International Journal of Agriculture and Biological Sciences- ISSN (2522-6584) May & June 2021

June 30, 2021

On the Efficiency Performance of Bitter Leaf Farming by Cooperative Members in Anambra State, Nigeria

***Obianefo A. Chukwujekwu[1,2], Onyekineso J. Chimezie[3], Okafor P. Ifeoma[3], Okoroji O. Nma[3]**
[1]IFAD Assisted Value chain development Programme, Awka Anambra State
[2]Department of Agricultural Economics and Extension, Nnamdi Azikiwe University, Awka
[3]Department of Cooperative Economics and Management, Nnamdi Azikiwe University, Awka
***Correspondence:** obianefoca@gmail.com

Received Date: 30-Apr-2021 Accepted Date: 26-May-2021 Published Date: 30-June-2021

Abstract:
The study on the efficiency performance of bitter leaf farming by cooperative members in Anambra State, Nigeria used a restrictive Cobb Douglas stochastic frontier approach; production and cost function after testing the null hypothesis for model appropriateness to analyze the data and later predict the technical and economic efficiencies. Data were collected from a cross-section of 205 randomly selected bitter leaf farmers who are members of agricultural cooperatives. The study revealed that fertilizer and labour are the important inputs for bitter leaf production in the area. The study witnessed under-utilization of fertilizer inputs, we, therefore, advised that farm managers should reduce the volume of fertilizer given to the farmers by 54.95% or that policymakers should increase the price of fertilizer available to the farmers by 54.95%. The technical efficiency was found as 77.0% implying that farmers are operating 23.0% below their optimum. For bitter leaf farmers to attain cost-efficiency, they would have to save costs by 3.72%, while cost-inefficient farmer would save 19.35% cost. But, in the short run, the farmers still reserve the chance to increase cost (economic) efficiency by 4.2% through adopting improve agricultural technology. Years of formal education and household size improve the technical efficiency of farmers, while only household size improves economic efficiency. This study is crucial at this time the world needs to grow crops that have so much medicinal value to tackle the menace of the Covid-19 pandemic.

Keywords: *productivity, under-utilization, likelihood ratio, stochastic frontier, bitter leaf*

1.0 INTRODUCTION

Bitter leaf is botanically known as *Vernonia amygdalina* which is a small tree or shrub that is commonly found in Sub- Sahara Africa [1], morphologically, *V. amygdalina* is a perennial soft wooded shrub that can reach a height of 10 m with 40 cm stem diameter [2]. Due to its medicinal value, it is useful for health maintenance and treatment of various diseases use as a protective. The leaf earned its name as bitter leaf due to its abundant bitter principles [1, 3]. Bitter leaf is cultivated in Nigeria and Africa at large because of its nutritional value and health benefits [4]. *Vernonia amygdalina* is useful in the hypnotherapy of diabetes [4, 5, 6].

Vernonia amygdalina especially the edible leafy part has so many health benefits, in corroboration, Nursuhaili asserts that bitter leaf is a source of therapeutic substance produced organically with no harm or possible toxicity to humans, the environment and even to animals [7]. Bitter leaf is rich in protein and can act as an alternative source to animal (beef, pork etc.) protein which is conventionally becoming expensive to the common man [8]. The leaf is good for the treatment of schistosomiasis, malaria, asthma, [9], measles, diarrhea, tuberculosis, abdominal pain and fevers, cough, (4, 10]. The fact that bitter leaf contains very high tannins, saponins, alkaloids, and flavonoids, steroids and triterpenoids, and cardiac glycosides which served as a good source of pharmacologically active phytochemicals make it an effective supplements for human and animal nutrition [11].

Bitter leaf is used for a common dish in Nigeria especially in Anambra State, bitter leaf soup is native to Anambra people, the demand for bitter is increasing in Nigeria since bitter leaf can be used as a substitute for hops in the brewing industry which is now is gaining popularity [12, 13]. Bitter leaf has an exportable value which is one of the sources of revenue to the Anambra State government. Anambra State Ministry of agriculture export vegetables to Europe which bitter leaf is part of. The exported bitter leaf is cultivated among some selected cooperative farmers in some selected local government areas (Ogbaru, Anambra west etc.) of the State to meet the standard required for export. This cooperative of farmers has been earlier defined as coming together of a group of individuals who have specific common needs to form a formidable group to maximize economies of scale [14]

Considering the health benefits identified in the study, there is a need to improve the productivity and efficiency of cooperative farmers in *Vernonia amygdalina* production since this can act as an immune booster at this time of the Covisd-19 pandemic. Productivity is the ratio of total agricultural output to the index of total input used in farm production [15]. Obianefo *et al*. saw productivity as securing an increase in output from the same input or getting the same output from smaller input [16]. Researchers like Adeoye pointed that the high cost of inputs, high cost of labour, small farm holding, limited access to improved seeds, poor extension contacts, storage facilities have been found to distort the productivity and efficiency of leafy vegetable which bitter leaf is part. This efficiency mentioned by scholars means the relative performance of the processes used in transforming input into output [17, 18] or the attainment of production goals without waste [19]. The knowledge of efficiency will help these cooperative farmers understand when to raise agricultural productivity [20]. Despite improving the productivity of cooperative farmers at this Covid-19 time, the onus of production is to maximize profit as a way of measuring the financial performance of a firm. Thus, this study hopes to investigate the technical, economic and allocative efficiency of bitter leaf among cooperators in Anambra State, Nigeria.

2.0 CONCEPTUAL REVIEW

2.1 Concept of Efficiency

Efficiency is a common term in production economics used to described the extent to which time, effort, or cost is well managed for production purpose (Nnamdi *et al.*, 2016), efficiency is often used to refer to the success of producing the highest amount of output possible at a given level of input [21, 22]. Studies have aloud that efficient utilization of production or scarce resources leads to improvement in the production process [23]. Thus, efficiency is a policy and farm management issue because its measurement is an important step in agricultural production aimed at substantial resource-saving. After all, inefficiency is linked to low productivity [24].

Efficiency is an important economic concept. There is a need to expand and sustain cooperative farmers through efficient use of resources because the majority of farmers in developing countries are resource-poor [25]. There are three dimensions to which scholars could tackle production efficiencies, [26] Farrell in 1975 provided the bases for estimating the three dimensions of efficiency as technical, economic and allocative efficiency [27]. Again, these three types of efficiency are measured using four approaches [28, 29], which are; the non-parametric programming approach [30], the parametric programming approach [31]; [32], the deterministic statistical approach [33, 34], and the stochastic frontier approach [35, 36]. Among the four approaches, the non-parametric programming; known as Data Envelopment Analysis (DEA) and stochastic frontier are common.

2.1.1 Technical Efficiency

There is a need for cooperators to strive and improve their technical efficiency (TE) which will lead to a better crop yield, food security and better standard of living [37], this is necessary since the world needs to improve its diet since the onset of Covid-19 pandemic. TE is the degree to which output is maximized for a given level of input, it is the degree to which the actual output of production approaches maximum. It might interest the audience to note that, production technology is modelled through production function, this production function is a scalar output that specified the maximum output obtainable from an input vector [38]. This production function is approached stochastically.

A stochastic frontier analysis (SFA) could be addressed with a Cobb Douglas production function; is a more restrictive approach or a flexible trans-log function that has problems of data convergence due to the presence of multi-collinearity and heteroscedasticity. This stochastic frontier analysis allows for differentiation between random error and inefficiency components [39] the inefficiency components is being subtracted for the random noise because the goal of TE is to maximize output. Aigner *et al.* pointed that the Cobb Douglas production function has an advantage over the trans-log hence it is efficient for inputs modelling due to its ability to take care of multi-collinearity and heteroscedasticity [35]. The stochastic function is defined in equation 1 as:

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

Where: Y_i is maximum output obtained from the *ith* farm, X_i is the vector of inputs of the *ith* farm, β is the vector of the unknown parameters to be estimated, V_i is asymmetric error term that accounted for random variation in maximum output due to external factors identically distributed [20, 40], U_i is a non-negative error term that represents a stochastic frontier shortfall from optimum output [41].

The maximum likelihood estimation (MLE) technique adopted by SFA yields an estimator such as Sigma (σ) and Gamma (γ) mathematically defined as:

$$\sigma^2 = \sigma^2_u + \sigma^2_v \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (2)$$

$$\gamma = \sigma^2_u / \sigma^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (3)$$

Gamma (γ) represents the total variation in maximum output that is attributed to technical inefficiency components whose values lies between zero to one ($0 \leq \gamma \leq 1$).

TE gives an insight to the current state of technology adoption in the *ith* firm [42]. The level of TE is affected by factors associated with farm management: level of education, age, household size, etc. [13, 43] and structural factors (on-farm; farm type, farm location, farm size, fertility, extension contact etc.) and off-farm; infrastructural facilities. TE is defined in terms of observed output (Y_i) to expected output (Y^*) as:

$$TE_{ij} = Y_i / Y^* \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (4)$$

$$TE_{ij} = \frac{f(X_i;\beta)\ exp(V_i - U_i)}{f(X_i;\beta)\ exp(V)} = exp(-U) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

2.1.2 Economic Efficiency

The goal of every manager is to minimize cost or maximize profit, this is why the influence of the external noise and inefficiency components are summed when it comes to economic efficiency. Economic efficiency (EE) uses a cost function approach that combines the concepts of technical (TE) and allocative efficiency (AE) in the cost relationship [25]. A sufficient condition to achieving EE is when TE and AE occur together [44]. Economic efficiency is therefore defined as the ability of farmers or farmers' cooperative members to maximize profit, again EE can be described as the product of TE and AE. It indicates the costs per unit of output for a firm that perfectly attains both technical and price efficiencies [25]. EE is estimated from the stochastic cost function defined as:

$$C_i = f(Y_i, P_{ic};\alpha)\ exp\ \varepsilon_{ic},\ i = 1, 2, \ldots n \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where: C_i is the normalized cost of bitter leaf production, P_{ic} is the vector of input prices, Y_i is the bitter leaf output, α is the vector of unknown parameters to be estimated, ε_{ic} is the composite error term $(V_i - U_i)$. Using the cost function by Sheppard's Lemma, EE is obtained by:

$$\frac{\delta C_i}{\delta P_{ic}} = X_i\ (W, Y, \alpha) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Sheppard's Lemma approach is a system of minimum cost of input demand equations [45]. Substituting the farm's input prices and quantity of output in equation 7 yields the economically efficient input vector (X_c), with observed levels of output the given, the corresponding technically and economically efficiency costs of production will equal X_{ijp} X_{ic}, respectively. Also, the actual operating input combination of the farm is X_{ip}. Using the cost measures to compute the economic efficiency (EE) index is defined as:

$$EE = \frac{X_{ic}}{X_i P} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

2.1.3 Allocative efficiency

It is possible to measure the use of scarce resources by simple input-output ratio or using a Cobb Douglas functional form, but the measurement using input-output relation depends on the contributions of individual resources [46]. This, therefore, means that allocative efficiency is the ability of farm managers to derive maximum output per unit of resources presented [28]. Productivity of resources is the same as allocation of resources such as land, labour, capital, management and water for irrigation between competing alternative [22]. Due to the diversity of capitals in the agricultural sector, measuring resource productivity has remained a herculean tax [22]. Allocative efficiency is often calculated from the elasticity of multiple regression outputs. This study adopted the method of allocative efficiency defined in [46, 47, 48] as:

$$r = \frac{MVP}{MFC} = \frac{MPP{*}P_y}{P_{xi}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Where: r is the allocative efficiency, MVP is the marginal value products (incremental contribution of revenue), MFC is the marginal factor cost, MPP is the marginal physical product, P_y is the mean price of bitter leaf output for the j^{th} farmers, P_{xi} is the unit price of inputs for the j^{th} farmers. r is said to be efficient when equal to 1 (r = 1), resources are said to be over-utilized when r is less than 1 (r < 1), and under-utilized when r is greater than 1 (r > 1).

The relative percentage (%) of MVP of each resource required for maximum output or optimal resource allocation (when r = 1) was defined by [49, 50] as:

$$D = \left(1 - \frac{MFC}{MVP}\right) \text{ or } \left(\frac{1}{r}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

3.1 METHODOLOGY

The study was carried out in Anambra State, the State is located in the south-east geopolitical zone of Nigeria, the State has 21 Local Government Areas (LGAs) such as Aguata, Awka North, Awka South, Anambra East, Anambra West, Anaocha, Ayamelum, Dunukofia, Ekwusigo, Idemili North, Idemili South, Ihiala, Njikoka, Nnewi North, Nnewi South, Ogbaru, Onitsha North, Onitsha South, Orumba North, Orumba South and Oyi. The state has four (Onitsha, Aguata, Awka and Anambra) agricultural zones, with a state administrative headquarter in Awka [51].

The state is bounded by Delta State to the West, Imo State and Rivers State to the South, Enugu State to the East, and Kogi State to the North. The indigenous ethnic groups in Anambra state comprised of 98% Igbo and 2% Igala that are living in the north-western part of the State. Anambra State is located on a latitude of 5°32ˈ and 6°45ˈ N and longitude of 6°43ˈ and 7°22ˈ E, with annual temperature and rainfall of 25.9°C and 138 mm respectively. The State has an estimated land area of 4,865sqkm^2 and 4,177828 people as at the last official census [52].

We employed a multi-stage sampling technique to select the study representatives. In the first stage, the list of over 6000 cooperatives society in Anambra State was obtained from the State Ministry of agriculture in 2020 from where the sample was drawn. Three LGAs: Anambra West (Anambra zone), Orumba North (Aguata zone) and Ogbaru (Onitsha zone) purposively played a host community to the study due to a high number of bitter leaf cooperators in the area. In the second and last stage, 70 (Anambra West), 70 (Ogbaru) and 65 (Orumba North) were randomly selected across the rural villages in the LGAs. This brought the sample size to two hundred and five farmers (205) farmers for the study. A well-structured questionnaire and facial interview was the research instruments used by the enumerator for data collection.

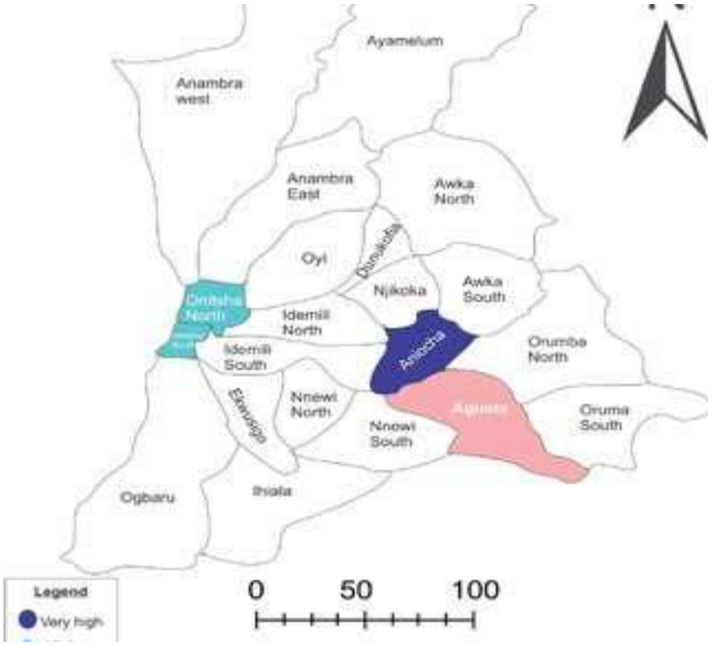

Figure 1: Map of Anambra State.

3.2 Test of Hypotheses

Log-likelihood ratio test developed by Kumbhakar was used to test for the assumptions of the null hypothesis before deciding on the choice of model to be adopted. This test allows the researchers to examine the appropriateness of the restrictive Cobb Douglas model over a flexible trans-log function. Again the generalized likelihood moment (GLM) regression analysis was used to verify the presence of inefficiency components. The likelihood ratio test (LRT) is compared over a table Chi-square distribution value at a probability level of 0.001

alpha. When the value of LRT is greater than the table Chi-square distribution at a certain degree of freedom and alpha of 0.001, the null hypothesis is rejected and we proceed with the alternative function [53]. The LRT is defined in equation 11 as:

$$LRT = -2[(H_o) - (H_1)] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(11)}$$

Where: H_o is the restrictive likelihood ratio, H_1 is the flexible likelihood ratio. The degree of freedom is the difference in estimated parameters between the restrictive and unrestrictive functions. The results of the hypothesis testing is shown in Table 1.

Table 1: Hypotheses testing for appropriateness

Statement	**Model**	**H_o**	**H_1**	**LR-stat**	**Chi square value**	**DF**	**Decision**	**Remark**
Cobb Douglas restrictive model is more appropriate	Production function	-45.581	-35.283	24.596	51.979	25	we fail to reject	proceed with Cobb Douglas model
There is no presence of inefficiency factors	Production function	-45.581	-76.502	61.842	31.264	11	Rejected	Inefficiency present
	Cost function	9.162	345.118	671.910	36.123	14	Rejected	Inefficiency present

3.3 Model Specification

Haven tested the assumptions of the null hypothesis in Table 1, we proceeded with a double log stochastic frontier approach using Stata version 14 to estimate the production function and the cost function respectively. The production function is defined as:

$$LnY = \beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \beta_4 LnX_4 + \beta_5 LnX_5 + exp\,(V_i - U_i) \quad \ldots\ldots\ldots\ldots \text{(12)}$$

Where: X_1 = cuttings (bundle), X_2 = fertilizer (kg), X_3 = organic manure (kg), X_4 = agrochemical (lit), X_5 = labour (man-day). We expect that all the explanatory variables will have a positive sign. Therefore, $\beta_0 > 0; \beta_1 > 0; \beta_2 > 0; \beta_3 > 0; \beta_4 > 0$ and $\beta_5 > 0$. V_i and U_i remained as earlier defined. U_i is assumed to follow an exponential function since we used a single stage maximum likelihood estimation procedure proposed by [54]. Therefore, the farm specific efficiency is given as 1 – TE values [55].

The determinants of inefficiency among bitter leaf farmers is defined as:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(13)}$$

Where: Z_1 = sex (dummy; male = 1, female = 0), Z_2 = age (year), Z_3 = marital status (dummy; married = 1, otherwise = 0), Z_4 = years of formal learning (year), Z_5 = farming experience (year) and Z_6 = household size (No). We expects δ_1, δ_2, δ_3, δ_4, δ_5 and δ_6 to be negative and significant.

Furthermore, the cost function followed a Cobb Douglas approach as is defined as:

$$LnC = \beta_0 + \beta_1 LnP_1 + \beta_2 LnP_2 + \beta_3 LnP_3 + \beta_4 LnP_4 + \beta_5 LnP_5 + \beta_6 LnP_6 + exp\,(V_i + U_i) \quad \ldots\ldots\ldots \text{(14)}$$

Where: C = total cost of production, P_1 = normalized cost of cuttings (USD), P_2 = normalized cost of fertilizer (USD), P_3 = normalized cost of organic manure (USD), P_4 = normalized cost of agrochemical (USD), P_5 = normalized cost of labour (USD), P_6 = normalized cost of asset depreciation (USD) and Y = total output of bitter leaf (kg). Summation of exp $(V_i + U_i)$ is because the farm manager is expected to produce at a minimal cost.

The economic inefficiency follows the single-stage pattern as was stated in equation 13, while the allocative efficiency maintains the formula defined in equation 9.

4.0 RESULTS AND DISCUSSIONS

4.1 Summary of Bitter leaf Farmer's variables used for Frontier Analysis

Table 2 summarized the data collected from the members of farmer's cooperative engaged in bitter leaf farming in Anambra State, the variables were used for the stochastic frontier analysis of both production and cost function. Data on the determinants of technical and economic efficiency summarized the average age (33.897), years of formal education (9.941), farming experience (11.423) household size (6.557) and cultivable land (0.707 ha). Their units of measurements are also shown in table 2. All their standard deviation is above 0.5 to show high variability in responses. Their mean age and years spent in formal learning (table 2) indicate that the farmers are young and in their active farm age and are fairly educated to understand the adoption of agricultural technology or innovations. The average (5,542.429 kg/ha) bitter leaf output produced was as a result of the combination of cutting (86.107 bundles/ha), fertilizer (160.756 kg/ha), organic manure (1878.459 kg/ha), agrochemical (3.415 lit/ha) and labour (18.454). The cost implication of the production inputs was measured in USD for standardization and clarity for all race. The farmers on average spent 236.335 USD/ha (cuttings), 62.525 USD/ha (fertilizer), 436.983 USD/ha (organic manure), 11.174 USD/ha (agrochemicals), 65.620 USD/ha (labour) and 15.327 USD/ha (asset depreciation).

Table 2: summary of bitter leaf farmer's variables used for frontier analysis

Variables	**Mean**	**Std. Dev.**	**Min**	**Max**
Sex	0.434	0.497	0	1
Age (year)	33.897	10.482	19	64.831
Marital status (dummy)	0.585	0.494	0	1
Years of formal learning	9.941	4.567	3	19
Farming experience (year)	11.423	6.274	4	33
Household size (No)	6.557	3.098	1	14
Farm size (ha)	0.707	0.811	0.216	6
Output (kg)	5,542.429	1,467.968	2,839.000	7,951.000
Cutting (bundle)	86.107	21.597	49.000	123.000
Fertilizer (kg)	160.756	53.461	70.000	245.000
Organic manure (kg)	1,878.459	599.867	902.000	2,980.000
Agrochemical (Lit)	3.415	1.729	1.000	6.000
Labour (man-day)	18.454	5.376	10.000	27.000
Cuttings (USD)	236.335	90.752	83.211	476.995
Fertilizer (USD)	62.525	26.000	23.039	125.079
Organic manure (USD)	436.983	185.987	134.871	970.532
Agrochemical (USD)	11.174	5.693	2.637	23.589
Labour (USD)	65.620	22.627	28.547	120.079
Asset depreciation (USD)	15.327	9.296	0.272	77.415

Source: Field Survey Data 2021.

4.2 Estimation of the Production function

The stochastic Cobb Douglas production function (table 3) produced a 0.773 Gamma value which explains the percentage variation in frontier/optimal output as a result of the presence of inefficiency components, this implies that deviation on technical efficiency (TE) of bitter leaf farmers from the optimal output emanated from the socioeconomic characteristics of the farmers and not from random noise. Thus, the Gamma of 0.773 implies that the inefficiency components explained 77.3% variation in technical efficiency of farmers in the study area. The likelihood ratio of -39.873 is significant at a 1% level of significance indicating goodness of fit.

Relative to the significant variables, the coefficient (0.086) of fertilizer was positive and significant at a 10% level of significance, this implies that increasing the quantity of fertilizer use by 10% will increase bitter leaf output by 8.6%. These findings have shown that fertilizer is an important input to improve bitter leaf productivity among cooperators in the area. Again, the coefficient (0.047) of agrochemical was negative and significant at a 10% level of significance, this implies that increasing the use of agrochemical by 10% will conversely reduce bitter leaf output by 4.7%. This suggests that farmers should be careful on the choice of agrochemical to avoid toxicity to the plant, farmers should also endeavor to follow directives on the application of agrochemicals. Equally, the coefficient (0.109) of labour was positive and significant at a 10% level of significance, this implies that increasing labour employment in the farm by 10% will increase bitter leaf output by 10.9%. The implication is that bitter leaf farming among cooperators is labour intensive which is a common phenomenon among smallholder farmers in Nigeria and Africa at large. Furthermore, if all things being equal and the entire production factors are held constant, bitter leaf output will increase above 100%.

Table 3: Estimation of production function

Explanatory variables	Parameters	Coefficient	Std. Err.	t-ratio
Cuttings (bundle)	β_1	0.068	0.067	1.02
Fertilizer (kg)	β_2	0.086	0.049	1.74*
Organic manure (kg)	β_3	-0.021	0.052	-0.40
Agrochemical (lit)	β_4	-0.047	0.028	-1.67*
Labour (man-day)	β_5	0.109	0.060	1.82*
Constant	β_0	7.983	0.607	13.15***
Diagnostic statistics				
Likelihood ratio	LR	-39.873		
Sigma	σ	0.111		
Gamma	γ	0.773		
n		205		
Determinants of TE				
Sex	α_1	-0.207	0.327	-0.63
Age (year)	α_2	0.024	0.017	1.41
Marital status	α_3	-0.317	0.326	-0.97
Years of formal learning	α_4	-0.076	0.040	-1.9*
Farming experience (year)	α_5	0.035	0.027	1.3
Household size (No)	α_6	-0.104	0.052	-1.99**
Constant	α_0	-2.022	0.816	-2.48**

Source: Field Survey Data, 2021. (*) Sig. @ 10%, (**) Sig. @ 5%, (***) Sig. @ 1%

Down table 3 is a reflection of the determinants of technical efficiency, the years of formal education, and household size increases the technical efficiency (TE) of bitter leaf production. The coefficient (0.076) of years of formal education was negative and significant at a 10% level of significance, which implies that formal education increases technical efficiency by 7.6%. Education is important to improving farmer's productivity as this will help the farmers to adopt improved agricultural technologies. Also, the coefficient (0.104) of household size was negative and significant at 5% significance level, this implies that household size increases TE by 10.4%. Large household size supplied cheap labour to the farm and its availability will aid the adoption of improved agricultural technology for optimal productivity.

4.3 Estimation of Cost Function

The stochastic Cobb Douglas cost function (table 4) produced a 0.913 Gamma value which explains the percentage variation in the minimal cost of production due to the farmer's management ability, this implies that deviation on economic efficiency (EE) of bitter leaf farmers emanated from the socioeconomic characteristics or their ability to allocate scarce resources to minimize cost and maximize profit. Thus, the Gamma of 0.913 implies that the inefficiency components explained 91.3% variation in the economic efficiency of farmers in the study area.

Relative to the significant input cost, the coefficient of the price of production inputs are all significant at a 1% significance level, this implies that a 1% increase in the price of cuttings, fertilizer, organic manure, agrochemicals, labour and depreciation on the asset will increase the total cost of bitter leaf production by 26.5% (cuttings), 6.6% (fertilizer), 50.8% (organic manure), 1.6 (agrochemical), 8.8% (labour) and 3.5 (depreciation on asset) respectively. The result reflects the *a priori* expectation of the researchers, from the result, it is evident that farmers depend more on organic manure than NPK fertilizer, this could be influenced by their decision to meet export criteria or standards.

Down table 4 is a reflection of the determinants of economic efficiency, sex, marital status and farming experience increase economic inefficiency, while household size increases economic efficiency in the study. The coefficient (0.577) of sex was positive and significant at a 10% significance level, this implies that targeting more male cooperators by 10% will increase economic inefficiency by 57.7%. Male cooperators may not be patient to apply the agronomic practices disseminated by the extension agents. Again the coefficient (0.545) of marital status was positive and significant at a 10% significance level, this implies that increasing the number of married cooperators by 10% will increase economic inefficiency by 54.5%. Marriage comes with responsibilities and the cooperators will have more activities to be engaged in or other family issues to attend to other than bitter leaf farming alone. This divided attention will greatly affect their economic efficiency level. Equally, the coefficient (0.038) farming experience was positive and significant at a 10% significance level, this implies that a 10% increase in their farming experience will increase economic inefficiency by 3.8%. When farmers seem to stick more to their indigenous knowledge as a result of age-long experience instead of adopting improved agricultural technology, they may become resource wasteful and this will greatly affect economic efficiency. Furthermore, the coefficient (0.118) of household size was negative and significant at a 5% significance level, this implies that a 5% increase in the number of household members will increase economic efficiency by 11.8%. Household members will supply cheap labour which will help to lower the cost of production among bitter leaf farmers in the area.

Table 4: Cost function

Explanatory variables	Parameters	Coefficient	Std. Err.	t-ratio
Cuttings (USD)	β_1	0.265	0.007	39.27***
Fertilizer (USD)	β_2	0.066	0.005	12.27***
Organic manure (USD)	β_3	0.508	0.008	64.21***
Agrochemical (USD)	β_4	0.016	0.003	4.86***
Labour (USD)	β_5	0.088	0.007	13.05***
Asset depreciation (USD)	β_6	0.035	0.006	6.01***
Output (kg)	β_7	0.003	0.007	0.42
Constant	β_0	1.571	0.137	11.5***
Diagnostic statistics				
Likelihood ratio	LR	389.678		
Sigma	σ	0.002		

Gamma	γ	0.913		
n		205		
Determinants of EE				
Sex	α_1	0.577	0.321	1.8*
Age (year)	α_2	-0.004	0.014	-0.29
Marital status	α_3	0.545	0.316	1.72*
Years of formal learning	α_4	-0.034	0.036	-0.95
Farming experience (year)	α_5	0.038	0.023	1.65*
Household size (No)	α_6	-0.118	0.051	-2.34**
Constant	α_0	-6.115	0.730	-8.37***

Source: Field Survey Data, 2021. (*) Sig. @ 10%, (**) Sig. @ 5%, (***) Sig. @ 1%

4.4 Allocative Efficiency of Bitter Leaf Production

The resource allocation ability of the cooperators is presented in table 5, apart from fertilizer; every other input like cuttings, organic manure, agrochemicals and labour were over-utilized. Fertilizer was under-utilized. The implication is that policymakers should increase the price of fertilizers available to bitter leaf farmers by 54.95% or the farm management should reduce the quantity of fertilizer given to the farmers by 54.95% which will help to ensure optimal allocation of resource (fertilizer) in the area. The farmers are generally inefficient in resource allocation.

Table 5: Allocative efficiency of bitter leaf production

Variables	MPP (β)	MVP	Input quantity	Input price	MFC	r	D (%)	Decision
Cuttings	0.068	0.560	86.107	236.335	2.745	0.20	490.43	Overused
Fertilizer	0.086	0.708	160.756	62.525	0.389	1.82	54.95	Underutilized
Organic manure	-0.021	-0.173	1,878.46	436.983	0.233	-0.74	134.60	Overused
Agrochemical	-0.047	-0.387	3.415	11.174	3.272	-0.12	845.90	Overused
Labour	0.109	0.897	18.454	65.62	3.556	0.25	396.39	Overused

Source: Field Survey Data, 2021.

4.5 Technical and Economic Efficiency index

Table 6 reflect the technical efficiency (TE) and economic efficiency (EE) index or ratio of bitter leaf farmers. The TE of majority (56.1%) of the farmers are 0.802 and above, the rest ranges from 0.602 – 0.801 (25.4%), 0.402 – 0.601 (17.6%) and 0.000 – 0.401 (1.0%) respectively. The mean TE index of bitter leaf farmers is 0.770. This implies that farmers are 77.0% technically efficient and are operating or producing 23.0% below their optimal potentials.

Furthermore, the majority (99.5%) of the farmer's economic efficiency (EE) index ranges from 0.802 and above, while the remaining 0.5% ranges from 0.602 – 0.801. The minimum EE index is 0.800 and the maximum is 0.995, while the mean EE index is 0.958. For an average bitter leaf farmer to attain the level of a most cost-efficient farmer, he/she would save costs by 3.72% (1 – mean/max). While the most cost-inefficient farmer would save 19.35% (1 – min/max) cost. Thus, in the short run, there is scope for increasing the farmer's cost (economic) efficiency by 4.2% (1 – mean), by adopting improve technology and techniques used by best-practised bitter leaf farmers.

Table 6: Technical and Economic Efficiency index

		TE		EE
Efficiency index	**Freq.**	**Percentage (%)**	**Freq.**	**Percentage (%)**
0 - 0.401	2	1.0	0	0
0.402 - 0.601	36	17.6	0	0

0.602 - 0.801	52	25.4	1	0.5
0.802 and above	115	56.1	204	99.5
Mean	**0.770**		**0.958**	
Std. Dev.	0.158		0.040	
Min	0.057		0.800	
Max	0.944		0.995	

Source: Field Survey Data, 2021.

5.0 CONCLUSIONS

The study on the efficient performance of bitter leaf farming by cooperative members in Anambra State, Nigeria revealed that bitter leaf production is in the hand of smallholder farmers as evident by mean farm size of 0.707 ha, these smallholder farmers are young, active (mean age = 33.897) and fairly educated (average = 9.941). Also, smallholder farmers are operating 23.0% below their optimal production capacity. It is important to reiterate that fertilizer and labour are the important inputs for bitter leaf production in the area. Due to the under-utilization of fertilizer inputs, we have advised that farm managers should reduce the volume of fertilizer given to the farmers by 54.95% or that policymakers should increase the price of fertilizer available to the farmers by 54.95%. The study also revealed that, for an average bitter leaf farmer to attain cost efficiency, he/she would have to save costs by 3.72%, while a cost-inefficient farmer would save 19.35% cost. But, in the short run, the farmers still reserve the chance to increase cost (economic) efficiency by 4.2% through adopting improve agricultural technology.

REFERENCES

i *Nwogwugwu CP, Nwakpu EP, Oyeagu CE & Obi CL (2015). Effect of Vernonia amygdalina (bitter leaf) extract on growth performance, carcass quality and economics of production of broiler chickens. International Journal of Agriculture and Earth Science, 1(5): 1-13.*

ii *Yeap SW, Ho WY, Beh BK, Liang WS, Ky H, Noaman Yousr AH & Alitheen NH (2010). Vernonia amygdalina, an ethnoveterinary and ethnomedical used green vegetable with multiple bioactivities. Journal of Medicinal Plants Research, 4(25): 2787-2812.*

iii *Ekpo A, Eseyin OA, Ikpeme AO & Edoho EJ (2007). Studies on Some Biochemical Effects of Vernonia Amygdalina in Rats. Asia Journal of Biochemistry; 2(3): 193-197.*

iv *Owen OJ, Amakiri AO & Ezeano CI (2010). The cost benefit analysis of incorporating bitter leaf (Vernonia amygdalina) meal in broiler finishers' diet. Journal of Environmental Issues and Agriculture in Developing Countries, 2(1): 131-141.*

v *Ukegbu FO & Ogbuehi KJ (2004). Effect of the aqueous extract (crude) of leaves of Vernonia amygdalina on blood glucose, serum cholesterol and serum albumin levels in alloxan induced diabetic albino rats. Global Journal Pure Applied Science, 10: 189 - 194.*

vi *Nwajo HU (2005). Efficacy of aqueous leaf extract of Vernonia amygdalina on plasma lipoproteins and oxidative status in diabetic rat model. Nigerian Journal Physiological Science, 20: 39 - 42.*

vii *Nursuhaili AB, Nur Afiqah Syahirah P, Martini MY, Azizah M & Mahmud TMM (2019). A review: medicinal values, agronomic practices and postharvest handlings of Vernonia amygdalina. Food Research pp-pp: 1-13.*

viii *Maduabuchi IA, Bede IE, Okpoko VO, Ugokwe CU & Okereke HN (2019). Effects of three leafy vegetables on the growth performance of Giant African Snail Achatina (Lissachatina) fulica. Journal of*

Agriculture and Rural Development in the Tropics and Subtropics, 120 (1): 15–20.

ix *Masaba SC (2000). The antimalarial activity of some traditional medicinal plants. Ethiopian Journal Health Development, 13: 211-216.*

x *Akinpelu DA. (1999). Antimicrobial activity of Vernonia amygdalina leaves. Fitoterapia Journal Study Medicinal Plants, 70: 432 - 435.*

xi *Usunobun, U. & Ngozi, O. (2016). Phytochemical analysis and proximate composition of Vernonia amygdalina. International Journal of Scientific World, 4(1), 11.* https://doi.org/10.14419/ijsw.v4i1.5845

xii *Adanna KK, Oberafo AA & Dika SI (2011). Bitter leaf as a local substitute for hops in the Nigerian brewing industry. Archive of Applied Science Research, 3(4): 388-397.*

xiii *Adenuga AH, Muhammad-Lawal A & Rotimi OA (2013). Economics and technical efficiency of dry season tomato production in selected areas in Kwara state, Nigeria. Agris On-line Papers in Economics and Informatics, 5(1):11-19.*

xiv *Raychelle M (2016). A wealth of opportunities in a world of limits: free enterprise. Economics of Cooperation, Federal Reserve Bank of Dallas;* www.dallasfed.org

xv *Sule A & Yusuf A (2019). External financing and agricultural productivity in Nigeria. Journal of Economics and Finance, 3(1), 307-320.*

xvi *Obianefo CA, Osuafor OO, Ezeano CI & Anumudu OO (2020). Mediation effect of adopting good agronomic practices on rice productivity in Anambra State, Nigeria. Intl Journal of Agric. and Rural Dev., 23(1): 4913-4926.*

xvii *Lissitia A & Odening G (2005). Efficiency and Total Factor Productivity in Ukrainian Agriculture in Transition. Agricultural Economics 32: 311-328.*

xviii *Aliyu A & Shelleng AB (2019). Analysis of Technical, Allocative and Economic Efficiencies of Yam Producers in Ganye Local Government Area of Adamawa State, Nigeria." International Journal of Engineering Technologies and Management Research, 6(7): 129-143.*

xix *Ajibefun IA, Battese GE & Daramola AG (2002). Determinants of Technical Efficiency in Small Holder Crops Farming: Application of Stochastic Frontier Production Function. Quarterly Journal of International Agriculture, 41(3): 225 -240.*

xx *Obianefo CA, Nwigwe CA, Meludu TN & Anyasie IC (2020). Technical efficiency of rice farmers in Anambra State value chain development programme. Journal of Development and Agricultural Economics, 12(2): 67-74.*

xxi *Ajayi OO, Amos TT & Aminu TJ (2018). Analysis of the technical efficiency of Tomato production in Oyo State, Nigeria. Second International Conference on Food Security and Hidden Hunger (8th –10th October 2018), Alex Ekwueme Federal University Ndufu-Alike, Ebonyi State, Nigeria, pp. 13-16.*

xxii *Ohajianya DO, Onu PN, Ugwu JN, Osuji MN, Nwaiwu IU, Orebiyi JS, Godson-Ibeji CC & Enyia CO (2013). Technical efficiency of table egg producers in Imo State, Nigeria. Asian Journal of Agricultural Extension, Economics and Sociology, 2(2): 118-127.*

xxiii *Najjuma E, Kavoi MM, Mbeche R (2016). Assessment of technical efficiency of open field tomato production In Kiambu County, Kenya (stochastic frontier approach). Jomo Kenyatta of Agriculture and Technology Journals. 17 (2): 21-39.*

xxiv *Amos TT (2018). Agricultural production and productivity: the game changing food security paradigm in Nigeria. Inaugural Lecture Series 95, Federal University of Technology. Akure, Ondo State.*

xxv *Adeoye IB (2020). Factors Affecting Efficiency of Vegetable Production in Nigeria: A Review. Agricultural Economics. DOI: 10.5772/intechopen.92702.*

xxvi *Farrell PV (1975). Purchase and material management. Journal of Supply Chain Management, 11(1): 4-4.*

xxvii *Biam CK, Okorie A & Nwibo SU (2016). Economic efficiency of small scale soyabean farmers in Central Agricultural Zone, Nigeria: A Cobb-Douglas stochastic frontier cost function approach. Journal of Development and Agricultural Economics, 8(3): 52-58.*

xxviii *Mahesh S & Mahima B (2018). Resource use efficiency analysis for potato production in Nepal. Journal of Nepal Agricultural Research Council, 4: 54-59. DOI: http://dx.doi.org/10.3126/jnarc.v4i1.19690*

xxix *Coelli TJ, Prasada RDS & Battese GE (1998). An Introduction to Efficiency and Productivity Analysis. Boston: Kluwer Academic Publishers.*

xxx *Charnes A, Cooper W & Rhodes E (1978). Measuring the efficiency of decision making units. Eur. J. Oper. Res. 2:429-444.*

xxxi *Aigner DJ & Chu SF (1968). Estimating the Industry Production Function. Am. Econ. Rev. 58:826-839.*

xxxii *Ali M & Chaudhry MA (1990). International farm efficiency in Pakistan Punjab: a frontier production function study. J. Agric. Econ. 41(3):42-74.*

xxxiii *Fasasi A. R. (2006). Resource use efficiency in yam production in Ondo State, Nigeria. Agric. J., 1 (2), 36-40.*

xxxiv *Fleming P, Fleming E, Griffith G & Johnston D (2004). Animal Efficiency in an Intensive Beef Production Genetic Breeding Unit, Armidale: University of New England, NSW, Australia.*

xxxv *Aigner DJ, Lovell CAK & Schmidt P (1977). Formulation and estimation of stochastic frontier production model. J. Econ. 6:22-37.*

xxxvi *Kirkley JE, Squires D & Strand IE (1995). Assessing technical efficiency in commercial fisheries: the Mid-Atlantic Sea Scallop fishery. Am. J. Agric. Econ. 20:31-34.*

xxxvii *Tabe-Ojong MP, Molua EL (2007). Technical efficiency of smallholder tomato production in semi-urban farms in Cameroon: A stochastic frontier production approach. Journal of Management and Sustainability, 7(4):27-35.*

xxxviii *Rolf F & Knox LCA (1978). Measuring the technical efficiency of production. Journal of Economic Theory, 19: 150-162.*

xxxix *Malinga N, Masuku M & Raufu M (2015). Comparative analysis of technical efficiencies of smallholder vegetable farmers with and without credit access in Swazil and the case of the Hhohho Region.*

xl *Nnamdi E, Stephen O, Glory BC, Ubon E, Emeka Osuji & Melissa Okwara (2016). Farming techniques, environmental challenges, and technical efficiency of Sweet Potato production in Abia State, Nigeria. International Journal of Agricultural Management and Development, 409-420.*

xli *Osawe OW, Adeqeye-Bolarin AJ & Omonona-Bolarin O. (2018). Technical efficiency of small scale farmers: An application of the stochastic frontier production function on fish farmers in Ibadan*

Metropolis. Electronic Journal, 1-41. DOI: 10.2139/ssrn.1819042.

xlii *Ogunniyi LT & Oladejo JA (2011). Technical Efficiency of tomato production in Oyo State Nigeria. Agricultural Science Research Journal, 1(4): 84 – 91.*

xliii *Martin M, Taylor TG. 2003. A comparison of the efficiency of producers under collective and individual modes of organization. Colombian Economic Journal. 1(1):246-266.*

xliv *Jorgenson DW & Lau LJ (1973). The duality of technology and economic behavior. Discussion paper number 252 (Cambridge: Harvard Institute of Economic research.*

xlv *Bravo-Ureta, B.E. & Evenson, R.E. 1993. Efficiency Analysis of Developing Country Agriculture: A Review of the Frontier Function Literature. Agricultural and Resource Economic Review, 22: 88-101.*

xlvi *Obianefo CA, Nwike CM, Anumudu OO & Onyekineso CJ (2020). Analysis of the Resource Management Ability by Catfish Farmers in Nigeria: A Case of Ogbaru Local Government Area, Anambra State. International Journal of Agricultural Economics, 5(5): 156-164.*

xlvii *Awunyo-Victor D, Abawiera CW & Aidoo R (2016). Resource use efficiency among maize farmers in Ghana. Agric. & Food Security, 5 (28): 1-10.*

xlviii *Fasasi AR (2006). Resource use efficiency in yam production in Ondo State, Nigeria. Agric. J., 1 (2), 36-40.*

xlix *Mijindadi N. B. (1980). Production efficiency on farms in Northern Nigeria. An unpublished Ph.D Thesis, Cornell University, U.S.A.*

l *Ochi JE, Sani RM & Idefoh F. K. (2015). Economic analysis of resource use efficiency among small scale cassava farmers in Nasarawa State, Nigeria: Implications for Agricultural Transformation Agenda. International Journal of Research in Agriculture and Forestry, 2(2):14-21.*

li *Obianefo CA, Aguaguiyi NF, Umebali EE & Ezeano CI (2019). Comparative Analysis of Rainfed and Dry Season Rice Farming in Value Chain Development Programme in Ayamelum Local Government Area- Anambra State. International Journal of Science and Research 8(7):1655-1659.*

lii *Nigeria data portal: Nigeria Population Censor (NPC, 2006). http://http://nigeria.opendataforafrica.org/ifpbxbd/statepopulation-2006*

liii *Kumbhakar SC, Wang HJ, Horncastle A (2015). 'A practitioner's guide to stochastic frontier analysis using Stata'. Cambridge University Press. www.cambridge.org/9781107609464.*

liv *Coelli TJ & Battese GE (1996). Identification of factors which influence the technical inefficiency of Indian farmers. Australian Journal of Agricultural Economics, 40(2): 103-128.*

lv *Assa MM, Abdi-Khalil E & Matchaya GC (2012). Unexploited Profit among Smallholder Farmers in Central Malawi: What are the Sources? International Journal of Applied Economics 9(2):83-95.*