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Technical efficiency of maize production in Ogun State, Nigeria

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This study examined the technical efficiency of maize production in Ogun State, Nigeria. Primary data were collected for this study using a multistage sampling technique to select 100 maize farmers from the study area. The data were analysed using descriptive statistics, gross margin analysis and stochastic production frontier. The socio-economic characteristics of respondents as evident from the data analysis revealed that 73% were males with an average age of 50.1 years. Most (85%) of them were married with average household size of 6 people. Also, 89.0% had below secondary school education and 84.8% were full time farmers while 55.0% were engaged in inter-cropping activities. The mean total variable cost per hectare was estimated as ₦109,599.17 per year while the mean total revenue per hectare was ₦111,436.00. The gross margin per hectare was estimated as ₦1, 836.83. The significant variables affecting maize production were seeds (α0.05), herbicide (α0.10), labour (α0.01), and farm size (α0.05), while the factors affecting inefficiency were household size (α0.05) and educational level (α0.01). The study recommended that provision should be made by governments and other stakeholders in the agricultural sector to provide farmers with access to affordable inputs such as seed, herbicides as well as making provision for alternative source of family labour.

Key words: Technical efficiency, maize production, Ogun State, Nigeria.

INTRODUCTION

Maize and other cereals constitute important sources of carbohydrate, protein, vitamin B and mineral. It is a staple food crop for most sub-Saharan Africans including Nigeria (Zalkuwi et al., 2010). It is one of the most abundant food crops in Nigeria. According to FAO (2013), Maize (9,180,270 tonnes) has been rated as the second grown food crop in Nigeria after Cassava (52,403,455 tonnes) then followed by Sorghum (6,897,060 tonnes) and Rice (4,567,320 tonnes). Due to its high adaptability and productivity, the cultivation of maize spread rapidly around the globe and currently it is being produced in most countries of the world (Anupama et al., 2005). It provides food for man and feed for livestock. Maize is an important food crop grown on a large scale in Nigeria, Ghana and to a lesser extent in Sierra Leone (Oladipo et al., 2008). The global output of maize in 2011 was recorded to be 883,460,240 tonnes and Nigeria produced about 9,180,270 tonnes, which constituted about 1.04%

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of the world's production. The world maize production ranking for year 2011 shows that Nigeria was ranked 14th position (FAO, 2013).

The need for improved technology has risen in recent years due to the geometrical increase in population rate and consequently, the forces of demand for maize relative to supply are evident in frequent rise in price of maize. This has a great effect on the food security status of Nigeria, given its importance as a staple crop. The production of maize is affected by the development of advanced technologies, as fertilizer, hybrid seeds, pesticides, herbicides and better management practices which remains a limiting factor for developing countries.

One of the strategies for increasing agricultural productivity is the use of improved technology. But no matter how productive the technology may be, optimal productivity can only be obtained when the technology is efficiently used. Due to inadequate knowledge about the optimum level of farm resources and their efficient utilization, high risk of uncertainties often characterize the entire process of production. Therefore, this research seeks to determine the profitability and technical efficiency of maize production in Ogun State, Nigeria.

Stochastic frontier production function

Ojo (2004), used stochastic frontier production function and confirmed the presence of technical inefficiency effect in yam production and suggested that production, productivity and technical efficiency would be improved if those variables with negative elasticities of production are improved upon. According to Battese and Coelli (1995) the stochastic frontier production function postulates the existence of technical inefficiencies of production of firms involved in producing a particular output. Since the Stochastic frontier production framework (SFPF) was developed by Aigner et al. (1997) and Meeusen and Broeck (1977), evaluating the efficiency of individual firm and industry has become popular with the increasing availability of firm level data and growing capacity of computer to process them. The most common approach to estimate stochastic frontier production function is to specify a deterministic production plus a random, symmetric, firm-specific error term. This frontier represents the largest production for individual firm. Associated with firms is a second, non-negative error term, denoted as the technical efficiency term. Total production for each firm is defined as the frontier minus the inefficiency (Dhawan and Jochumen, 2012). The stochastic frontier production postulates the existence of technical inefficiencies of production of firm involved in producing particular output. Battese and Coelli (1995) and Ajibefun (2002) stated that the stochastic frontier production function has the advantage in that it allows simultaneous estimation of individual technical efficiency of the respondent as well as determinants inefficiency.

The idea of frontier production can be illustrated with a farm using n inputs ($X_1, X_2 \ldots\ldots\ldots\ldots X_n$) to produce output Y. Efficient transformation of inputs into outputs is characterized by the production function f(X), which shows the maximum output obtainable from various input vectors (Oyewo, 2011). The Stochastic frontier production function, assumes the presence of technical inefficiency of production. Hence, the function is defined by:

$$Y_i = f(X_i, E) \exp(V_i - U_i) \quad i = 1, 2, 3, \ldots\ldots\ldots\ldots n$$

Where V is a random error associated with random factors not under the control of the farmer. The model is such that the possible production Yi is bounded above by the stochastic quantity f (X_i, E) exp (V_i), hence the term stochastic frontier.

The random error Vi is assumed to be independently and identically distributed as N(0,Φ2V) random variables independent of Ui s. Technical efficiency of an individual farmer is defined in terms of the ratio of the observed output to the corresponding frontier output, given the available technology.

Technical Efficiency: (TE) =Yi/Yi*dfdfd

$$TE = f(X_i, E) \exp(V_i - U_i) / f(X_i, E) \exp(V_i)$$

$$TE = \exp(-Ui)$$

Where, Yi is the observed output and Yi*, the frontier output.

METHODOLOGY

This study was conducted in Ogun State, Nigeria. Ogun State is situated within the tropics, with a total land area of 16,762 square km which lies within latitude 6°20' South and 7° 58' North in the tropics and longitude 2° 40' West and 4° 35' East of the Greenwich Meridian, and has an estimated population of 4,054,272. The state borders Lagos state to the south, Oyo and Osun states to the North, Ondo state to the east and the republic of Benin to the west. A multistage random sampling technique was used for this study. The first stage involves purposive selection of one Local Government Area from each of the four ADPs zones in Ogun State (Abeokuta, Ilaro, Ijebu-ode and Ikenne). The second stage involves a random selection of one rural community in each of the Local Government Areas. Finally, a systematic random sampling technique was adopted to randomly select 25 respondents from each of the community. As a result one hundred farmers were used for the study. Primary data were collected from the selected farmers through a well structured questionnaire which was randomly administered to farmers. The data collected were subjected to descriptive analysis, gross margin analysis and Cobb Douglas stochastic frontier production functions.

Model specification

The stochastic Frontier Production Function proposed by Battese and Coelli (1995) which assumes the existence of technical inefficiency of different firms in production will be adopted for this study. This is depicted using the model below.

$Y_i = f(X_i, \beta_i) \exp (V_i – U_i); i = 1,2,……n$ (1)

The functional form of this model to be used in estimating the level of technical efficiency is the Cobb-Douglas type (Bravo-Ureta and Evenson, 1994):

$Ln\ Y_i = \beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \beta_4 LnX_4$ +------Write the equation till the last variable written below. $V_i - U_i$ (2)

Where: ln = natural logarithm, i = 1, 2, 3, 4….6, Y = Maize output (kg), X_1= Seeds (kg), X_2 = Fertiliser (kg), X_3 = Insecticide (litres), X_4 = Herbicides (litres), X_5 = Labour (family + hired in man-days.), X_6 = Farm size (Ha), β_0 = Constant term, β_i = parameters to be estimated, V_i = Symmetric error associated with uncontrollable factors related to production process, U_i = Inefficiency component of error term.

Inefficiency model

$U_i = \delta_o + \delta_i Z_i$

Where: U_i = Technical inefficiency, $_o$ = Constant tern, δ_i= Coefficient to be estimated, Z_1 = Gender, Z_2 = Age (in years), Z_3 = Household size, Z_4 = Level of Education, Z_5 = Farming Experience, Z_6 = Age squared.

The value of U_i may be obtained from the observable value of $V_i – U_i$ with the assumption that the composed error $V_i – U_i$ is known and is the best predictor for technical efficiency. The prediction which is presented in Battese and Coelli (1995) is estimated at the maximum likelihood estimates of the parameters of the full frontier inefficiency model stated above.

RESULTS AND DISCUSSION

Tables 1 and 2 revealed that the socio-economic characteristics of respondents as evident from the data analysis revealed that 73.0% were males with an average age of 50.1 years. Most of them were married (85%), 63.0% had between 5 and 8 persons in their household, with an average of 6 people. Majority (89.0%) had below secondary school education and 84.8% were full-time farmers while 55.0% were engaged in inter-cropping activities. Table 3 shows the mean total variable cost per hectare is estimated as ₦109, 599.17 while the average total revenue is ₦111,436.00. The gross margin per hectare was estimated as ₦1, 836.84. This shows that profitability of maize farming was relatively low in the study area.

Estimated production function

The maximum likelihood estimate (MLE) of the stochastic frontier model of maize farmers is presented in Table 4. The sigma-square (δ^2) estimate of 1.43 ($\alpha_{0.01}$) attests to the good fit and correctness of the model. Also, the gamma (γ) estimate of 0.79 ($\alpha_{0.01}$) shows the amount of variation in output resulting from the technical inefficiencies of the farmers. This means that 79% of the variation in farmer's output was due to technical efficiency.

The results reveal that the variables as seeds, herbicide quantity, labour, farm size are factors which positively influence the quantity of outputs of maize. The seed variable had a positive sign which is statistically significant ($\alpha_{0.05}$). This indicated that a percentage increase in the quantity of seed planted would result in 0.21% increase in maize output. This finding corroborates with Shehu et al. (2007) and Oyewo (2011). The elasticity of seed equals 0.21 indicating inelasticity of seed in the production process; thus the importance of the input in maize production cannot be over-emphasised.

The estimated coefficient of herbicides which is another significant factor is at $\alpha_{0.10}$. This means that an increase in the quantity of herbicide used by the maize farmers will lead to increase in the quantity of output of maize produced by the farmers. The elasticity of herbicide equals 0.10 which also shows herbicide inelasticity indicating its invaluable nature as input in maize production. Labour is positively correlated and significant ($\alpha_{0.01}$), with an elasticity of 0.41 while farm size also have positive estimated elasticity of 0.19 implying that increase in these variables will also increase the quantity of maize produced. The mean technical efficiency of the farmers was estimated as 0.69 indicating relatively high efficiency of maize production within the ambit of production resources available in the study area.

Sources of inefficiencies

The sources of inefficiency were examined simultaneously and the results as specified by the maximum likelihood parameter estimates are presented in Table 4. The results of the inefficiency model show household size ($\alpha_{0.05}$) and educational level ($\alpha_{0.01}$) of the respondents are significant determinants of technical inefficiency. The sign of the variables in the inefficiency model is very important in explaining the observed level of technical efficiency of the farmers. A negative sign implied that the variable had the effect of reducing technical inefficiency, hence increasing farmers' production efficiency, while a positive coefficient indicate that the variable has the propensity of increasing inefficiency, thus reducing farmers' production efficiency. These indicate therefore, that increase in household size would significantly increase production efficiency. This juxtaposes the fact inherent in many literature that farmers usually rely on household labour to boost production given it availability, less cost and ease of manipulation to suit different farm activities. The fact that improvement in education reduces maize production efficiency leaves a worry as it does not conform to the *a priori* expectation. This may probably mean that non-formal education provided by extension officers, which directly impinges positively on the production process, would have been better captured in the model instead.

Table 1. Distribution of respondents by socio economic characteristics.

		Frequency	Percent	Mean	Standard deviation
Gender	Female	27	27		0.45
	Male	73	73		
Marital status	Single	8	8		0.71
	Married	85	85		
	Widow	4	4		
	Separate	3	3		
Age group(years)	30 or less	14	14	50.1	16.03
	31 to 40	23	23		
	41 to 50	15	15		
	51 to 60	17	17		
	61 to 70	19	19		
	Above 70	12	12		
Household size group	4 or less	22	22	6	2.43
	5 to 8	63	63		
	9 to 12	13	13		
	Above 12	2	2		
Farming exp group	10 or less	37	37	20.15	14.08
	11 to 20	23	23		
	21 to 30	19	19		
	41 to 50	15	15		
	Above 50	6	6		
	Total	100	100		
Level of Educational	No formal	21	21.0		1.17
	Primary	43	43.0		
	Secondary	25	25.0		
	NCE/OND	8	8.0		
	HND/BSC	3	3.0		
Total		**100**	**100**		

Source: Field survey 2013.

Conclusion

This study examined the technical efficiency of maize production in Ogun state, Nigeria with the aid of stochastic production frontier model. The estimated gross margin implies that profitability of maize farming in the study area was relatively low. The maximum likelihood estimate (MLE) revealed that efficiency of maize production in the study area is significantly influenced by seed; herbicide, labour and farm size. However, the mean technical efficiency was 0.693 which indicates that production can still be increased by 30.9% using available technology.

This means that substantial opportunities should be explored to increase productivity and income of such farmers through availability and efficient utilization of productive resources.

RECOMMENDATIONS

In order to meet up with the goal of improved productivity of maize production in Ogun state, this study recommends the following:

(i) For an effective improvement in the level of efficiency among the maize farmers, provision should be made by governments and other stakeholders in the agricultural sector to provide farmers with access to affordable inputs such as seed, herbicides as well as making provision for

Table 2. Distribution of respondents by production characteristics.

		Frequency	Percent	Mean	Standard deviation
Mode of farming	Full time	56	56		0.50
	Part time	44	44		
Fund source	Bank loan	1	1		0.61
	Esusu	6	6		
	Personal	88	88		
	Friend	1	1		
	Money lender	2	2		
	Others	2	2		
Cropping pattern	Sole cropping	45	45		0.50
	Inter cropping	55	55		
Variety	Local	36	36		0.65
	Improved	52	52		
	Both	12	12		
Maturity period	2.5	4	4	3.07	0.30
	3	86	86		
	3.5	2	2		
	4	8	8		
Farm size group(Ha)	0 through 1	55	55	1.63	2.67
	1.1 to 2	26	26		
	2.1 to 3	6	6		
	3.1 to 4	6	6		
	4.1 to 5	7	7		
Total		**100**	**100**		

Source: Field survey 2013.

Table 3. Gross margin per hectare for maize production in the study area.

Variable	Minimum (₦)	Maximum(₦)	Mean(₦)
Total Variable cost (TVC)	5,700.00	1,105,935.00	109,599.17
Total Revenue (TR)	10,270.00	500,000.00	111,436.00
Gross Margin (GM)			1836.83

Source: Computed from Field Survey, 2013.

Good Agricultural Practises (GAP). Also, the government should introduce the farmers to access non-formal education more, through extension education and establishment of demonstration farms to boost their productive capacity.

(ii) A land redistribution policy that will increase the farm size of farmers (since they are mainly small scale farmers) will boost maize production. And also policies that will encourage the expansion of existing farm lands that are not currently under cultivation should be formulated. This could be through the provision of support such as low interest funds for the purchase or development of such farm lands through the Nigerian Agricultural Bank.

Conflict of Interest

The authors have not declared any conflict of interest.

Table 4. Maximum likelihood estimates of the stochastic frontier production function.

Variable	Parameters	Coefficient	Standard-error	t-ratio
		Efficiency		
Constant	B	5.867892	0.44569592	13.16568500
Seeds	X_1	0.21037706**	0.1072168	1.9621651
Fertiliser	X_2	-0.030510525	0.033871828	-0.90076405
Insecticide	X_3	0.049002906	0.07446027	0.65810812
Herbicide qty	X_4	0.10201794*	0.05685250	1.7944321
Labour	X_5	0.41538462***	0.16329108	2.54382920
Farm size	X_6	0.19385539**	0.09890650	1.95998620
		Inefficiency		
Gender	Z_1	-0.322718	0.89506359	-0.3605526
Age	Z_2	0.003763	0.067568225	0.05569144
Household size	Z_3	-0.178588**	0.10595548	-1.68549870
Educational Level	Z_4	0.19328224***	0.061632006	3.13606930
Farming Experience	Z_5	0.042178	0.0299376	1.40887790
Age squared	Z_6	-0.001338	0.0013587638	-0.98505757
Diagnostic statistics				
Sigma square	δ^2	1.430479***	0.4556956	3.1391109
Gamma	γ	0.78534257***	0.11442896	6.8631451
Log likelihood		-100.75684		
Mean		0.69		

Source: Computed from Field Survey 2013, *** Parameters significant 1% probability level, ** Parameters significant at 5% probability level, *Parameters significant at 10% probability level.

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