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Analysis of Technical Efficiency of Guava Farmers in Yobe State: A Stochastic Frontier Approach

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Abstract

This study was carried out to analyses the technical efficiency of Guava farmers in Yobe State. A multistage sampling technique was employed to select a total of 200 respondents from Potiskum and Fune Local Government Areas for the study. Data collected were analyzed using frequency distribution, means and percentages. A Stochastic Frontier Production Function which incorporated inefficiency causes were estimated using Maximum Likelihood Estimation technique. The results of the stochastic frontier function analyses revealed a mean technical efficiencies levels of 74%, implying that there was scope for increasing efficiencies by 26%. The main sources of technical inefficiencies were years of farming experience, extension contact, membership of cooperative societies, amount of credit obtained and educational level. The study recommends that extension contact, years of cooperative membership and access to credit were the sources of the inefficiencies and should be addressed through adequately trained and equipped extension workers, right use of credit facilities and the formation of cooperative societies and making membership a condition for microcredit benefit.

Keywords: Guava production; Horticultural Crop; Technical efficiency; Stochastic frontier; Yobe state

Abbrevations: TE: Technical Efficiency; CD: Cobb-Douglas; MLE: Maximum Likelihood Estimation

Introduction

The primacy of agriculture to African economies has never been in doubt. Its role in the provision of foreign exchange and development of economies cannot be overstated, as it remained for a long time the main machine for the earnings [1]. For most developing countries, enhancing the total production and productivity is not an option rather it is a must and the first priority in their policies. Agricultural production can increase either through introduction of modern technologies or by improving the efficiency of inputs with existing technologies. These two are not mutually exclusive, because the introduction of modern technology could not bring the expected shift of production frontier, if the existing level of efficiency is low [2].

Technical efficiency is a major component of productivity used in measuring farm performance [3]. Technical efficiency can be output, reflecting the maximum output that can be achieved from each input, or alternatively representing the minimum input used to produce a given level of output [4]. Analysis of technical efficiency in agriculture has received particular attention in developing countries like Nigeria because of the importance of productivity growth in agriculture for overall economic development [5]. Increased efficiency levels are becoming particularly import ant nowadays since opportunities to increase farm production by bringing additional virgin land into cultivation or by increasing the utilization of the physical resources have been diminishing.

It was the opinion of [6], that Nigerian agriculture has remained at the traditional and rudimentary level due to technical inefficiency mainly responsible for poor productivity performance in Nigerian agriculture. For Nigeria to achieve its potentials and attain sustainable agricultural development, there is the need to raise the productivity of their farm by improving efficiency within the limits of the existing resource base and available technology [7].

In Nigeria, horticultural crops such as guava possess a great potential and comparative advantage to compete in the liberalized economy [4]. Guava has been identified as one of the horticultural crops with enormous potentials for nutritional and health benefits, foreign exchange earnings, industrial growth and development [8]. It is one of the most common fruits in Nigeria, which has become popular because of its availability almost throughout the year, adaptability to a diversity of soil and climate conditions, and it is found to grow satisfactorily in all parts of the country [9]. Guava is a rich source of calcium, nicotinic acid, phosphorous, unsaturated fatty acid and protein, but low in saturated fat and soluble sugars, which lower cholesterol level in blood and particularly have high nutritional significance [8].

However, despite the adoption of the numerous technologies and investment in guava production enterprise in commercial scale, information on the level of production efficiency on this economic crop is lacking. Therefore, the study will formulate appropriate policies and provide information to ensure efficient utilization of resources in guava production in the study area. The main objective of this study is to analyse technical efficiency of small-scale guava farmers using stochastic frontier model approach. The specific objectives are to;

a. To describe the socio-economic characteristics of guava farmers in the study area.

b. To estimate the technical efficiency of guava production in the study area.

Technical Efficiency (TE)

Technical Efficiency (TE) is the achievement of maximum potential output from a given quantity of input under a given technology. Thus, it is the attainment of production goals without wastage as stated by [10]. Technical efficiency shows the ability of these inputs to employ the best practice in an industry, so that no more than the necessary amount of a given set of inputs is used in producing the best level of outputs. Technical efficiency is a major component of productivity being used in measuring farm performance. It is used to measure the ability of a farm performance. It is used to obtain maximum output from a given set of inputs [11]. A technically efficient farm operates on the production frontier while a technical inefficient farm operates below the frontier and could be made efficient by increasing its output with the same input level or using fewer inputs to produce the same level of outputs. As such, the closer a farm gets to the frontier, the more technically efficient it becomes [11].

Technical efficiency is defined as the ability to achieve a higher level of output given similar level of production inputs. Russel and Young [12], stated that technical efficiency arises when less than maximum output is obtained from a given combination of factors. The authors further stressed two measures of technical efficiency; these are Timmer measures of technical efficiency as the ratio of actual output to potential, given the level of input used on farm and Kopp measures the technical efficiency, compares the actual output of farm to the given ratio of the same input usage. Both measures yield substantial similar results.

Theoretical framework

Cobb-douglas production function: The theoretical basis of this study focused on Cobb-Douglas (CD) production function which shows a functional relationship between inputs and output. The Cobb-Douglas (CD) function further assumes constant returns to scale and unitary elasticity of substitution. For two variable inputs, the function can be expressed as;

$$Y = AL^{b1}K^{b2}e$$

Where;

Y = Level of output

L and K = Variable inputs

A = Multiplicative constant

b^1 and b^2 are the coefficient of L and K and they represent the direct measure of elasticity of the respective factors of production

e = Error term

The sum of b^1 and b^2 indicates the nature of returns to scale. Terfa and Terwase [13], observed that, the Cobb-Douglas production function cannot show both increasing and diminishing marginal productivity in a single response curve and as a result it does not give a technical optimum and may lead to the over estimation of the economic optimum. Despite these disadvantages researchers still find the Cobb-Douglas production function useful in analysis of survey where many variable inputs are involved, and it is necessary to measure returns to scale, intensity of factors of production and overall efficiency of production.

It can also provide a means of obtaining coefficients for testing hypotheses [13-15]. While commenting on the superiority of Cobb-Douglas production function over other forms of production functions, Terfa and Terwase [13] stated that, Cobb-Douglas production function is used more than the other two because it satisfies the economic, statistical and econometric criteria of many studies than others.

Methodology

Study area

The study was conducted in Yobe State which is located between latitude 12°00′N 11°30′ and Longitude 12°N 11.5°E. Yobe State was created out of the old Borno State in 1991 and has seventeen local government areas. The state has an estimated population of about 2.5 Million people according to the 2006 National population census. The major ethnic groups in the state include the Kanuri, Fulani, karekare, Bade and Hausa. The people are predominantly peasant farmers cultivating mainly food crops such as Millet, Maize, Sesame, Sorghum, Groundnuts, Beans, Cotton etc. The state is also said to have one of the largest cattle markets in West Africa located in Potiskum.

Sampling size and sample technique

A multistage sampling technique was used in selecting respondents for this study. The first stage was a purposive selection of Potiskum and Fune Local Government Area of Yobe state due to the presence of large number of Guava farmers in the two local government areas. The second stage was a random selection of four villages each from the two selected local government areas to make a total of eight villages. The third stage was a random selection of 25 farmers from each of the selected villages. In all,

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a total of 200 guava famers were selected and Primary data were collected in using a well-structured questionnaire.

Data collection

Primary data was used for this study was collected with the aid of structured questionnaire. The information was collected on farmer's socio-economic characteristic and Production information; level of inputs used and output in guava production.

Data analysis techniques

Both descriptive and inferential statistics were used in the analysis of data. Descriptive statistics involving the use of means, frequencies distribution and percentages were used to achieve objective (i) and stochastic frontier production function was used to achieve objective (ii).

The empirical stochastic frontier production model

The stochastic frontier production model was independently proposed by Aigner, Lovell & Schmidt [16]. It employs a Cobb – Douglas production function to simultaneously estimate the random disturbance term (V_i) which is outside the control of the production unit and the inefficiency effect (U_i) as proposed by Battese & Coelli [17]. The farm frontier production function can be written as:

$$Y_i = f\left(X_i . \beta i\right) + e_i \cdots\cdots\cdots 1$$

$$e_i = V_i - U_i \cdots\cdots\cdots 2$$

Where:

Y_i = Quantity of output of the i[th] farm

X_i = Vector of the inputs used by the i[th] farm

B_i = A vector of the parameters to be estimated

e_i = Composite error term

V_i = Random error outside farmer's control

U_i =technical inefficiency effects

The production form of Cobb-Douglas stochastic production frontier is given as:

$$LnY = \beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \beta_4 LnX_4 + \beta_5 LnX_5 + V_1 - U_1 \cdots\cdots\cdots 3$$

Where:

Ln = Natural logarithm to base 10

Y_i = Guava output of the i[th] farmer in kilogram per hectare (kg/ha)

β_i = The parameters to be estimated

X_1= Quantity of seeds planted in kilogram per hectare (kg/ha)

X_2= Farm size (hectares)

X_3= Quantity of agrochemicals used in liters per hectare (litres/ha)

X_4= Quantity of fertilizers applied per hectare (kg/ha)

X_5= Labour used per hectare (man days)

V_i = random variability in the production that cannot be influenced by the farmer.

U_i = deviation from maximum potential output attributable to technically inefficiency.

The inefficiency of production, Ui, was modeled in terms of the factors that are assumed to affect the efficiency of production of farmers. These factors are related to the socio – economic and institutional variables of the farmers. The determinants of technical inefficiency are defined by:

$$U_1 = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 \cdots\cdots\cdots 4$$

Where:

U_i = inefficiency effects of individual farmers

δ_0 = constant

$\delta_1 - \delta_6$ = parameters to be obtained.

Z_1= Age of farmers in years

Z_2= Experience (Years)

Z_3= Farming experience (years) number of years of farming experience in guava production

Z_4= Household size (number of members living together in a house)

Z_5= Extension contact (number of extensions contact in a year)

Z_6= Membership of cooperative Society (years)

Z_7= Credit (₦)

Stochastic frontier production function model was estimated using the maximum likelihood estimation procedure (MLE).

Results and Discussions

Socio-economic characteristics of the respondents

The result of the study shows that about 60% of the guava farmers were within the age range of 20-40 years. This implies that the farmers are strong, agile, and active and can participate adequately in farming activities. This agrees with the findings of Ugbajah & Uzuegbuna [8], that younger farmers are more active in guava production. From the results in Table 1, 72% of the respondents were males and 28% were females. This conforms to the findings of Baruwa [18], that horticultural crop production is male dominated. Majority of the respondents (60%) have household size of 6-10 people. The large family size could be as a result of the polygamous nature of the society. The large family size provides a source of labour supply in small holder food crop production in most part of Africa. The result agrees with the finding of Ibrahim, Umar & Ahmed [19]. The majority of the guava farmers (67%) had on formal education. This result implies that literacy level among the guava farmers in the study area is relatively low which makes it very difficult for them to use emerging opportunities to adopt new innovations. The result also

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revealed that majority of the respondents (72%) have between 1 & 10years experience in guava production. Experience influences individual's perception and understanding of the management requirements and it is also an important factor determining both the productivity and the production level in guava farming. 88% of the guava farmers have a land holding of less than 1.5ha. This indicates that majority of the farmers are small scale producers of guava.

Table 1: Socio economic characteristics of the respondents.

Variable	Frequency	Percentage
Age		
1 - 20	40	20
21 - 40	80	40
41 - 60	50	25
61 and above	30	15
Total	100	100
Gender		
Male	144	72
Female	56	28
Total	100	100
Household Size		
1 - 5	44	22
6 - 10	120	60
> 11	36	18
Educational Background		
Non-Formal Education	134	67
Primary School	30	15
Secondary School	16	8
Tertiary Institution	4	2
Arabic Education	16	8
Total	100	100
Farming Experience (Years)		
1 - 5	76	38
6 - 10	68	34
11 - 15	36	18
16 - 20	10	5
Above 20	10	5
Total	100	100
Farm Size (ha)		
<1.0	94	47
1.0 - 1.5	82	41
1. 6 - 2.0	16	8
Above 3	8	4
Total	100	100
Extension Visit (No of Days)		
No Contact	40	20
1 - 5	140	70
6 - 10	20	10
Sources of Labour		
Family	110	55
Hired	50	25
Both	40	20

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Sources of Credit		
Personal Savings	148	74
Borrowed	32	16
Both	20	10

Source: Field Survey, 2018

The results in Table 1 indicated that 70% of the respondents had at least 1-5 extension visits in a year 12%. The implication of regular extension visits is increase exchange of information between the agents and farmers; it also enables timely response to challenges. This agrees with Girei, Dire, Yuguda & Salihu [20], who discovered a positive effect of extension contacts on adoption of technologies. The result also revealed that majority of the respondents (55%) use family labour in the production of guava in the study area. Table 1 also shows that 74% of the guava farmers used their personal savings in starting their guava farms.

Effect of socio-economic characteristics of guava farmers using stochastic frontier production function

Table 2: Socio economic characteristics of the respondents.

Variable	Parameter	Coefficient	Std. Error	t - Ratio
Constant	β_0	8.261	0.259	31.712***
Seed	β_1	0.451	0.058	7.736***
Farm Size	β_2	0.147	0.069	3.126***
Agrochemicals	β_3	0.128	0.072	2.104**
Fertilizer	β_4	0.011	0.002	5.594***
Labour	β_5	0.004	0.03	0.096
Inefficiency Model				
Constant	δ_0	0.011	0.635	0.016
Age	δ_1	0.009	0.012	0.601
Years of experience	δ_2	-0.041	0.028	-1.733*
Educational level	δ_3	0.252	0.21	1.223
Household size	δ_4	0.012	0.009	1.32
Extension contact	δ_5	-0.258	0.036	-8.201***
Membership of cooperative	δ_6	-0.12	0.021	-4.968***
Credit	δ_7	-0.04	0.023	-1.911*
Sigma (δ_2)	0.187	0.038	6.513*	
Gamma (γ)	0.263	0.022	7.459*	
Log likelihood	-46.214	15		
Mean technical efficiency	0.741	8		

Source: Field Survey, 2018

The maximum likelihood estimates (MLEs) of the stochastic frontier production function for guava farmers are presented in Table 2 revealed the estimates of the parameters for the frontier production function and the variance parameters of the model. The variance parameters Sigma (δ2) was 0.187 and was statistically significant at 1% level of probability. This indicates a good fit and correctness of the distributional form assumed for the composite error term. The gamma (γ) which is the proportion of deviation from frontier that is due to inefficiency estimate was 0.263 and is statistically significant at 1% it shows the amount of variation resulting from the technical inefficiency of Guava farmers. This means that more than % of the variation in farmers output is due to the difference their technical efficiencies. The mean technical efficiency of the farmers was 74%. This implies that on the average, the respondents are able to obtain about 74% of potential output from a given mix of production inputs. Thus, in the short-run, there is a scope for increasing Guava production by 26%, by adopting the technology and techniques used by the best Guava farmer.

Technical inefficiency in guava production

The estimates of the coefficient of the technical inefficiency model are shown in Table 3. The result shows that years of experience in Guava production, extension contact with farmers, years of cooperative membership and amount of credit received by farmers have negative signs while age, educational level, and household size have positive signs.

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Table 3: Coefficients of the inputs.

Variables	Coefficient
Seed	0.451
Farm size	0.147
Agrochemicals	0.128
Fertilizer	0.011
Labour	0.004
Return to scale (RTS)	0.741

Source: Field Survey, 2018

The coefficient of age (0.009) was positive but not significant and therefore, decreases technical

Efficiency which does not agree with a prior expectation. It could be explained that since Guava farming is less laborious compared to other food crops, age may not be a hindrance. The negative sign on the years of farming experience variable indicates that an increase in the number of years in Guava production, decreases farmers experience and enhances technical efficiencies. This is in agreement with the findings of Djomo, Odoemenem & Biam [21], that years of farming experience was negative and statistically significant at 10% among rice farmers in the west region of Cameroun. The coefficient of education (0.252) was positive but not significant. This indicates that the level of education attained reduce technical efficiency. This implies that high level of education is not desired for farming of Guava and indeed, educated people opt for salaried employment in the study area. This result is in agreement with the findings of Ibrahim, Umar & Ahmed [19], among water melon farmers in Borno state. The coefficient of household size was 0.012 positive but not significant. The positive sign indicates that the larger the family size, the greater is the technical inefficiency. This is in line with the findings of Ehinmowo & Ojo [22], among Cassava Processing Methods among Small Scale Processors in South-West Nigeria.

The coefficient of extension contact (-0.258), was negative and statistically significant at 1%. This agrees with the a priori expectation that extension contact is positively correlated to adoption of improved technology and techniques of production that enhances technically efficiency. This is in agreement with the works of Girei, Dire, Yuguda & Salihu [20], who found out that extension contact increases productivity among cassava farmers in Taraba state. The coefficient of years of cooperative membership is -0.120 and statistically significant at 1%, meaning it increases technically efficiency of the farmers. This is in line with the findings of Ogunyinka and Ajibefun [23,24], among farmers in Ondo state. Farmers' access to credit has a coefficient of -0.040 and is statistically significant at 10%. Farmer's access to credit enhances their timely acquisition of production inputs that would enhance productivity through efficiency. This is in line with earlier result Adeniyi & Olufunmilola [7], among Cassava farmers in Ogun State.

Coefficients of the inputs

The coefficients of the inputs reveal that seed, farm size, fertilizer and labour significantly explained yield at 1% levels of probabilities respectively while agrochemicals significantly explained yield at 5% level of probability. The summation of the input elasticities was 0.741, which indicates that Guava production in the study area was in the stage II of the production surface. Stage II is the stage of decreasing positive returns to scale where resources and production were believed to be efficient. Hence, it is advisable that the production units should maintain the current level of variable input utilization but may increase the use of the fixed inputs in order to ensure maximum output, ceteris paribus.

Frequency distribution of technical efficiency of guava farmers

Table 4: Frequency distribution of technical efficiency of Guava farmers.

Efficiency	Frequency	Percentage
0.1 - 0.49	2	1
0.50 - 0.59	78	39
0.60 - 0.69	70	35
0.70 - 0.79	24	12
0.80 - 0.89	18	9
0.90 - 0.99	8	4
Total	20	100

Source: Field Survey, 2018

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The frequency distributions and summary statistics of efficiency measures for Guava production were presented in Table 4. The mean technical efficiency of the sampled farmers in the study area was 0.69, with 0.91 for the best farmer and 0.30 for the least farmer, indicating that there are substantial inefficiencies in Guava producers. This means that on the average, output fell by 31% from the maximum possible level due to inefficiency. The mean technical efficiency indicates that, if the Guava farmers operated at full efficiency level, they would increase their output by 31% using the existing resources and level of technology. In other words, on average the sample households decrease their inputs by 31% to get the output they are currently getting.

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