The Influence of Crop Production Intensification on Technical Efficiency of Maize-Based Farming Households in Kwara State, Nigeria.

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ABSTRACT:
Efficiency Analysis is an issue of interest among economists in recent times, given that the overall productivity of an economic system is directly related to the efficiency of production of the components within the system. Thus, this study examined crop production intensification and technical efficiency of maize-based farming households in Kwara State, Nigeria. Data used for this study were obtained using structured questionnaire administered to 144 randomly selected maize-based farming households in Kwara state. The stochastic frontier production function methodology was used to empirically determine the level of technical efficiency of maize-based farming households as well as the factors that influence the efficiency. Given the specification of a Cobb-Douglass stochastic production function, in which the technical inefficiency effects are specified to be functions of several explanatory variables, the inefficiency effects of the smallholder farming households were significant. The estimated technical efficiency of the sampled households varied widely, ranging from 11.0% to 99.9%, with a mean value of 39.3%. Farming households were generally relatively not efficient, they still have room to increase the efficiency in their farming activities as about 60.7% efficiency gap from the optimum (100%) remains yet to be attained by all Kwara state maize-based farming households. Therefore, in the short run there is room for increase in technical efficiency of maize-based households in the study area. Farming experience, household size, credit access and crop production intensification were factors found significant in influencing the level of technical efficiency of Kwara state maize-based households.

Keywords: Technical efficiency, maize-based farming households, crop production intensification.

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Introduction

Agricultural growth in Nigeria is increasingly recognized to be central to sustained improvement in economic development. The sector plays a very significant role in food security, poverty alleviation and human development chain (Amaza and Maurice, 2005). However, in recent years, there has been a marked deterioration in the performance of Nigeria's agriculture. The contribution of agriculture to the gross domestic product (GDP) which stood at an average of 56 percent in 1960-64 declined to 47 percent in 1965-69 and further decline to 35 percent in 2002-2004.

Maize is a staple food of great socio-economic importance in Nigeria. Maize is important as a food security crop- as it meets the consumption and income needs of the households. It is also an important component of livestock feeds. The total land area planted to maize in 2003 in Nigeria was about 4.7 million hectares with an estimated output of about 5.2 million metric tonnes. The output increased by 14.5 percent to 5.9 million metric tons in 2005 (FAO, 2006). Maize has also achieved the highest growth rate of the major crops since the 1970s (Kamara et al; 2006). Despite the high yield potential of maize, its production is faced with numerous constraints (Amaza et al; 2008). One of these is drought both at the beginning and during the growing season, which significantly reduces grain yield. Therefore, early maturing varieties that are tolerant to drought or extra- early maturing varieties that could escape drought are desirable in the region. In view of this, national and international bodies have developed interest in promoting maize production for households' food security and poverty alleviation through crop production intensification which according to Tiffen et al., (1994); is the use of increased average inputs on smallholding for the purpose of increasing the value of output per hectare. Some of these efforts have been channeled through biological and agronomic research into the development of high–yielding and drought-varieties along with best cultural practices. Despite these efforts however, the available studies on the productivity gains in maize production in spite of government investment in the agricultural sector suggest little improvement in productivity and the goal of self-sufficiency in food production remains a long-term target (Oyewo et al; 2009).

Given the importance of food crops and especially maize in Nigeria economy, the estimation of efficiency will facilitate answering questions on the current farm level efficiency in smallholder maize-based production, and factor(s) that are holding back smallholders from increasing their productivity. An understanding of the relationships between efficiency, policy indicators and farm-specific practices would provide policy makers with information to design programmes that can contribute to increasing food production potential among smallholder farming households, who produce the bulk of the country's food. The main objective of this paper is therefore, to analyze maize-based production systems in Nigeria, with the aim of finding way to increase production and productivity. Specifically we estimate the levels of efficiency of Kwara State farming households; provide an empirical analysis of the determinants of inefficiency by examining the relationship between efficiency level and various farm and farmer-specific attributes and; considers implications for policy and strategies for improving maize-based production efficiency.

METHODOLOGY

Area of the Study

This study was conducted in Kwara State with a total of sixteen Local Government Areas. It is located between latitudes $7^0$45'N and $9^0$30'N and longitude $2^0$30'E and $6^0$25'E. The topography is mainly plain lands to slight gentle rolling. The annual rainfall ranges between 1,000mm and 1,500mm. Average temperature ranges between 30^0C and 35^0C. Kwara State is divided into four zones by the Kwara State Agricultural Development Project (KWADP) in consonance with ecological characteristics, cultural practices and project's administration convienence. These are: Zone A: Baruteen and Kaima Local Government Areas; Zone B: Edu and Patigi Local Government Areas; Zone C: Asa, Ilorin East, Ilorin West, Ilorin South and Moro Local Government Areas; and Zone D: Ekiti, Ifelodun, Irepodun, Offa, Oyun, Isin and Oke-Ero Local Government Areas.

Sampling Procedure and Sample Size

The target population for this study is the maize-based farming households in Kwara state.

A two-stage sampling technique was used to select sample for the study. The first stage involved the random selection of 4 villages from each of the four ADP zones in the state. The Agricultural Development Projects (ADPs) village listing served as the sampling frame for the selections in the state. In each village, 10 farming households were selected among the farming households in the area to make up a sample size of 160. However, only 144 questionnaires were retrieved and analyzed.

Analytical Techniques:

Descriptive and inferential statistics as well as Cobb–Douglas stochastic production frontier approach was used to estimate the production function and the determinants of technical efficiency among smallholder maize-based farming household. Given the potential estimation biases of the two-step procedure for estimating technical efficiency scores and analysing their determinants, the one-stage procedure is adopted following Battese and Coelli (1995). Although this approach has its own limitations, it remains one of the popular production functions in production frontier studies. The following model is estimated on the basis of the Battese and Coelli (1995) procedure:

$Yi = Xi\beta + (Vi - Ui), i = 1, N,$--(1)

Where Y_i is the output of maize crop in grain equivalent. Xi is a k x 1 vector of input quantities of the $_i$th household (land is measured as the total plot area cultivated in hectares; and labour is estimated as man-days worked; fertilizer is the amount of fertilizer used on the plot in kilogram; seed is the quantity of seed in kilograms, regardless of the type of maize and agrochemicals is the quantity of chemicals used in liters). β is a vector of unknown parameters to be estimated: Where Vi are random variables, two-sided ($-\infty < vi < \infty$) normally distributed random error N ~ (0,δv2), which are assumed to be independent of the Ui that captures the stochastic effects outside the farmer's control (e.g., weather, natural disasters, and luck, measurement errors in production, and other statistical noise).

The two components v and u are also assumed to be independent of each other. Thus, to estimate a Cobb-Douglas production functions, we must log all the input and output data before the data is analyzed (Coelli, 1995). The estimating equation for the stochastic function is given as:

$\ln Y = \beta 0 + \beta 1 \ln X1 + \beta 2 \ln X2 + \beta 3 \ln X3 + \beta 4 \ln X4 + \beta 5 \ln X5 + Vi - Ui$ -----(2)

The maximum likelihood estimation of equation yields consistent estimators for β, the variance parameters; gamma (γ), lambda (λ) and Sigma squared (δ^2).

Determinants of Technical Inefficiency

U_i =Inefficiency component of error term. It is assumed that the inefficiency effects are independently distributed and Ui truncation (at zero) of the normal distribution with means 0 and variance $\sigma^2 u$ where Ui is specified as:

$U_i = o + iZ_{1i} + {}_2Z_{2i} + {}_3Z_{3i} + {}_4Z_{4i} + {}_5Z_{5i} + {}_6Z_{6i} + {}_7Z_{7i}$----------------------(3)

Where

U_i=Technical inefficiency of maize-based farming household.

$Z_{1=}$ Farm size was measured in hectares

$Z_{2=}$ Farming Experience in years

$Z_{3=}$ Household size was based on the number of direct and dependants of the household and was adjusted to adult equivalent.

$Z_{4=}$ Extension contact was based on the number of visits by the extension agent.

$Z_{5=}$ Crop Production Intensification which was measured using Shriar, (2005) index.

$Z_{6=}$ Credit Access measured by a dummy. 1 if the household head has access and 0 if otherwise.

Elasticity of Production and Return to Scale Measurement.

Other estimates derived from our stochastic equation (2) for maize–based farming household in the study area are elasticity of production (EOP) and return to scale (RTS). EOP is the same as the estimated coefficients of the independent variables (Kumbhakar, 1994).

$RTS = \sum EOPi \qquad i =$ ---------,n---(4)

Inferentially, RTS < 1, decreasing return to scale

RTS > 1, increasing return to scale

Results and Discussion.

Socio-economic characteristics of Farming Households

The farming household's socio-economic characteristics are summarized in Table 1.

Ninety five percent of the household head were male, against only 5 percent of female. The average year of experience was 28.9 years. This indicates that most of the household' heads have been practicing farming for long. The accumulated years of experience may help farming households' heads in crop selection and enable them to evolve the farming practices that are most suitable to their fragile environment. The age of the farming households' heads ranged between 30 and 75 years with an average of 48 years. This implies that the household's heads are still in their active ages. Sixty–five (65) percent of farming households used fertilizers, against 35 percent who did not. About 23.6 percent of the respondents had access to credit, against 76.4 percent who had not. The average household size is 10 persons in the state. Most (62.3%) households are polygamous in nature. Polygamous nature of the people probably explains the large family size recorded in the area. Majority (75.7%) of the household heads are predominantly farmers, while others were involved in both agricultural and non-agricultural trading, business and civil service as their secondary sources of livelihood. This result has effect on the cropping practices adopted and also enhances the intensity with which agricultural land is used.

Majority of the farming household heads (81.9%) are literate with most of them having primary education (31.9%) and this is closely followed by Quranic education (30.6%) Those who had tertiary education (2.8 %) probably constituted the civil servant who engaged in part-time farming in the area. Given this level of literacy it is expected that information can be disseminated with ease among these households' heads. Basically, the levels of education of households' heads have significant impact on productivities, income earning opportunities and ability of farming households heads to effectively adopt better management practices. Eight crop combinations were popular among the sampled household heads. Maize intercropped with cassava had the largest number of occurrence (31.5%). This may be due to the easy adaptation of maize and cassava to the environment. Maize-cowpea mix, maize-sorghum mix, sole maize and maize-millet mix were the second, third, fourth and fifth widely adopted crop mixtures. Other crop mixtures are maize-sorghum-millet mix, maize-okro mix, maize-yam mix, maize-cassava-yam mix, and maize-okro-tomatoes mix.

Table: 1 Socio-economic Characteristics of the Household Heads

Variables	Frequency	Percentage
i) Age of the Household Head		
21-40 years	35	24.3
41-60 years	92	63.9
61-80 years	17	11.8
Total	144	100
ii)Sex of the Household Head		
Male	137	95.1
Female	07	04.9
Total	144	100.0
iii) Marital Status of the Household Head		
Married	110	76.4
Single	24	16.7
Widower/Separated	10	06.9
Total	144	100
iv)Household Size		
1 - 5	15	10.4
6 - 10	67	46.5
11-15	56	38.9
16-20	06	04.2
Total	144	100.0
v)Education Status of the Household Head		
No formal Education	26	18.1
Quranic Education	44	30.6
Primary Education	46	31.9
Secondary Education	17	11.8
Tertiary Education	04	02.8
Adult Education	07	04.9
Total	144	100.0
vi)Primary Occupation of the Household Head		
Farming	109	75.7
Agricultural Trading	11	07.6
Non-Agricultural Trading	13	09.4
Business	06	05.2
Civil Service	05	03.5
Total	144	100.0
vii)Farming Experience of the Household Head		
1 - 10	07	4.86
11-20	31	21.5
21-30	43	29.9
31-40	32	22.2
41-50	31	21.5
Total	144	100.0
viii) Access to Credit		
Have Access	34	23.6
Do not Have Access	110	76.4
Total	144	100.0

Technical Efficiency of the Kwara State Maize-Based Farming Households.

The expected parameters and the related statistical test results obtained from the analysis of the MLE of the Cobb-Douglass based stochastic frontier production function parameters for the Kwara State farming households are presented in table 2.

Table 2: Stochastic Production Function for the Kwara State Farming Households.

Variables	Parameters	Coefficient	t-values
Physical inputs			
Constant	β_0	0.4867	3.8614
Land (ha) (X_1)	β_1	-0.2462	-0.8579
Labour (man-days)(X_2)	β_2	0.4228*	1.7257
Seeds (Kg) (X_3)	β_3	-0.0741	-0.5922
Fertilizer (kg) (X_4)	β_4	0.5494***	4.2074
Agrochemical (litres) (X_5)	β_5	-0.1010	0.1236
Inefficiency model			
Constant term	δ_0	0.1686	0.4120
Farm Size (Z_1)	δ_1	0.1178	0.1068
Farming Experience (Z_2)	δ_2	-0.1447*	-1.8618
Household size (Z_3)	δ_3	0.4861*	1.7721
Extension contact (Z_4)	δ_4	-0.7981	-0.1256
Crop intensification (Z_5)	δ_5	-0.4551***	2.9091
Credit Access (Z_6)	δ_6	-0.6029**	-2.0549
Diagnostic statistics			
Sigma square (δ^2)	$(\delta u^2+\delta v^2)$	0.3203***	5.1645
Gamma (γ)	$(\delta u^2/\delta^2)$	0.9089***	12.272
Lambda	$(\delta u/\delta v)$	83.766	
Log-likelihood function			-0.9728
δu^2	0.07009		
δv^2	0.00001		
δu	0.26470		
δv	0.00316		
Sample size (n)		144	
Source: Data Analysis,	2009, ***	significant at 1%,	**significant at 5%

The sigma square is 0.3203 and statistically significant at 1%. This indicates a good fit and the correctness of the specified distributed assumption of the composite error term (Table 2). The gamma (γ) ratio of 0.9089 which is significant at 1% level implied that about 90.89 percent variation in the output of the Kwara state maize-based farming households was due to differences in their technical efficiencies.

The coefficient of fertilizer is positive and significant at 1% level of probability. The estimated coefficient of this variable is positive, which conform to a priori expectation. The positive coefficient of this variable input implies that increase in quantities of this input would result in increased output. Availability of fertilizer at affordable price generally determines the increase in land area under maize production in any particular year. Thus areas cultivated to maize decrease as fertilizer subsidies are withdrawn (Ado et al; (2007). The estimated coefficient of labour is also positive and significant at 1% level. Thus, labour is one of the most significant inputs in the production of maize among Kwara State farming households. This is expected since most of the maize production in country uses traditional technology that relies heavily on family labour. On the other hand, the estimated coefficient of land and seeds are negative and statistically not significant.

The result of the inefficiency model (Table 2) shows that the coefficient of crop production intensification is negative and significantly related to technical inefficiency at 1% level of probability. The negative coefficient of crop production intensification implies that the use of increased average inputs on smallholding would reduce technical inefficiency of households. The estimated coefficient of farming experience is negative and significantly related to technical inefficiency. This implies that the more experienced a maize-based farming household becomes the higher its technical efficiency. This is contrary to the findings of Oyewo et al; (2009) who found a positive and significant relationship between farming experience and technical inefficiency among maize producing farmers in Ogbomosho South Local Government of Oyo State.

The co-efficient of household size is positive and statistically significant at 10%. This implies that increase in household size could lead to increase in the technical in-efficiency of the maize-based farming households and hence a decrease in the technical efficiency of the households. This result is inconsistent with the findings of Ebong (2005) and Onyenweaku *et al.* (2005), which identified a positive relationship between household size and technical efficiency among crop farmers. Access to credit is negative and significantly related to technical inefficiency. This is as expected since the availability of credit loses the production constraints thus facilitating timely purchase of inputs and therefore increasing productivity via efficiency. The result is consistent with the findings of Muhammad (2009) but contrast with that of Haji (2006) who rather found a negative impact of credit access on technical, allocative and cost efficiency.

Elasticity of Production Inputs and Returns to Scale

The input elasticities of production of the Kwara State households are shown in table 3.

Table 3: Estimated Elasticity of factors inputs and Return to scale of Kwara State Households.

Variable1	Co-efficient (Elasticity of Production)
Farm size (X_1)	-0.2462
Labour (X_2)	0.4228
Seeds (X_3)	-0.0741
Fertilizer(X_4)	0.5494
Agrochemical (X_5)	-0.1010
Return to scale	0.5509

Source: Field survey, 2009

The summation of elasticities obtained indicated that the estimated return to scale is 0.5509, implying that maize is produced at a decreasing returns to scale on the sampled plots.

Technical Efficiency Estimates of Kwara State Maize- Based Farming Households.

The frequency distribution of technical efficiency of Kwara State maize-based households is presented in table 4.

Table 4: Distribution of Technical Efficiency Indices among Kwara State Maize-Based Households.

Efficiency class index	Frequency	Percentage
0.11 – 0.20	18.0	14.4
0.21 – 0.30	27.0	21.6
0.31 – 0.40	31.0	24.8
0.41 – 0.50	21.0	16.8
0.51 – 0.60	13.0	10.4
0.61 – 0.70	04.6	03.2
0.71-- 0.80	4.0	03.2
0.81 – 0.90	4.0	03.2
0.91 – 1.00	3.0	02.4
Total	125	100.0
Mean	0.393	
Maximum value	0.999	
Minimum value	0.110	

Source: Computed from MLE results

Individual technical efficiency indices range between 11.0% and 99.9% with a mean of 39.3%. The level of technical efficiency obtained in this study suggest that opportunities still exist for increasing productivity and income through increased efficiency in resource utilization by maize-based farming households in the study area. About 60.7% efficiency gap from the optimum (100%) was yet to be attained by all the Kwara State maize-based households.

Conclusion and Recommendations

This empirical study is on return to scale, estimates of technical efficiency and the determinants of farm level technical inefficiency among maize-based farming households in Kwara State. A Cobb-Douglass production frontier was estimated by Maximum Likelihood Estimation (MLE) method to obtain ML estimates and inefficiency determinants. Labour and fertilizer used were found to be the significant production factors determining the output of maize in the study area. The results also revealed that the important factors directly and significantly related to technical efficiency are farming experience, household size, crop production intensification and credit access. In view of current global effort in achieving the Millennium Development Goals (MDGs), Nigerian government should embark on policy measures that will strategically ensure the maize-based farming households have access to credit facilities as well as agricultural inputs as at when due. Policies aimed at reducing household size should also be vigorously pursued. These findings stresses the need for appropriate policy formulation and implementation to enable farming households reduce their technical inefficiency in production as this is expected to have multiplier effects ranging from maize productivity growth, food security, food self-sufficiency, increased household income to economic growth and poverty reduction.

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