Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.7, No.6, 2017

Technical Efficiency Differentials of Maize Production Technologies in Southwestern Nigeria

Foluso Olayinka Osundare
Department of Agricultural Economics and Extension Services, Ekiti State University, Ado Ekiti, Nigeria

Acknowledgement: The author appreciates Prof E.A. Aderinola and Prof A.I. Ajibefun who read the manuscript of this paper. I

Abstract

In terms of area cultivated and level of output, maize is the third most important cereal crop in Nigeria after guinea corn and millet. Apart from its importance for human consumption, the use of Maize as a major raw material in livestock feeds production and its increasing domestic uses makes its local supply to lack behind its demand. Thus, this study was aimed at determining and comparing the technical efficiency of maize production under different production technologies and across the study areas with the view to identifying the most technically efficient type of technology in South-Western Nigeria. Data collected from a cross-sectional survey of 311 maize farmers randomly selected from Ondo and Oyo states were analyzed using stochastic frontier production function and analysis of variance. Results showed that the pooled maize farmers used three types of production technologies: traditional technology (TRATEC), improved technology (IMPTEC) and semi improved technology (SEITEC). With the computed values of goodness of fit as 0.13, 0.77 and 0.39 for TRACTEC, IMPTEC and SEITEC respectively each of the models was significantly different from zero at 5.0%. the maximum likelihood estimates having quantities of seed planted; labour, fertilizer usage; amount spent on herbicides; contact with extension workers and farm size as regressors influenced the level of maize output under the different technology types. In addition, results of technical inefficiency effects showed that age, years of schooling, household size and farming experience influenced the level of technical inefficiency in all the production technologies. TRACTEC was the most technically efficient – having mean technical efficiency of 0.93 followed by SEITEC (0.69) and IMPTEC (0.65). With mean technical efficiency values of 0.75 and 0.62 for TRACTEC and IMPTEC respectively, Oyo state maize farmers were found to be more efficient than their Ondo state counterparts who had mean technical efficiency values of 0.72 and 0.64 respectively for the same technology types.

INTRODUCTION

The awareness of the importance of cereals in the food economy of Nigeria is on the increase. In terms of agricultural land use under major crops, the cereals accounted for about 72% of the area devoted to food crops. Maize came third in terms of area cultivated and volume of production. It is the most important cereal crop grown in Southwestern Nigeria where it attains significance in view of the limited amount of protein-rich cereals in Southern diets. The economic and agricultural policies in Nigeria have further put maize in a prominent position in the country's food economy. The ban placed on the importation of rice and wheat flour makes maize a very important raw material being sought after by the feed mills, flour mills and breweries in Nigeria.

CBN report (2005) shows that although there were considerable increases in hectarages put into maize production over a period of two and a half decades, the average output has been pathetically low. For instance, maize yield per hectare has decreased from 2.23 tonnes in 1986, to 0.38 metric tonnes in 1991 and between 0.7 to 1.5 metric tonnes in 2001 while the world average was 3.0 metric tonnes per hectare (Jeminsin 1986, Scholtes, Bokanga and Sundin (2011), On the other hand, the demand for maize is expected to be on a rapid increase consequent upon the establishment of agro-industries that rely on maize for the supply of major raw materials and the increasing domestic uses. As a result of this, a wide gap exists between the quantity of maize demanded and supplied occasioned not only by low yield/ha but on increasing pressure on land. In order to improve this situation, many programmes and policies have been put in place leading to the establishment of research institutes and generation of improved production technologies that are capable of doubling or tripling the level of maize output. However, the application of these technologies is not synonymous t oefficient production until it is backed up by empirical evidence.

In view of this, the efficiency with which available resources and technology are used by the maize farmers becomes a priority subject of investigation. It is argued that agricultural production can be increased either through an efficient use of traditional technology and practices or through the introduction of a package of improved technologies like fertilizer, improved seeds and cultural practices (UNDO 2012) In Nigeria, maize is produced under varying production technologies and it is important to ascertain those technologies that are not only cost-saving but also promoting increamental output of the crop so that policies and research efforts could be properly focused. It is against this background that this paper intends to estimate and compare the levels of technical efficiency among maize production technologies in Southwestern Nigeria with a view to determining the most technically efficient technology for policy options.

Hypothesis of study

The following null hypotheses were tested to achieve the objectives of the study:

(a) There are no significant differences in the levels of technical efficiency among the maize production technologies used by farmers.

(b) There are technical inefficiency effects among the maize production technologies.

The Model and Data

The Model

A stochastic frontier production function where the functional form of the production frontier is Cobb-Douglas proposed by Battese and Coeli (1995) was used. The stochastic frontier production comprises of a production function of the usual regression type with a composite disturbance term equal to the sum of two error component covers the random effects on production outside the control of the decision unit, it is normally distributed with mean and constant variance independent of the U. The other error component captures systematic influences that are explained by the production function and are attributed to the effect of technical inefficiency. For comprehensive surveys on the frontier literature, readers are referred to Battese and Tessema (1984).Mosanga (2012), Omondi and Shikuku (2013)

In this paper, the stochastic frontier proposed by Battese and Coalli (1995) was used and is defined by:

$$\text{In } Y_i = \beta_0 + \beta_1 \text{In} X_{1i} + \beta_2 \text{In} X_{2i} + \beta_3 \text{In} X_{3i} + \beta_4 \text{In} X_{4i} + \beta_5 \text{In} X_{5i} + \beta_6 \text{In} X_{6i} + V - U \text{ - - - - - - - } (1)$$

Where:

In represents the natural logarithm, the subscript ith represents sample farmer

ϒ = Maize output (in kg);
X_1 = quantity of maize seed planted (kg);
X_2 = Labour used (man-days);
X_3 = amount spent on herbicides;
X_4 = quantity of fertilizer used (kg);
X_5 = Contact with extension;
X_6 = Farm sizes (ha).

V was the random error which was assumed to be normally distributed with zero mean and constant variance. U was non-negative random variables called technical efficiency of maize farmers and which were assumed to be independent of V having normal distribution with mean zero and constant variance (δV^2).

For the inefficiency models, it was assumed that the technical inefficiency measured by mode of the truncated normal distribution (Ui) is a function of socio-economic factor (Awal 2016). Thus the technical efficiency in equation (1) was simultaneously estimated with the determinants of technical efficiency presented in equation (2):

$$Ui = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} \text{ - - - - - - - - - - - - - - } (2)$$

Where:

U = technical inefficiency of the i-th farmer;
Z_1 = age of farmers (years);
Z_2 = years of schooling;
Z_3 = household size;
Z_4 = farming experience (years)

Equation (2) was used to examine the influence of some farmers' socio-economic variables on their technical efficiency. Therefore, the socio-economic variables in the model were included for the technical inefficiency effects to indicate possible effects of farmers' socio-economic characteristics on the technical efficiency of the maize farmers.

Survey Area, Sampling Technique and Data Collection

The study area purposively selected is Southwest Nigeria. Maize is the most popular cereal crop grown in this area. It is the Yoruba speaking part of Nigeria. Multi-stage random sampling was used in selecting the respondents; Ondo and Oyo states were randomly selected from states in South West Nigeria; two agricultural zones prevalent in maize production were purposively selected from each states; four local government areas were randomly selected from each state; five communities from each local government and twenty maize farmers randomly selected from the list of farmers using different production technologies obtained from the state Agricultural Development Project. A total of 371 maize farmers were interviewed. Eight extension workers were employed, trained and used as enumerators.

Farmers were categorized into three groups according to primary data that were collected using structured questionnaire to elicit information on the socio-economic characteristic of the respondents, total value of the maize outputs (both fresh and dried) and those consumed in the households; human labour both family and hired (man-days), extension contacts, cost items and some agronomic practices. The secondary sources include the states ministry of Agriculture and National Resources, ADP reports, Agricultural Input Supply Agency (AISA) and Project Coordinating Unit (PCU). Three hundred and seventeen copies of administered questionnaire were accepted for analysis.

Hypotheses Testing

Analysis of Variance (ANOVA) was used to test the null hypothesis that there were no significant differences in the levels of technical efficiency of maize farmers using the three types of production technologies. The decision rule was that null hypothesis be accepted if the computed "F-ratio" (FC) was less than or equal to "F tabulated" (FT) at the 5% level of significance. The second hypothesis was selected using the generalized likelihood ratio test defined by a test statistic X_C^2 where:

$$X_C^2 = -2In\left[L(Ho)/LHa\right]$$

L(Ho) = value of the likelihood function for the frontier model in which parameter restrictions are specified by the null hypothesis.

L(Ha) = value of the likelihood function

The X_C^2 has a mixed chi-square distribution with the degree of freedom equals to the number of parameters excluded in the unrestricted model. The computed X_C^2 is then compared with the tabulated X_C^2. The null hypothesis is accepted if the computed chi-square is less than the tabulated ch-square at 5% level of significance and a given degree of freedom.

Review of Empirical Studies

The importance of efficiency measurement has generated interests in the academic world. Notable among these interests is the pioneering work of Farrell (1957) about half a decade ago. Farrell's model which is known as deterministic non-parametric frontier, attributes any deviation from the frontier to inefficiency and imposes no functional form on the data. Drawing from the experience Farrell and some inefficiency measurement scholars both at national and international levels using various models, have estimated frontier production function in an effort to bridge the gap between theory and empirical work. Bragi (1984) developed a model of stochastic frontier production function for a farm-level technical efficiency of full-time and part-time farms in West Tennese. Boris and Laszlo (1991) measured efficiency in dairy farms in New England using stochastic frontier to analyze technical economic and allocative efficiency using data from three Indian villages estimated a stochastic frontier production with time-varying technical efficiencies. A non-parametric analysis of technical allocative scale and scope efficiency of agricultural production was carried out by Chavas and Aliber (1993) based on a sample of Wisconsin farmers; Habibullah and Ismail (1994) determined the status of technical efficiency of a sample of bee farmers in Malaysia using stochastic frontier production function; Ashok et al (1995) measured economic efficiency in Pakistan, specifically they compared the measures of cost inefficiency obtained and related it to socio-economic frontier and behavioural approaches;; Adesina and Djato (1997) applied the stochastic frontier model to measure the relative efficiency of women as farm manager. In a more recent study, Awal (2016) analysed the technical efficiency of smallholder cotton farmers in three selected districts in Ghana using stochastic frontier production function approach. The study was conducted on 150 cotton farmers selected through multi stage random sampling. The results showed that the technical efficiency of the cotton farmers in the area ranged from 16.50% and 98.13 with mean efficiency score of 84.50% suggesting that average smallholder cotton farmers in the northern Ghana would have produced 15.00% more output with the same level of inputs if farmers were to produce on the most technically efficient frontier. Other technical efficiency studies involving the use of stochastic frontier production function include, Onyenweaku and Nwan (2005),, Oladeebo (2006), Mosanga (2012), among others.

Estimates of the Frontier Model

Table 1 shows that except X5 that is contact with extension agents, all the explanatory variables in TRACTEC carried the expected negative signs. Quantity of improved seeds, labour cost, cost of herbicides, quantity of fertilizer, were negatively signed – implying that an increase in these variables would bring a decrease in the level of maize output in farmers using traditional technology while farm size (X6) contributed positively to farmers level of output.

Table 1: Maximum likelihood estimates for production frontiers in Maize production technologies in South Western Nigeria

Variable	Parameter	Coefficients		
		TRATEC	**IMPTEC**	**SEITEC**
Constant	β	0.521- (0.20)	0.48 (0.60)	0.72 (0.81)
Quantity of Maize Seed Planted	β_1	-0.58 (0.20)	0.77* (0.18)	-0.34 (0.27)
Labour Used	β_2	*-0.59 (0.35)	-0.38 (0.24)	-0.48* (0.22)
Herbicide Cost	β_3		0.24 (0.21)	-0.63 (0.73)
Quantity of fertilizer used	β_4		-0.26 (0.32)	0.56 (0.48)
Contact with Extension	β_5	-0.18 (0.20)	0.98* (0.22)	-0.58* (0.12)
Farm Sizes (ha)	β_6	0.39 (0.39)	0.32 (0.80)	0.32* (0.11)
Inefficiency Models				
Constant (Z0)	δ_0	-0.67 (0.11)	-0.38 (0.10)	-0.31 (0.71)
Z1 (Age)	δ_1	0.70* (0.11)	-0.28 (0.20)	0.43* (0.12)
Z2 (Yrs of Schooling)	δ_2	0.51* (0.16)	-0.29 (0.43)	-0.43 (0.53)
Z3 (Household Size)	δ_3	0.47 (0.95)	0.15 (0.54)	-0.11 (0.10)
Z4 (Farming Experience)	δ_4	-0.67* (0.22)	-0.19* (0.17)	-0.35* (0.17)
Sigma Squared	δ^2	0.13	0.39	0.77
Gamma	ϒ	0.97	0.100	0.99

*Figures in parentheses are standard errors of estimates.
Estimate is significant at 5%
Source :Computed from Data Analysis

Contrary to a prior expectation, contact with extension agents contributed negatively to the level of farmers under TRATEC. This could be attributed to the fact that traditional seeds may not do well with all other technological packages recommended by the extension agents. Also, probably the farmers did not comply strictly with the instruction of the extension agents due to scarcity of inputs or inadequate finance to purchase complimentary inputs as recommended. In SEITEC, the result was different. Only the quantity of fertilizers applied and farm size positively contributed to output levels of farmers in this category. The coefficients of the explanatory variables in IMPTEC show that quantity of maize seed planted, contact with extension and farm size contributed positively to the quantity of maize produced by farmers using improved technology. However, quantity of fertilizer applied had a negative contribution contrary to a priori expectation probably due to leaching and/or wrong application. Only quantity of maize seed planted and contact with extension were statistically significant at 5.0%.

The estimate for the (ϒ) gamma parameter in the stochastic frontier production function was quite large in all the three types of production technologies which mean that the inefficiency effects were highly significant in the analysis of the value of output of the farmers at 5% level.

Inefficiency Models

The estimated coefficients for the inefficiency function provide some explanations for the relative efficiency levels among the three categories of maize production technologies. Since the dependent variable of the inefficiency function represents the mode of inefficiency, a positive sign of an estimated parameter implies that the associated variable has a negative effect on efficiency and a negative sign indicate that the reverse is true.

In this study, the estimated coefficients of the explanatory variables in the model of the technical inefficiency effects are of interest and have important application. The inefficiency effects were compared among the maize production technology. The positive coefficient for the age variable in TRATEC and SEITEC implies that older farmers were more technically inefficient then the younger ones. This could be explained in terms of the adoption of modern technology. Old farmers tend to be more conservative and less receptive to modern and newly introduced agricultural technology. Also the positive sign in the coefficient of household size in TRATEC and SEITEC suggest that large household sizes are more technically inefficient. Although large household size could be advantageous in view of its prominent role in the provision of family labour but now that children go to school and school leavers engage in non-farm activities, large household could constitutes a serious setback to farmer' productivity. In addition, large household size increases the household consumption thereby reducing the farm income. The same explanation is tenable for the coefficient of the same variable being negatively signed in SEITEC.

The coefficient for farming experience was negatively signed in all the production technologies under consideration implying that farmers with more experience tend to be less inefficient. This is because farmers learn from their mistakes year-in-year-out. Similarly, the years of schooling was negatively signed in IMPTEC and SEITECsuggesting that the more the years of schooling, the less inefficient the farmers using these production technologies become. This is reasonable because level of formal education is a significant determinant of the adoption of improved production technologies.

On the other hand, the positive sign on the years of schooling in TRATEC means the contrary. The implication is that the higher the formal educational level acquired, the less dissatisfied the respondents were in the use of traditional technology. This is reasonable because an educated person would want to know and seek improved ways of doing things.

Technical Efficiencies

The individual technical efficiencies were obtained using estimated stochastic frontier model (equation 14). The technical efficiencies were compared between the technology types and states. The results are discussed in this subsection of the study.

The Efficiency Estimates

The predicted technical efficiencies among maize farmers using the three types of technologies are compared in table 16. The predicted technical efficiencies differ substantially among the farmers using the three groups of production technologies.

Table 2: Comparative Efficiency Estimates for Maize Production Technologies in South Western Nigeria

Efficiency	**TRATEC**		**IMPTEC**		**SEITEC**	
Range	Frequency	Relative Frequency (%)	Frequency	Relative Frequency (%)	Frequency	Relative Frequency (%)
0.0-0.10	0	0	0	0	0	0
0.11-0.20	0	0	2	3.13	0	0
0.21-0.30	5	5.81	6	9.38	16	9.94
0.31-0.40	6	7	7	10.94	14	8.70
0.41-0.50	6	6.92	4	6.25	9	5.59
0.51-0.60	4	4.65	7	10.94	12	7.45
0.61-0.70	11	12.19	5	7.81	21	13.04
0.71-0.80	15	17.44	12	18.75	26	16.15
0.81-0.90	33	38.31	12	18.75	51	31.61
0.91-1.00	6	6.92	9	14.06	12	7.45
Total	86	99.16	64	100.00	161	99.93*
Mean		0.73		0.65		0.69
Less than 100 because of rounding up errors						

Source: Computed from field survey data

For instance, in TRATEC, predicted technical efficiencies range between 0.27 and 0.93 with the mean technical efficiency estimated to be 0.73. In IMPTEC and SEITEC, the technical efficiency estimates range between 0.22 and 0.94, with mean technical efficiency of 0.65 and 0.69 respectively. To give a better indication of the technical efficiencies, a frequency distribution of the predicted technical efficiencies presented in table 7. The frequencies of occurrence of the predicted technical efficiencies in deciles ranges indicated that the three groups of production technologies appeared to be similar, the largest number of farmers had technical efficiencies of between 0.80 and 0.90 in all the types of technology (see table 2). About 20% of farmers using TRATEC had technical efficiency of 0.5 and less while SEITEC had 35.7% and 24.2% respectively for the same range. However, the mean technical efficiency shows that farmers using TRACTEC were the most efficient (0.73) followed by semi improved technology (0.69) and improved technology (0.65).

The efficiency of traditional farmers could be attributed to the following reasons: one, they are early rain users who plant at the onset of rains before soil nutrients are leached without depending on improved seeds and fertilizer which are unreliable. Two, many of the farmers who claimed to grow improved seeds were not able to apply complementary inputs either due to poverty or scarcity and so may not get the expected result and Three, the use of traditional technology has become part of the farmers with many years of experience being the earliest form of deliberate effort in agricultural production which could lead to good crop husbandry practices unlike improved methods that farmers are just being persuaded and trained to adopt.

These findings corroborate the studies of Oladunni (1996) and Omondi and Shikuku (2013) They all posited that resource use on small farms was very efficient within the framework of static technology.

State Comparison of Technical Efficiencies

The mean technical efficiency estimates indicate that Oyo farmers were more efficient in the use of TRATEC and IMPTEC than Ondo state farmers with mean technical efficiencies of 0.753 and 0.671 respectively while Ondo farmers had mean technical efficiency of 0.719 and 0.637 for the same type of technologies (see table 3). Ondo state was more efficient in the use of Semi Improved technology with mean technical efficiency of 0.712 while Oyo state had 0.689. However, the frequency distribution of the technical efficiencies of farmers in the two states indicates that there is a wide distribution of technical efficiencies among the maize farmers. Also there appears to be considerable room for improvements in the technical efficiencies of the farmers using the three types of technologies in the region.

Table 3: Comparisons of Technical Efficiencies of Maize Farmer on State Basis

Efficiency Range	**ONDO**			**OYO**		
	TRATEC	**IMPTEC**	**SEITEC**	**TRATEC**	**IMPTEC**	**SEITEC**
	%	%	%	%	%	%
0.11-0.20	0.00	0.00	12.00	0	0	0.00
0.21-0.30	4.25	6.5	13.33	5.56	11.11	8.14
0.31-0.40	8.5	12.90	9.33	2.78	8.33	18.60
0.41-0.50	4.25	9.68	6.66	8.33	5.56	8.14
0.51-0.60	6.38	3.23	12.00	5.56	5.56	9.30
0.61-0.70	21.28	29.03	6.66	11.11	5.56	17.44
0.71-0.80	12.77	22.58	12.00	22.22	22.22	10.47
0.81-0.90	38.30	12.90	14.67	36.11	33.33	11.63
0.91-1.00	4.25	3.23	13.33	8.33	8.33	16.28
Total	99.98	100.00	99.98	100.00	100.00	100
Mean T.E	0.719	0.637	0.712	0.671	0.689	70.43

Source : Computed from Field Survey

Test of Hypothesis

The results of the hypotheses tested are presented Table 3

Conclusion and Policy Implications

The study empirically and economically compared the technical efficiency of maize production technologies using stochastic frontier production function. The results indicated that maize farmers using the three technology types in South West Nigeria on the average had high level of predicted technical efficiencies clustering around 0.8 and 0.9. Notwithstanding, maze production under traditional technology was the most efficient followed by semi-improved and improved. Oyo state was more efficient in the use of improved production technologies than Ondo. Generally, there appears to be considerable room for improvement in the technical efficiencies of farmers using the three technology types in South Western Nigeria. Results of hypotheses show that technical inefficiency existed in production of farmers using the three types of technology implying that the traditional average response function which does not account for inefficiency of production is not an adequate representation of the data. And also that socio-economic variables used had influence on their technical efficiency. Lastly, although farmers are small scale and resource poor, they are efficient in the use of available production technologies and any expansion in the use of improved technology would bring more than proportionate increase in their output given the increasing returns-to scale value obtained in this study.

REFERENCES

Awal Abdul-Rahaman (2016). Stochastic Frontier Analysis (SFA) of technical efficiency,lnsights from Smallholder cotton farmers in the Northern Region Ghana. *Global Journal of Agricultural Economic* Economics and Extension, FUT, Akure. 104pp

Battese, G.E and Coelli (1995): jondrow, j; lovelli, c.a.k; materov, f.sSchmidt.p. (1982): “On the Estimation of

Technical Inefficiency in the Stochastic Frontier Production Function Model" Journal of Econometrics 19:233-238.

Battese, G.E. and Tessema, G.A (1993): Estimation of Stochastic Frontier Production Functions With Time – Varying Parameters and Techniccal Efficiencies Using Panel Data from Indian Villages vier Science Published B.V Amsterdam.

Chavas J.P. and Aliber, M. (1993): "An Analysis of Economic Efficiency in Agriculture: A Non-Parametric Approach" Journal of Agricultural Association 18(1):1-16.

Farrel, M.J (1957): The Measurement of Productive Efficiency" Journal of The Royal Statistical Society Series A 120,pp 253-28.

Habibullah, M.S. and Ismail, M.M (1994): "Production Frontier and Technical Efficiency: The case for Beekeeping Farms in Malaysia" Bangladesh Journal of Agricultural Economics, xvii, land 2 (1994):31-43.

Masanga A.M (2012). Technical efficiency and its determinants in Irish Potato Production: Evidence from Dettza District, Central Malawi. Afr. J. Agric. Res 7: 1797-1799

Oladeebo, J.O (2006): Economic Efficiency Of Upland Rice Production in Osun and Oyo states of Nigeria Unpublished PhD Thesis In the Department of Agricultural

Onyeweaku, C.E and Nwaru, J.C (2005): "Application of A Stochastic Frontier Production in Imo State, Nigeria". Nigeria Agricultural Journal 36:1-12

Omondi SO, Shikuku KM (2013). An analysis of Technical efficiency of rice farmers in Ahero Irrigation Scheme, Kenya J .econ. Sustain Deve. 4: 9-16

Scholtes P. Bokanga M, Sundin K (2011): Revitalizing the Ghanian Cotton sector Background paper for Discussion. 3 ADI. Jhingan (2009)

UNDO (2012): Revitalizating the cotton industry, Ghana cotton Facts sheet.