0.000
Inputs	
Seed (kilogram per hectare)	0.103
Fertilizer (kilogram per hectare)	0.838
Agrochemicals (Litre per hectare)	0.071
Labour (Man days per hectare)	0.170

Source: Field survey data, 2016.

3.2. Factors Influencing Technical Inefficiency

Table 4 reveals that the coefficients of years of education, extension contact and planting technology are factors significantly reducing the technical inefficiency of the respondents in the surveyed area. Higher number of years in formal education will expose farmers to new ideas and increase their managerial capacity in production, market accessibility and increase efficiency. The finding agrees with [9]. The coefficient of extension visit is statistically significant. This implies that the more the farmer acquire extension services, the more they become less inefficient. The studyagrees with the finding of [20]. Also, planting technology (Transplanting) employed by the farmers significantly decrease their technical inefficiency.

Table 4. Estimates of the factors influencing technical inefficiency of the respondents

Variable	**Parameter**	**Coefficient**	**Standard Error**
Constant	β_0	0.4104***	0.098
Sex	β_1	-0.0371	0.036
Household Size	β_2	-0.0023	0.002
Education	β_3	-0.0022**	0.001
Years of farming	β_4	-0.0237	0.027
Extension contact	β_5	-0.0035**	0.002
Land ownership	β_6	-0.0096	0.017
Land cultivation Technology	β_7	0.0156	0.077
Planting Technology	β_8	-0.1137**	0.049
Harvesting Technology	β_9	0.0209	0.027

Source: Field survey data, 2016.**Note:** *, ** and *** represents 10%, 5% and 1% levels of significance.

IV. Conclusions

The investigation focussed on the technical efficiency of rice farms and the factors influencing technical inefficiency of the respondents. The finding revealed that rice cultivates in Kebbi State on the average achieved only output value of 0.656 when contrasted withthe best farm output value of 1. This implies that on the average farmers produced only 65.6 percent of the best possible output for a given input levels for the period of production under analysis, thus they are 34.4 percent below the best possible output at a given technology. The result revealed an opportunity for farmers in the study area to increase their output by 34.4 percent simply by accepting the technology of the best practice of the best farm.Education, extension contact and planting technology are factors significantly decreasing technical inefficiency of the respondents in the investigation area.

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[1]. Godwin, U. "Rice farm, milling plant: Sure money spinner." (2013).
[2]. Akinsuyi, Y. "Local government intervention: Impact in small scale farming." *This day Live* (2011): 4.
[3]. Evbuomwan, Grace O., and Lawrence U. Okoye. "Evaluating the prospects of the Anchor Borrowers Programme in Nigeria." (2017): 1-10.
[4]. Mojo, Dagne, Christian Fischer, and TerefeDegefa. "The determinants and economic impacts of membership in coffee farmer cooperatives: recent evidence from rural Ethiopia." *Journal of Rural Studies* 50 (2017): 84-94.
[5]. Erenstein, Olaf, et al. "Rice production systems in Nigeria: A survey." *Abidjan, Côte d'Ivoire: West Africa Rice Development Association* (2003).
[6]. FMARD.'' Agricultural Promotion Policy (2016-2020).'' Building on the success of the ATA, closing gaps, Federal Ministry of Agriculture and Rural Development (FMARD). 2016, Nigeria.
[7]. Ainembabazi, John Herbert, et al. "Improving the speed of adoption of agricultural technologies and farm performance through farmer groups: evidence from the Great Lakes region of Africa." *Agricultural economics* 48.2 (2017): 241-259.
[8]. Barrett, Christopher B., Paul Christian, and Bekele A. Shiferaw. "The structural transformation of African agriculture and rural spaces: introduction to a special section." *Agricultural economics* 48.S1 (2017): 5-10.
[9]. Coelli, Timothy J., et al. *An introduction to efficiency and productivity analysis*. Springer Science & Business Media, 2005.
[10]. Pokharel, Krishna P., and Allen M. Featherstone. "Estimating multiproduct and product-specific scale economies for agricultural cooperatives." *Agricultural Economics* (2019).
[11]. Usman, Suleiman. "Surface soil factors and soil characteristics in geo-physical milieu of Kebbi State Nigeria." *Eurasian Journal of Soil Science* 5.3 (2016): 209-220.
[12]. Oluwasemire, K. O., and S. O. Alabi. "Ecological impact of changing rainfall pattern, soil processes and environmental pollution in the Nigerian Sudan and northern Guinea savanna agro-ecological zones." *Nigerian Journal of Soil and Environmental Research* 5.1 (2004): 23-31.
[13]. Coelli, Tim J., and George E. Battese. "Identification of factors which influence the technical inefficiency of Indian farmers." *Australian Journal of Agricultural Economics* 40.2 (1996): 103-128.
[14]. Yusuf, S. A., and O. Malomo. "Technical efficiency of poultry egg production in Ogun state: a data envelopment analysis (DEA) approach." *International journal of poultry science* 6.9 (2007): 622-629.
[15]. Lim, Ghee Thean. *Efficiency Performance of Malaysian Brackish Water White Shrimp Production*. Diss. University Putra Malaysia, 2014.
[16]. Farrell, Michael James. "The measurement of productive efficiency." *Journal of the Royal Statistical Society: Series A (General)* 120.3 (1957): 253-281.
[17]. Giannakas, Konstantinos, Kien C. Tran, and Vangelis Tzouvelekas. "Predicting technical efficiency in stochastic production frontier models in the presence of misspecification: a Monte-Carlo analysis." *Applied Economics* 35.2 (2003): 153-161.
[18]. Mohd, Mansor Ismail, IdrisNurjihan, and BehroozHassanpour. "Technical efficiency estimates of paddy farming in Peninsular Malaysia: a comparative analysis." *Annals of Biological Research* 4.5 (2013): 114-118.
[19]. Cobanoglu, Ferit. "Measuring the technical efficiency of cotton farms in Turkey using stochastic frontier and data envelopment analysis." *Outlook on Agriculture* 42.2 (2013): 125-131.
[20]. Lemessa, SisayDiriba, et al. "Risk Adjusted Production Efficiency of Maize Farmers in Ethiopia: Implication for Improved Maize Varieties Adoption." *Turkish Journal of Agriculture-Food Science and Technology* 5.9 (2017): 1099-1107.

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