VOL. 3, NO. 5, May 2013 ISSN 2225-7217
ARPN Journal of Science and Technology

http://www.ejournalofscience.org

# Productıvıty Analysıs of Dry Season Tomato (Lycopersicon Esculentum Mill.) Productıon in Adamawa State, Nıgerıa

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## ABSTRACT

The study determined the productivity analysis of dry season tomato production in Adamawa state. The Primary data were collected from 200 tomato farmers selected using multi stage sampling techniques in four local government areas spread across the four Adamawa agricultural development programme (ADPs) zones of the state. The data collected were for 2011/12 cropping season with the aid of well structured questioners. Data collected were analyzed using stochastic frontier production function. The maximum likelihood estimate (MLE) of the stochastic frontier model production function revealed that farm size, seed and fertilizer were under-utilized. The mean technical efficiency (TE) index was 0.72. The inefficiency model revealed that farming experience, education, family size and extension contact, increase TE of farmers. The MLE of the parameters of stochastic cost frontier model of farmers were statistically different from zero at one and five level with the mean allocative efficiency (AE) of 0.81. Farmers age, education, extension contact and credit availability were found to increase (AE) of tomato farmers. The study therefore, recommends that input prices should be subsidized by public and private sectors and extension activities need to be intensified in all ADPs Zones through adequate funding by both private and public sectors, to increase the technical and allocative efficiencies of tomato farmers.

**Keywords:** *Economic, Efficiency, Farmers, production, Tomato*

## 1. INTRODUCTION

Tomato (Lycopersicom esculentum Mills) belongs to the family Solanaceae. It is one of the most important vegetables grown for edible fruits consumption in virtually every home in Nigeria [5]. Tomato as a vegetable crop is not only important as protective food and highly beneficial for the maintenance of health and prevention of disease, but it is also a source of livelihood for small farmers and foreign exchange earner for the national economy [14]. The demand for tomato and its bye-product far outweighs the supply in Nigeria. One way of increasing tomato production by small scale farmers is to efficiently utilize all the resources available in the production process. Afolami and Ayinde [3] revealed that resources such as fertilizer, land and seed are inefficiently utilized though tomato production is a profitable venture in the study area.

The analysis of efficiency is generally associated with the possibility of farms producing a certain optimal level of output from a given bundle of resources or certain level of output at least cost. The analysis of efficiency has fallen into two categories: parametric and non-parametric. The parametric approach relies on a parametric specification of the production function, while the non-parametric approach has the advantage of imposing non-apriori parametric restriction to the underlying technology [2]. The concept of efficiency is concerned with the relative performance of the processes used in transferring a given input to output [18]. According to the Farrel's interpretation of technical efficiency, it is not feasible to produce by using more inputs than required while valuing these inputs more than the market values. Yet it is also not efficient to use more inputs than required even if they are priced as the market values [7]. Technical efficiency is defined as the ability to achieve a high level of output given similar level of production inputs while allocative efficiency has to do with the extent to which farmers make efficient decision by using inputs up to a level at which their marginal contribution value is equal to the factors cost. Omonona [15] define Allocative Efficiency (A.E) as the choice of the optimal input proportions given relative prices.

Stochastic production frontier is widely used as a tool of analysis in agricultural studies in both developed and the developing countries of the world. In the recent past various studies on technical efficiency of farmers have been carried out across so many communities in Nigeria and most of their findings indicated that the farmers are utilizing their resources below frontier level that is below unity (less than 100%). A study by John [9] on productivity and resource use efficiency in tomato and watermelon farms in Ghana revealed that land and labour are inefficiently used in both tomato and watermelon production though labour did not significantly influence watermelon production. Also, the amount of fertilizer used in tomato production and the amount of capital used in watermelon production are inefficient in each case. In the study on technical efficiency of tomato production in Oyo State Nigeria, Ogunniyi et al. [13] found that tomato farmers were over utilizing all inputs especially fertilizer, family and hired labour. The study there for designed to determine the technical and allocative efficiencies as well as identify factors influencing the output of tomato in Adamawa State.

# 2. METHODOLOGY

## 2.1 The study area

The study was conducted in Adamawa State. Adamawa State is located in the North Eastern part of Nigeria. The state lies between Latitudes 7° and 11°N of equator and between Longitude 11° and 14°E of the Greenwich Meridian. It shares common boundaries with Taraba in the South and West, Gombe State in the North West and Borno to the North. It has an international boundary with Cameroon Republic to the east [1]. Adamawa State is made up of 21 local Government Areas divided into four zones by the Adamawa state Agricultural Development Programme (AD.ADP). The state cover a land area of 38,823.307km$^2$ with an estimated growing population of 3,178,950 comprising of 1,607,272 Males and 1,571,680 Female [11]. The mean Monthly temperature in the state ranges from 26.7C° in the south to 27.82C° in the north eastern part of the state. The Mean annual rainfall ranged from 700mm in the North West to 1600mm in the south east. The Mean annual rainfall is less than 1000mm in the central and North Western part of the state. While over 1000mm in the North eastern and southern parts [1].

The state has Fadama areas in Dwam, Loko, Mayo-Bani, Garkida Dasin Kumbo, Gerio, Tallum and Kiri, where irrigation activities take place for mainly growing of Cereals and Vegetables. The dominant soil groups in the state are luvisols, regosols, combisols, vartisols and lithosols derived from basemen complex, while few areas are on sandstones, shales and alluvium [16].

## 2.2 Sampling Procedure

The study used primary source of data which were collected through administration of questionnaire to tomato farmers, with the help of well trained enumerators. The data collected were for 2011/2012 cropping season. Multi-stage sampling techniques were adopted for the selection of respondents for the study. In stage one, one local government area were purposively selected in each of the four AD.ADP zones, making a total of Four LGAs. Stage two, three Villages were purposively selected from each of the four LGAs, namely, Digil, Vimtim, Hurda, Dadin kowa Hausawa, Baka, Domne, Opalo, Kokombe haying gada, Zangin, Dasin Hausa, Pariya and Farang-farang; making a total of 12 villages. Stage three, 200 tomato farmers were randomly selected in proportionate to their numbers in each of the 12 villages; in all 200 Questionnaires were retrieved and used out of 215 administered.

## 2.3 Data Analysis

Inferential statistics involving the use of stochastic frontier was used to estimate technical and allocative efficiency as well as identify factors influencing the output of tomato production. The model is specified as:

$Y_i = f(X_i;\beta) + (V_i - U_i)$ Battese et al. [6] ..……. (1)

Where:

$Y_i$=Production of the i$^{th}$ farm
$X_i$=Vector of input quantities of the i$^{th}$ farm
$\beta$=Vectors of unknown parameters

$V_i$= are random variables which are assumed to be normally distributed $N(0,\delta_v^2)$ and independent of $U_i$ i.e.. It covers random effects on production outside the control of the decision unit.
$U_i$ = These are non negative random variables called technical inefficiency effect which are assumed to be half normally distributed $N(0,\delta_u^2)$ [19].

**The empirical stochastic frontier production model**

The Cobb-Douglas production function was used to specify the production technology of the farms. The empirical stochastic frontier model is specified as:

$LnY = \beta_0+\beta_1 L_n X_1+\beta_2 L_n X_2+ \ldots \beta_7 L_n X_7+V_i–U_i$ …… (2)

Where:
Y=Output of tomato in Kg
$X_1$=Size of farm in ha
$X_2$=Quantity of seed in Kg
$X_3$= Hired labour (in man days)
$X_4$=Family labour (in man days)
$X_5$=Agro-Chemicals in liters
$X_6$=Quantity of fertilizer in kg
V and U as previously defined.

The technical efficiency of tomato producer for the i$^{th}$ farmer, defined by the ratio of observed production to the corresponding frontier production associated with no technical inefficiency, is expressed by;

$TE= Y^*_i/Y_i$……………………..… (3)

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

$TE = \exp (-U_i)$ ……………………. (4)

Where TE< 1 and $U_i > 0$. $Y_i$ achieves its maximum feasible value of $f(X_i ; \beta) \exp (V_i)$ if and only if TE =1, otherwise TE< 1 provides a measure of the shortfall of the observed output from the maximum feasible output.

The inefficiency model is defined by:

$U_i= \delta_0+\delta_1 Z_1+\delta_2 Z_2 \ldots+\delta_7 Z_7$ …………… (5)

Where:
$U_i$= Inefficiency effect
$Z_1$= Farmer's age (in years)
$Z_2$= Farmer's sex (1 for Male and 0 for Female)
$Z_3$= Farmer's experience (in years)
$Z_4$= Farmer's education (in years)

$Z_5$= Family size (in number)
$Z_6$= Extension contact (no of meetings)
$Z_7$= Credit availability (no of those accessed credit or otherwise)

Where $\delta_1$, $\delta_2$,---- $\delta_7$ are unknown parameters to be estimated. The Maximum Likelihood Estimate (MLE) for all the parameters of the stochastic frontier production was obtained using the computer programme frontier 4.1 [8, 4]. Objective three and four was achieved through this model.

**The stochastic cost function**

The corresponding cost as applied by Ogundari [12] can be specified as:

$$L_n C_i = f(P_i, \gamma_i,: \beta) + (V_i + U_i) \; \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where:
$C_i$ = Total cost of production of the $i^{th}$ farmer
$p_i$ = input price
$\gamma_i$ = output of the $i^{th}$ farmer
$\beta$ = parameters to be estimated

The stochastic cost function is specified thus:

$$LnC_i = \beta_0+\beta_1 L_n P_1+\beta_2 L_n P_2+ \ldots.\ \beta_7 L_n P_7+V_i–U_i \ldots\ldots\ (7)$$

Where;
$C_i$ = total cost of production (in ₦)
$P_1$ = Cost of Farm land (in ₦)
$P_2$ = Cost of seed (in ₦)
$P_3$ = Cost of Hired labour (in ₦)
$P_4$ = Cost of Family labour (in ₦)
$P_5$ = Cost of agro chemicals (in ₦)
$P_6$ = Cost of fertilizer (in ₦)

The Allocative efficiency of individual farmer is defined in terms of the ratio of observed cost ($C_i^*$) to the predicted minimum cost ($C_i$) given the available technology.

It is assumed that the technical inefficiency effects are independently distributed and $U_i$ arises by truncation (at zero) of the normal distribution with the mean $u_i$ and variance $\delta^2$.

Where the technical and allocative inefficiency is defined by:

$$U_i= \delta_0+\delta_1 Z_1+\delta_2 Z_2 \ldots +\delta_7 Z_7 \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Where:
$U_i$= Technical inefficiency effect
$Z_1$= Farmer's age (in years)
$Z_2$= Farmer's sex (1 for Male and 0 for Female)
$Z_3$= Farmer's experience (in years)
$Z_4$= Farmer's education (in years)
$Z_5$= Family size (in number)
$Z_6$= Extension contact (no of meetings)
$Z_7$= Credit availability (no of those accessed credit or otherwise)
$\delta_0$ = Constant term
$\delta_1$ to $\delta_6$ = are unknown parameters estimated.

A Cobb Douglas production function of the stochastic frontier model was employed to estimate the parameters by the method of maximum likelihood using Frontier 4.1 program.

## 3. RESULTS AND DISCUSSION

### 3.1 The Stochastic Frontier Production Function

The estimated parameter of the stochastic frontier production function of tomato farmers is presented in Table 1. The table revealed that four of the estimated coefficients of the variable of the production function were positive which confirm to apriori expectations while hired and family labour were negative. The parameters such as farm size and fertilizer are statistically significant at one percent while seed and family labour were significant at five percent level of significance. The variance parameter of the stochastic frontier production function were represented by sigma squared ($\delta^2$) and Gamma (ϒ). In Table 1, sigma squared is 0.62 and statistically different from zero at one percent level of significance. This indicates a good fit and correctness of the distributional assumption of the composite error term. The Gamma (ϒ) is estimated at 0.84, implies the existence of technical inefficiency among tomato farmers which account for 84% of the variation in the output level of tomato produced. This implies that the ordinary least estimates (OLS) will not be adequate in explaining the inefficiencies on tomato production. Thus, the specification of a stochastic frontier production function was confirmed. The variables that were statistically significant can be discussed thus:

The elasticity of production with respect to farm size (0.35%) and fertilizer (0.05) were positive and statistically significant at one percent level. This implies that they are positively related to output. Thus an increase in these variables by ten percent will result to an increase in output of tomato by 5.3% and 34.9% respectively. This agrees with findings of Ojo et al., [14] who also found positive relationship between farm size and output of tomato.

The elasticity of production with respect to seed and family labour were significant at 5% level. This implies that 10% increase in seed would lead to increase in output by 0.5%. Though family labour was negative which implies that any increase by 10%will lead to decrease in output by -0.21%. This does not conform to the apriori expectations of a positive effect. However, farmers complain of miss use of resources and accidents by engaging unskilled, immature, and uninterested family members in farming activities. Implies that there will be reduction in efficiency which will lead to low level of output; thus, the negative effect is justified. Stephen et al.

[17] also found that family labour was negatively related to output of cowpea.

The estimated coefficient of farming experience (–0.030) and family size (-0.21%) carries the expected sign and statistically significant at one percent level. This implies that increase in these variables by 10% will increase the efficiency of tomato farmers by -0.3 and 2.1 respectively. This result agrees with the findings of John et al. [9], who also found a positive relationship between farming experience and technical efficiency. While the estimated coefficient of education and extension contacts were estimated at 0.04 and 0.01 respectively; and they were statistically significant at five percent level. This means that the respondents who were educated and had contact with extension services were more efficient. The findings is in line with the study of Maurice [10],who reported that increase in extension services to farmers tend to increase technical efficiency in food crop production.

The distribution of technical efficiencies indices of tomato farmers in Table 2. Reveals a minimum and maximum technical efficiency of 0.27 and 0.98 respectively while the mean technical efficiency is 0.72(72%). This implies that the tomato farmers were not totally efficient as their observed output is 28% less than the maximum output. This can be increase by 28% through improve resource allocation under a given technology in the study area

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**Table 1:** Maximum Likelihood Estimates of the Parameters of the Stochastic Frontier Production Function for Tomato Farmers

| Variable | Parameters | Coefficient | Standard error | t-ratio |
|---|---|---|---|---|
| **Production factors** | | | | |
| Constant | $\beta_0$ | 3.5295 | 0.0918 | 38.470*** |
| Farm size ($X_1$) | $\beta_1$ | 0.5262 | 0.0426 | 12.320*** |
| Quantity of seed ($X_2$) | $\beta_2$ | 0.0495 | 0.0249 | 1.985** |
| Hired labour ($X_3$) | $\beta_3$ | –0.8234 | 0.5267 | –1.563 |
| Family labour ($X_4$) | $\beta_4$ | –0.0213 | 0.0088 | –2.431** |
| Agrochemicals ($X_5$) | $\beta_5$ | 0.0317 | 0.0170 | 0.187 |
| Fertilizer ($X_6$) | $\beta_6$ | 0.3490 | 0.0817 | 4.273*** |
| **Inefficiency effects** | | | | |
| Constant | $\delta_o$ | –0.2181 | 0.0761 | –2.868*** |
| Age ($Z_1$) | $\delta_1$ | –0.0302 | 0.1233 | –0.245 |
| Farmer's sex ($Z_2$) | $\delta_2$ | –0.0144 | 0.1143 | –0.125 |
| Farming experience ($Z_3$) | $\delta_3$ | –0.0473 | 0.0170 | –2.784*** |
| Education ($Z_4$) | $\delta_4$ | –0.3408 | 0.1690 | –2.018** |
| Family size ($Z_5$) | $\delta_5$ | –0.2116 | 0.0738 | –2.867*** |
| Extension contact ($Z_6$) | $\delta_6$ | –0.0126 | 0.0064 | –1.968** |
| Credit availability ($Z_7$) | $\delta_7$ | –0.0212 | 0.0135 | –1.565 |
| **Diagnostic statistics** | | | | |
| Sigma-squared | $\delta^2$ | 0.6236 | 0.0198 | 31.43*** |
| Gamma | $\Upsilon$ | 0.8429 | 0.3040 | 2.773*** |

**Source: Field survey, 2012.** *****Significant at1% level, ****Significant at 5% level

**Table 2:** Frequency Distribution of Technical Efficiency Indices of Tomato Farmers

| Efficiency level | | Frequency | Percentage |
|---|---|---|---|
| ≤0.29 | | 2 | 1 |
| 0.30–0.39 | | 6 | 3 |
| 0.40–0.49 | | 18 | 9 |
| 0.50–0.59 | | 30 | 15 |
| 0.60–0.69 | | 32 | 16 |
| 0.70–0.79 | | 38 | 19 |
| 0.80–0.89 | | 60 | 30 |
| 0.90–0.99 | | 14 | 7 |
| **Total** | | **200** | **100** |
| Minimum | 0.27 | | |
| Maximum | 0.98 | | |
| Mean | 0.72 | | |

**Source: Field survey, 2012.**

### 3.2 Allocative Efficiency

The maximum likelihood estimate (MLE) of the parameters of the stochastic cost frontier model used in estimating allocative efficiency is presented in Table 3.The result revealed that all the independent variables of the cost function have the expected positive sings; except for cost of land that is negative. Three of the parameters estimates (cost of seed, agro-chemicals and fertilizer) were significant which indicates that they are good determinants of tomato output; while three that is cost of farm land, cost of hired and family labour were not significant. The result implies that one percent increase in the cost of seed, agro-chemicals and fertilizer in tomato production result in 0.25%, 0.22% and 0.16% increase in the output of tomato respectively.

The diagnostic statistics of the variance parameter of the stochastic frontier cost function were represented by sigma squared $\delta^2$ and gamma ϒ, and were estimated at 0.43 and 0.77 respectively. They were significantly different from zero at one percent level, indicating correctness of fit of the model.

The inefficiency result in Table 3 reveals that the entire coefficients have expected signs. Age, education, extension contact and credit availability were significant at either one or five percent level. They were positively related to cost indicating that these variables increase allocative efficiency of the tomato farmers in the study area.

The distribution of farmers allocative efficiency derived from the analysis of the stochastic cost function is presented in Table 4. From the table, the mean allocative efficiency is 0.81 with minimum and maximum allocative efficiencies of 0.30 and 0.99 respectively. This result shows that tomato farmers in the study area were fairly allocative efficient, suggesting that opportunities exists for improvement in the allocative efficiency of the respondents.

**Table 3:** Maximum Likelihood Estimate of the Parameters of the Stochastic Frontier Cost Function
Source: Field survey, 2012

| Variables | Parameter | Coefficient | Standard error | t-ratio |
|---|---|---|---|---|
| **Cost factors** | | | | |
| Constant | $\beta_0$ | 2.052 | 0.211 | 9.729*** |
| Cost of land ($P_1$) | $\beta_1$ | –0.006 | 0.087 | –0.070 |
| Cost of seed ($P_2$) | $\beta_2$ | 0.246 | 0.067 | 3.656*** |
| Cost of hired labour ($P_3$) | $\beta_3$ | 0.031 | 0.039 | 0.785 |
| Cost of family labour ($P_4$) | $\beta_4$ | 0.025 | 0.129 | 0.197 |
| Cost of agrochemicals ($P_5$) | $\beta_5$ | 0.217 | 0.051 | 4.288*** |
| Cost of fertilizer ($P_6$) | $\beta_6$ | 0.157 | 0.031 | 5.025*** |
| **Inefficiency effects** | | | | |
| Constant | $\delta_o$ | –3.489 | 0.590 | 5.914*** |
| Age ($Z_1$) | $\delta_1$ | –0.065 | 0.032 | 2.063** |
| Farmer's sex ($Z_2$) | $\delta_2$ | –0.010 | 0.107 | 0.096 |
| Farming experience ($Z_3$) | $\delta_3$ | –0.080 | 0.047 | 1.698 |
| Education ($Z_4$) | $\delta_4$ | –0.260 | 0.114 | 2.277** |
| Family size ($Z_5$) | $\delta_5$ | –0.009 | 0.011 | 0.785 |
| Extension contact ($Z_6$) | $\delta_6$ | –3.036 | 0.860 | 3.530*** |
| Credit availability ($Z_7$) | $\delta_7$ | –0.130 | 0.059 | 2.195** |
| **Diagnostic statistics** | | | | |
| Sigma squared | $\delta^2$ | 0.434 | 0.062 | 7.020*** |
| Gamma | ϒ | 0.768 | 0.021 | 37.12*** |

**Source: Field survey, 2012.**
***Significant at 1%, **Significant at 5%

**Table 4:** Frequency Distribution of Allocative Efficiency Indices of Tomato Farmers

| Efficiency level | Frequency | Percentage (%) |
|---|---|---|
| 0.00–0.50 | 7 | 3.5 |
| 0.51–0.60 | 7 | 3.5 |
| 0.61–0.70 | 11 | 5.5 |
| 0.71–0.80 | 55 | 27.5 |
| 0.81–0.90 | 93 | 46.5 |
| 0.91–1.00 | 27 | 13.5 |
| **Total** | **200** | **100** |
| Mean 0.81 | | |
| Minimum 0.30 | | |
| Maximum 0.99 | | |

**Source: Field survey, 2012.**

## 4. SUMMARY AND RECOMMENDATIONS

The study determined the productivity analysis of dry season tomato production in Adamawa State. The analysis of both technical and allocative efficiencies revealed that, inputs such as farm size, seed, agro-chemicals and fertilizer were under-utilized. This implies that tomato farmers were not totally efficient; meaning that opportunities still exists to increase output by increasing the level of these inputs.

Based on the findings from this study it is recommended that input prices should be subsidized by public and private sectors and extension activities need to be intensified in all ADPs Zones through adequate funding by both private and public sectors, to increase the technical and allocative efficiencies of tomato farmers.

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