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Keywords: efficiency of resource-use, elasticity of production, maximum likelihood estimates, return to scale, stochastic frontier production function, inefficiency, irrigation.

I. Introduction

Tomato (*Lycopersiconlycopersicum*) is perhaps the most important popular vegetable crop grown all over the country. Tomato production in Nigeria is seasonal and consequently, its supply for home and industrial use is seasonal with a peak during harmattan season. The seasonality of supply affects price. About 90% of the country's food is produced by small-scale farmers cultivating tiny plots of land who depend on rainfall rather than irrigation systems (Maurice, 2007).

The benefit of irrigation (which is the artificial supply of water for agricultural crop growth) in Nigeria is not limited to food supply alone but it also serves as a source of income and employment during the slack period of rainfed agriculture. There are two distinct seasons in Nigeria. These are the rainy (April to October) and the dry (November to March) season. Farmers are usually less busy on the farm during the dry season; therefore, irrigation farming serves as an alternative employment and additional source of income during the period. Irrigation farming practice has increased tremendously because of increasing demand for tomatoes and other food items during off farming season. This has placed tremendous pressure on tomato production to meet up with the increasing demand, as limited foreign reserves have to be allocated to tomato importation in order to meet consumption requirements.

Resources used in any production activity are regarded as the inputs that drive the production process. In tomato farming, the resources required include the seeds, land, labour, capital and fertilizer. The main technology applied is the traditional cutlass, hoe, water can and bucket technology which has been blamed for the low output levels of tomato. In order to stem the decline in the number of farmers participating in irrigated tomatoes farming in the study area and at the same time increase production of tomatoes, the federal and state government introduced a number of agricultural development programmes/projects, yet tomato production has persistently remained below market demand (Maurice, 2007).

To cope with the predominant menace of low productivity of irrigated tomato farmers in Benue state, resource use efficiency is a prerequisite for optimum farm production since inefficiency in production, can distort food availability and security. It is against this background that this research is set out to empirically investigate the role of irrigated tomato which is becoming more prevalent within the farmers in Vandeikya local government area. The objective of this study is to ascertain the socio economic characteristics of irrigated tomato farmers in the study area, investigate whether the resource use in irrigated tomato are efficiently utilized among irrigated tomato farmers and also identify any gaps that may exist in the current level of resources employed by irrigated tomato farmers in the study area, as well as encouraging them to beef up

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their output level. This work is, therefore, organized under the following headings: the introduction; theoretical framework and literature review; methodology; result and discussion; conclusion and recommendation.

II. Theoretical Framework and Literature Review

The study has it theoretical underpinning from the production theory. That is, production function is the technical relationship between inputs and outputs; a function that summarizes the process of conversion of factors into a particular commodity. It shows the maximum amount of the good that can be produced using alternative combinations of the various inputs. Three types of efficiency are identified in the literature. These are technical efficiency, allocative efficiency and overall or economic efficiency (Farrell, 1957; Olayide& Heady, 1982). Technical efficiency is the ability of a farm to produce a given level of output with minimum quantity of inputs under a given technology. Allocative efficiency is a measure of the degree of success in achieving the best combination of different inputs in producing a specific level of output considering the relative prices of these inputs. Economic efficiency is a product of technical and allocative efficiency (Olayide& Heady, 1982).

This literature emphasizes two broad approaches to production frontier model (a) the non-parametric programming approach, and (b) the statistical approach. The non-parametric programming approach requires the construction of a free disposal convex hull in the input – output space from a given sample of observations of inputs and outputs (Farrel, 1957). The convex hull (generated from a subset of the given sample) serves as an estimate of the production frontier, depicting the maximum possible output. Production efficiency of an economic unit is thus measured as the ratio of the actual output to the maximum output possible on the convex hull corresponding to the given set of inputs, which is illustrated in figure 1. First take the case when the farm is producing all the good outputs that have positive prices. Suppose V is one such observation where a farm is operating, the technical efficiency of this farm is **TE = OV/OD**. The overall efficiency is defined as **OE = ry/R(x, r),** and is equal to **OV/OE.** It is the ratio of observed revenue to maximum revenue. Where **R(x, r)** is the maximum revenue, **ry** is the observed revenue of a farm, x and y is the input and good output vectors, and r is the output price vector. Allocative output efficiency is defined as: **AE = {ry/TE} / R (x, r),** and it equal to **OD/OE** in figure 1.

Thus from figure 1, it follows that, **OE = TE * AE.** In extending the case in a situation where a farm is producing one marketable product, **y** along with an undesirable output, **Z** (pollution). The desire output has positive market prices but the undesirable has either zero or negative price. Its price is negative when a tax is imposed on its production.Assume that in the production possibility set there are no points on the left of the line **OB,** due to technical or biological restrictions or in other words the production of good and bad outputs are null-joint.

The assumption of null-joint ness implies that some positive amount of bad output is necessarily produced when the farmers are producing some positive amount of good outputs. Therefore, point **B** in figure 1 is the single point where all of the resources, are conventional as well as naturally utilized efficiently. Because (i), point **B** is on the frontier, so the conventional resources (inputs) are used in a technically efficient manner, and (ii) in point **B** the natural resources are used optimally, since it is located on the radial with the lowest production of undesirable outputs per unit of desirable output.

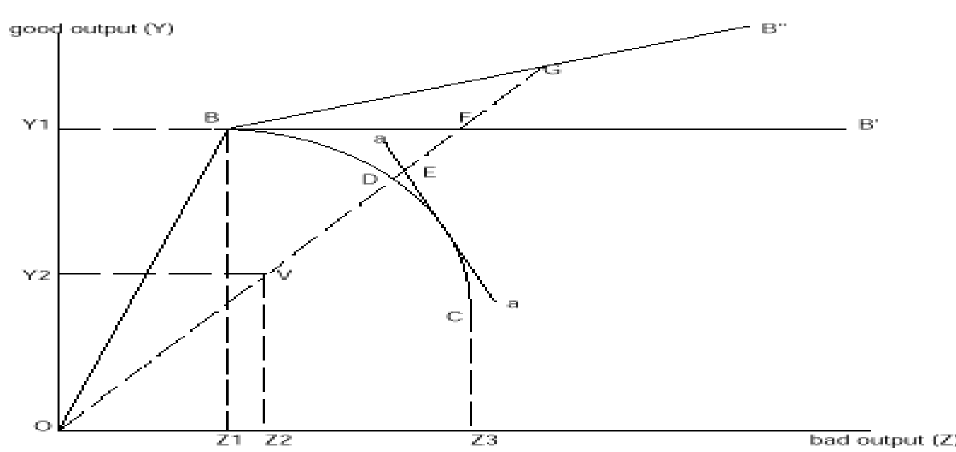

Figure : output Based Resource Use Efficiency Measure

In figure 1, the technical output-orientated efficiency measure (TE) at output bundle V is TE_v (Y_v, Z_v, X) = Do (Y_v, Z_v, X) and is equal to OV/OD. A farm is environmentally efficient if it is producing the lowest amount of undesirable output per unit of desirable output, i.e. point B in the figure. The measure of environmental efficiency (EE) has to relate the ratio of good and bad output at point D (equal to the ratio at V) to the maximum ratio at point B. Farrell (1995), recall that point B in the figure is 'resource use efficient' point. They compare point V to point B. Resource use efficiency for the output bundle V is equal to B: Therefore, resource efficiency can be decomposed into **TE** and **EE,** i.e. $RE_V = TE_V$. EEv. They concluded that resource efficiency is analogous to **OE** and EE is analogous to AE.

The study adopts the second approach that has it theoretical underpinning with Farrell's production frontier function with a multiplicative disturbance term of the farm:

$$Y = f (X_{a},;\beta)\, e^{E} \text{ ....(1)}$$

Where Y = output; X = vector of input, β = vector of parameter, e = error term; E is stochastic disturbance term consisting two independent element "V" and "U".

$$\text{Hence, } E = U + V \text{ .... (2)}$$

The symmetric element V account for random variation in output quantity attributed to factors outside the farmer's control (such as disease, weather). A one – sided component U < O reflects technical inefficiency relative to the stochastic frontier. Thus U = O for farm output that lie on the frontier (i.e. 100% technical efficiency in resource use) and U < O for farm output below the frontier as N ~ (o, σ_u^2 v). Thus equation (1) becomes:

$$Y = f (X_{a},;\beta)\, e^{u+v} \text{... (3)}$$

Several empirical applications have followed the stochastic frontier specification. The first application of the frontier model to farm level data was by Battese and Coelli (1995) who estimated deterministic and stochastic Cobb-Douglas production frontier for the economics of scale in sheep production in Australia. The variance of the farm effects was found to be in a highly significant proportion of the value of sheep production in Australia. Their study did not, however, directly address the technical efficiency of farms.Similarly, Bagi (2004) employed the stochastic frontier Cobb-Douglas production function model to investigate differences in technical efficiencies of sole and mixed enterprise farm in west Tennessee. The study found that the variability of farm effects was highly significant. The mean technical efficiency of mixed enterprise farms was found to be smaller (0.76) than for sole crop farms (0.85). The study show that, mixed enterprise farms were inefficient as compare to the sole crop farms as demonstrated by their various efficiency ratios.

The use of the stochastic frontier analysis in the study of agriculture in Nigeria is a recent development. Such studies include that of Udoh (2003), Okike (2006) and Amaza (2000). Udoh used the maximum Likelihood Estimation of the stochastic production function to examine the land management and resource use efficiency in south–Eastern Nigeria. The study found a mean output –oriented technical efficiency of 77% for the farmers, this indicates that farmers can still expand production by 23%. The 0.98 indicates 98% for the most efficient farmers and 0.11 indicating 11% for the least efficient farmers. Okike's study investigated irrigated vegetable production and technical efficiency of farmers in the savanna zones of Nigeria. The study found average technical efficiency of farmers arehigher in the zones. Also Amaza's work on small scale farm size and resource use efficiency in Kwara state, opined that, one of the means of proper utilization of farm inputs for greater efficiency is through farm size adjustment. The result was collaborated by the mean cost efficiency of 1.161 obtained from the data analysis which shows that an average farm in the sample area is about 16% above the frontier cost, indicating that they are relatively efficient in allocating their scarce resources.

III. Methodology

The study employed both primary and secondary.The study uses random sampling technique to analyze data. Samples were drawn from five wards in Vandeikya Local Government Area. The wards include: Mbakaange, Mbagbera, Ningev, Mbanyimagbah and Mbatyough council wards. In each ward, twenty four (24) questionnaires were randomly distributed to irrigated tomato farmers. Thus making a total of 120 questionnaires distributed in the study area. However, the questionnaires were given to educated irrigated tomato farmers to fill while uneducated ones were interviewed orally.Two analytical techniques were used to analyze the data collected. These are: Firstly, simple percentage analysis. Secondly, the Stochastic Frontier Production Function (SFPF) was used to estimate the resource use efficiency in irrigated tomato production. It is given by:

$$\ln Y_i = \ln\beta_o + \sum\beta j \ln Xij + Vi - Ui; \text{ ....4}$$

Empirical formulation of equation 4 requires functional specification process in the presence of inefficiency. Base on the theoretical underpinnings, Cobb- Douglas production functional form is therefore used. Hence the empirical model is as follow:

$$\text{Ln } Y = \beta_o + \beta_1 \ln(x_1) + \beta_2 \ln(x_2) + \beta_3 \ln(x_3) + \beta_4 \ln(x_4) + \beta_5 \ln(x_5) + Vi - Ui \ldots\ldots 5$$

Where, Yi = farm output from family; Xi = vector of farm inputs used; X_1 = labour (in man days); X_2 = farm size; X_3 = fertilization (dummy: 1 = use fertilizer, 0 = not use fertilizer); X4 = planting materials (in kg); X5 = pesticide; V = random variability in the production that cannot be influenced by the farmer; μi = deviation from maximum potential output attributable to technical inefficiency. βo = intercept; β = Vector of production function parameters to be estimated; i = 1, 2, 3, n farmers; j = 1, 2, 3, m farmers inputs.

The inefficiency model is: $\mu_i = \delta_o + \delta_1 z_1 + \delta_2 z_2 + + \delta_4 z_4 \ldots\ldots\ldots\ldots 6$

Where, μ_i= technical inefficiency effect of the ith farm; Z_1= educational level of farmers in years of formal education completed; Z_2 = household size; Z_3 = farm experience. Z_4 = age of farmer in years; δ = Parameters to be estimated. The parameters of the models will be obtained by the maximum likelihood estimation method using the computer programme, FRONTIER VERSION 4.1c (Coelli, 1994). The a priori expectation is that the estimated coefficients of the inefficiency function provide some explanation for the relative efficiency levels among individual farms. Since the dependent variable of the efficiency function represents the mode of the inefficiency, a positive sign of an estimated parameter implies that the associated variable has a negative effect on efficiency and a negative sign indicate the reverse. Also the estimated coefficient for inputs implies that the associated variable has positive effect on efficiency and a negative sign indicates the reverse.

IV. Result and Discussion

Efforts were made to understand the socio-economic characteristics of tomato farmers in the study area. This was done with the hope of identifying those characteristics that may explain the farming activities of the area. The characteristics considered were age, sex, educational attainments, classification of farmers based on farm size, source of income as well as farmers income level. Table 1 show that good number of respondents was within the productive age bracket of 18 - 55 years which account for 90% of the respondents.

Table 2 : Farm Size

Farm size Farmers	No of of land	Total Hecters Hecters size	Range in farm	Average
Small scale	52	88.22	0.4 - 1.8	1.1
Medium scale	50	237.06	2.0 - 4.0 3.0	
Large scale	18	435.6	5 – 7.2	5.9
Total	120	760.34	7.4 –13.6	100

Source : field survey, 2013

With respect tomarital status, 42% of the respondents were married, 29% were single, 8% were widows while 21% of the respondents had cases of divorce in the study area. while 42% had secondary education, while 25%, 21%, 8% and 4% had primary education, NCE/HND/Degree, postgraduate education and no formal education respectively. 53% of the population under study comprises of women and 50% of the respondents are farmers while 40% combines farmers and trading. 10% were civil servants and farming. This is an indication that the study area constitute of a farming population.Also 37.5% of the farmers are of the high – income bracket [arrived at, based on the mean income of twenty three thousand naira (23,000) in the study area] while 35% belong to the low-income group and 27.5% are of the middle income group. This shows that the farming population straddles both the high as well as low-income households. This implies that tomato farming in the study area may be driven by other factors more than subsistence needs. Table 2 indicates that, the total hectares of land cultivated by farmers in the study area were 44.22, 237.06 and 435.6 hectares and their averages are 1.1, 3 and 5.9 ha for small, medium and large scale respectively. This indicates that, the size of land owned and cultivated by a farmer is determines to a large extent the farmers' level of output (ceteris paribus).

Table 1: Socio-economic Characteristics of Tomato Farmers

Distribution of Responses	Number of Respondents	Percentage %
Age bracket(years)		
18	2	2
19 - 30	30	25
31 - 45	42	35
46 - 55	34	28
56 and above	12	10
Total	**120**	**100**
Marital status		
Single	35	29
Married	50	42
Divorced	25	21
Window	10	8
Total	**120**	**100**
Educational Attainment		
No formal education	5	4
Primary education	30	25
Secondary education	50	42
NCE/HND/Degree	25	21
Postgraduate	10	8
Total	**120**	**100**
Sex		
Male	56	47
Female	64	53
Total	**120**	**100**
Occupation		
Farming only	60	50
Farming & Trading	48	40
Civil Servant and farming	12	10
Total	**120**	**100**
Income level		
Low income (<₦23000)	42	35
Middle income (₦23,000)	33	27.5
High income (>₦23000)	45	37.5
Total	**120**	**100**

Source : Field Survey, 2013

a) *Stochastic Frontier and the Inefficiency Model Analysis*

The stochastic frontier and the inefficiency model are presented in the summary form in table 3. The variance parameters for δ^2 and γ are 0.4913 and 0.5634 for irrigated farmsrespectively. They are significant at the 1 percent level. The sigma squared δ2 indicate the goodness of fit and correctness of the distributional form assumed for the composite error term while the gamma γ indicates that the systematic influences that are un- explained by the production function are dominant sources of random errors. This means that the inefficiency effects make significant contribution to the technical inefficiencies for irrigated farms, thus, the hypothesis that the coefficient of $\delta = o$ is rejected. The result shows that inefficiency effects were present and significant. The results from the table shows that labour (β_1) appears to be the most important factor of production showing the labour intensive nature of farming in the study area. While Farm size (β_2), quantity of fertilizer (β_3), Planting materials (β_4) and pesticides (β_5) coefficient were all positive which conform to a priori expectation, and significant. The positive coefficient of these variables implies that efficient use of these inputs would result in increased output of Tomato.

The sources of inefficiency are examined by using the estimated δ coefficients in table 4. The contribution of farmers' personal characteristics-level of education, age, years of farming experience and household size to farm inefficiency was also studied. If the dependent variables of the inefficiency model have a negative sign on an estimated parameter, it implies that the associated variable has a positive effect on efficiency, and a positive sign indicate that the reverse is true. The (z1) coefficient of education variable in small scale farm is estimated to be negative, that is (-0.4558) and statistically significant at the 1- percent level. The implication is that farmers with more years of formal schooling tend to be more efficient in tomato production. Presumably due to their enhanced ability to acquire technical knowledge, which makes them move close to the frontier output. This finding agrees with comparable findings by Seyoum, Battese and Fleming (2007).

Household size coefficients indicates negative sign z_2 (-0.2990) this implies that household sizes of tomato farmers are more technically efficient since they do not make use of hired labour as such they save the cost of hiring labour, The positive coefficient for age z_3 (0.6667) variable in tomato farmers implies that the older farmers are more technically inefficient than the younger ones. The (z_4) coefficient of farming experienceirrigated tomato farmers is estimated to be negative, that is (-0.6912) and statistically significant at the 1 percent level. This implies that irrigatedtomato farmers with more years of farming experience tend to be more efficient in irrigated tomato production. This conforms to the findings of Battese and Coelli (1995).

Table 3 : Maximum Likelihood Estimates of the Stochastic Frontier Function and Technical Inefficiency

Parameter	Coefficient	SE	T - statistic
Constant(β_o)	0.1219**	0.1005	0.1027
LB(βx_1)	0.8406*	0.1077	0.1051
FS(βx_2)	0.5485**	0.1079	0.1077
Fert(βx_3)	0.1796**	0.1081	0.1045
PM(βx_4)	0.5209**	0.1087	0.1016
Pest(βx_5)	0.1219**	0.1005	0.1001
Inefficiency Model			
Constant(δ_O)	0.2237	0.1011	0.1421
ED(δz_1)	-0.45580.1225	0.1811	
HS(δz_2)	-0.2990	0.1312	0.1031
AGE(δz_3)	0.6667	0.1621	0.1011
FE(δz_4)	-0.6912	0.1011	0.1231
Variance Parameters of Farms			
Sigma Squared δ^2	0.4913		
Gamma γ	0.5634		
Log Likelihood Function	-0.5331		
LR test	0.4569		

Source : Author's computation. = significant at 5% level, ** = significant at 1% level.*

b) Technical Efficiency Ratings

Alongside with the parameters already presented and discussed above, the technical efficiency rating of farmers was also estimated and presented in table 4. More than 50% of the respondents were fund to be more than 60% technically efficient. The most efficient farmer operated at 79%, while the least efficient farmer was fund to operate at 19% efficiency level. Tomato farmers performed at an average technical efficiency 59%. From the results obtained, although farmers were generally relatively efficient, they still have room to increase the efficiency of their farming activities to 41% to close the efficiency gap from the optimum (100%). The technical return to scales measured by the sum of the elasticity of all significant factors showed that farms depict constant return to scale.

Table 4 : Distribution of Technical Efficiency

Class Interval of Efficiency Indices	Farms Frequency	Farms Percentage
0.10 - 0.19	4	3
0.20 - 0.29	16	13
0.30 - 0.39	10	8
0.40 - 0.49	19	16
0.50 - 0.59	20	17
0.60 - 0.6925	21	
0.70 - 0.79	26	22
0.80 - 0.89-		
0.90 - 1.00-		
120 100		
Efficiency Rating		
Mean Efficiency	0.59	
Minimum Efficiency	0.19	
Maximum Efficiency	0.79	

Source : Field survey, 2011

V. Conclusionand Recommendation

The study concludes that irrigation was not fully utilized althoughtheywere relatively efficient, but still have room to increase the efficiency of their farming activities to close the efficiency gap from the optimum (100%). This will increased output and income, and reduce poverty among the irrigated tomato farmers. Based on this study, it is therefore recommended that both government and individual should institute more maintenance mechanism to ensure efficiency in irrigation through public private partnership;also, there is the need for improve quantities of pesticide and fertilizer in order to boost production and moreso,extension agents need to be deployed to guide farmers on irrigation technique to enhance efficiency in tomatoproduction.

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