Economics and Technical Efficiency of Dry Season Tomato Production in Selected Areas in Kwara State, Nigeria

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Abstract

Tomato (Lycopersicon esculentum Mill) is one of the major fruit vegetables in Nigeria. In view of its seasonal availability and the need to make it available all-year round, effort must be made to increase efficiency of its production especially during the dry season. A study was therefore carried out to examine the economics of dry season tomato production in Kwara state, Nigeria. It estimated the costs and returns and assessed the technical efficiency of dry season tomato production. A two-stage random sampling technique was used to select 105 respondents for the study. A well-structured questionnaire was used to collect data from the respondents. Major tools of analysis used for the study were the gross margin analysis and the stochastic frontiers model. Results of the study showed that a gross margin of N 18,956.75/ha (US$ 120.74/ha) was realized from dry season tomato production. Furthermore, the result of the stochastic frontier model shows that age, education status of the farmers and access to credit had significant effect on the efficiency of dry season tomato production. This study therefore highlights the need for government to invest in public education and to make credit available to farmers as a way of reducing the burden of high cost of production.

Key words

Tomato production, technical efficiency, stochastic frontier production model, gross margin analysis, Kwara state.

Introduction

Despite the remarkable progress made in increasing world food production at the global level, approximately half of the population in the developing countries including Nigeria does not have access to adequate food supply, with lot of children suffering from vitamin “A” deficiency. Between 100 and 140 million children are vitamin A deficient with an estimated 250,000 to 500 000 vitamin A-deficient children becoming blind every year, half of them dying within 12 months of losing their sight (World Health Organization). Vegetable production can be adopted as a strategy for improving livelihood and alleviating the nutritional status of the people.

Tomato (Lycopersicon esculentum Mill)) is one of the most popular vegetables in the world, grown in practically every country of the world in outdoor fields, greenhouses and net houses. In 2010, the world tomato production was estimated to be about 145 million tons produced on 4.3 million hectares while estimate of tomato production in Nigeria stood at 1.86 million metric tons from total area of about 264,000ha giving an average of 7 tons per hectare (Food and Agricultural Organisation, 2011). It is an important component of the daily diet used in preparation of different delicacies. Tomato may be eaten fresh as salad or they may be processed into pastes or purees, which are used for cooking in soups or stews and producing fruit drinks. Tomato is grown by most dry season market gardeners who regard it as principal crop. Tomato can be processed and exported to other West African nations or sold within the country because demand is very high locally.

According to the United State Department of Agriculture (USDA) National Nutrient Database, tomatoes are packed with a variety of nutrients including fiber, potassium and vitamins A and C, providing about 20 percent of the daily recommended requirements of vitamin A based on a 2,000 calorie diet (United State Department of Agriculture Nutrient Database). A medium tomato also provides about 26 percent of the daily recommended levels of vitamin C. Tomato contains lycopene, a very powerful antioxidant which can help prevent the development of many forms of cancer. Apart from its nutritional significance, tomato production serve as a very important source of livelihood to small scale farmers being a source of employment and income to both rural and urban dwellers. It contributes significantly to economic growth and it is a source of foreign exchange for the national economy with industries making use of it as raw material for processing into ketchup, sauce and paste, which are mainly used in the kitchen. Studies have shown that dry season market gardening is an important commercial agricultural enterprise dominated by the masses operating on small-scale basis. The bulk of tomato production in Nigeria is carried out during the wet season. In order to make for its all-year round availability, there is a need for an increased production, especially during the dry season (Oladoja, Akinde and Adisa, 2006). With this, farmers who otherwise would have very little income for about half of the year would have been gainfully employed throughout the year, if there is an efficient production in both seasons.

In spite of the nutritional and economic importance of tomato, comprehensive and up-to-date information about the level of technical efficiencies of the farmers is still inadequate. Several methods have been developed to determine the most efficient production frontier by different researchers (Farrel, 1957; Timmer, 1970; Aigner, et al., 1977 and Meeusen and Van den Broeck, 1977). Battese (1992) proved that the econometric modeling of frontier production functions provides useful insights into best practice technology and the measures by which the productive efficiencies of different firms may be compared. Though sufficient information on the status of the allocative and technical efficiencies is available for the agricultural sector, very little attention has been paid to the estimation of the technical efficiency in horticultural crops production in Nigeria. The efficiency, with which farmers use available resources and improved technologies, is important in agricultural production (Rahji, 2005). Enquiry into efficiencies of the farmers and factors that determine their levels of efficiency is very essential in developing policies aimed at raising the productivity of the small scale farmers within the limits of existing resource base and available technology (Yusuf and Malomo, 2007; Hazarika, and Awang, 2003). However, there has been no empirical study of the level of farmers' efficiency and the factors influencing the efficiency of dry season tomato production in the study area. Against this background, this study therefore aims to measure the possibilities of productivity gains from enhancing the efficiency of tomato farmers in the study area. Results from the study will provide guidance to various stakeholders on how to increase tomato production by identifying the extent to which tomato production efficiency could be raised with the available technology and resource base. Hence, the study was designed to:

(i) estimate the cost and returns to dry season tomato production in the study area

(ii) determine the level of technical efficiency of dry season tomato farmers in the study area and

(iii) analyse the determinants of technical efficiency in dry season tomato production in the study area.

Material and methods

Area of Study

This research work was carried out in Kwara state, Nigeria. The state has sixteen Local Government Areas, situated between parallels 8° and 10° north latitudes and 3° and 6° east longitudes. The population of the state is put at 2,371,089 and covers an estimated land area of 32,500km2 out of which 75.3% is cultivable (Federal Office of Statistics 2006). Agriculture is the mainstay of the state's economy accounting for about 70 percent of its labour force. The state has two main climatic seasons, the dry and wet season with annual rainfall ranging between 1000 to 1500 mm while the average temperature lies between 30ºc and 35ºc. The climate is conducive for growing fruits and vegetables, such as mangoes, pineapples, bananas and tomatoes. The rainy season lasts between April to October while the dry season starts in November and ends in March of the following year giving ample opportunity for dry season tomato production. The state is divided into four main agro-ecological zones by the Kwara state Agricultural Development project (KWADP), namely: Zone A: Baruteen & Kaima; Zone B: Edu and Patigi; Zone C: Asa, Ilorin East, Ilorin South, Ilorin West & Moro; and Zone D: Ekiti, Ifelodun, Irepodun, Isin, Offa, Oke-Ero & Oyun (Kwara State Agricultural Development Project (KWADP), 2006).

Sampling Technique

The target population for the study was dry season tomato farmers in Kwara State. A three stage random sampling technique was used to collect data for the study. Zone C was purposively selected for the study because of the predominance of dry season tomato farmers in the zone. There was a random selection of two Local Government Areas from the zone (Moro and Ilorin East) after which 3 villages were randomly selected from each of the two local government areas. The final stage involves a random selection of 20 dry season tomato farmers from each of the villages. A total number of 120 questionnaires were administered out of which 105 contained adequate information used for analysis.

Method of data analysis

The data collected was analysed using; descriptive statistics, gross margin analysis and the stochastic production frontier.

Gross Margin Analysis

The cost and returns to dry season tomato production were estimated using the gross margin analysis. It is given as follows;

$$GM/ha = TVO/ha - TVC/ha$$

Where:

GM/ha = Gross margin in naira per hectare

TVO/ha = Total value of output in naira per hectare

TVC/ha = Total variable cost in naira per hectare.

Stochastic frontier production (SFP) and efficiency measurement

The model employed for the stochastic production function of individual farm economic efficiencies in this study is in the form of the Coelli and Battese (1996) inefficiency model. The model overcomes the deficiency of the deterministic production function employed by earlier studies with parameters computed using mathematical programming techniques, inadequate characteristics of the assumed error term, and has an inherent limitation on the statistical inference on the parameters and resulting efficiency estimates (Ogundari and Ojo, 2006). The stochastic frontier model was originally proposed for the analysis of the panel data by Battese and Coelli (1995). However, a general stochastic frontier production function for the cross-sectional data is considered in this paper and it is basically specified as a composed error model of the general form:

$$Y_i = f(X_i \beta_i) \exp(V_i - U_i), \quad i = 1, 2, \qquad (1)$$

Where

Y_i = output of the i-th farm,

X_i = vector of input quantities whose values are functions of inputs and other explanatory variables for the i-th farm

β_i = vector of unknown parameters to be estimated

$f(.)$ = an appropriate function (e.g. Cobb Douglas, translog, etc)

V_i = symmetric error which accounts for random variation in output due to factors beyond the control of the farmer e.g. weather, disease outbreaks

U_i = non negative random variable representing inefficiency in production relative to the stochastic frontier

The random error V_i is assumed to be independent and identically distributed as N $(0, \sigma v^2)$ random variables independent of the Uj which are assumed to be non-negative truncation of the N$(0, \sigma u^2)$ distribution (i.e. half-normal distribution) or have exponential distribution (Aigner, Lovell and Schmidt, 1977).

The technical efficiency of an individual farmer is defined in terms of the ratio of the observed output to the corresponding frontier output given the available technology (Onyenweaku, and Effiong, 2006)

Technical efficiency (TE) = Y_i/Y_i^*

$$= f(X_i, \beta_i) \exp(V_i - U_i) / f(X_i, \beta_i) \exp(V_i)$$
$$= \exp(-U_i) \qquad (2)$$

So that $0 < TE < 1$.

Where

Y_i = observed Output

Y_i^* = Frontier Output

Technical inefficiency effect model proposed by Battese and Coelli (1995) is described by

$$U_{it} = \delta_0 + \delta_i Z_{it} \qquad (3)$$

Where

U_{it} = non negative random variable representing inefficiency in production relative to the stochastic frontier in the t^{th} time period

Z_{it} = Vector of explanatory variables associated with the technical inefficiency effects in the t^{th} time period

δ = Vector of unknown parameters to be estimated

If $U_i = 0$, the farm were 100 percent efficient.

Maximum-likelihood estimates of the parameters in the model are obtained using FRONTIER 4.1 which is developed by Coelli (1994). In case of cross-sectional data, the technical inefficiency model can only be estimated if the inefficiency effects U_i's are stochastic and have particular distributional properties (Battese and Coelli, 1995). As a result, it is important to test the null hypotheses that technical inefficiency effects, γ (gamma), which is the variance ratio, explaining the total variation in output from the frontier level of output and defined by $\sigma^2/\sigma^2+\sigma^2$, are non-stochastic. The parameter, γ has a value between zero and one, such that it is desirable to test the null hypothesis of H_o: γ = 0 whether traditional production function is an adequate representation of the sample data. If so, the non-negative random variable U_i, is absent from the model. The generalised likelihood-ratio test statistic can be calculated from the logarithms of the likelihood function associated with the unrestricted and restricted maximum likelihood estimates for the special case in which the appropriate parameter is zero by using the program FRONTIER 4.1 (Battese and Tessma, 1993).

Test of hypothesis for the parameters of the frontier model is conducted using the generalized likelihood-ratio statistics, λ, defined by

$$\lambda = -2 \log [L(H_1)-L(H_0)] \qquad (4)$$

Where L (H_0) is the value of the likelihood function for the frontier model, in which parameter restrictions specified by the null hypothesis, H_0, are imposed; and L (H_1) is the value of the likelihood function for the general frontier model. If the null hypothesis is true, then λ has approximately a chi-square (or mixed square) distribution with degrees of freedom equal to the difference between the parameters estimated under H_1 and H_0, respectively.

Cobb-Douglas Model

For this study, the production technology of dry season tomato farmers in the study area is assumed to be specified by the Cobb Douglas frontier production function. Despite its well-known limitations which include: Its rigidity emanating from assuming a perfect substitution between production factors and having its substitution elasticities summing up to one (Klacek, et al., 2007). However, its ease of computation and interpretation and its requirement of few parameters for estimation (Bravo-Ureta, and Pinheiro, 1997; Battese and Coelli, 1995) gives it an edge over the more flexible but complex translog production function which is difficult to interpret, requires greater number of parameters that have to be estimated thereby imposing hard constraints on the result feasibility, and with high probability of the occurrence of harmful collinearity among production factors (Pavelescu, 2010b; Allen and Hall 1997). The Cobb-Douglas functional form has been widely used in farm efficiency analysis for both developing and developed countries. Ekanayake and Jayasuriya (1987) estimated both deterministic and stochastic frontier production of the Cobb-Douglas type for rice and other field crops in the Mahaweli System. Dinh Xuan Tung and Rasmussen (2005) Using a cross section survey of 360 smallholder poultry keeping farms located in three agro-ecological regions in Vietnam adopted the Cobb-Douglas production functions to analyse and compare semi subsistence and semi-commercial smallholder poultry systems in the three regions. Considering the number of parameters included in the model and other econometric criteria, the Cobb Douglass production function was adopted for this study and estimated using the maximum likelihood method.

The function has the following form

$$\text{Ln } Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln_7 + v_i - u_i \qquad (5)$$

Where ln denotes logarithms to base e

Y_i = output of tomato (kg)

X_1 = Farm size (ha)

X_2 = Labour (man day)

X_3 =Water (in liters)

X_4 = seed (in liters)

X_5 = Fertilizers (kg)

X_6 = Herbicides (in liters)

X_7 = Pesticides (in liters)

β_0 = constant

β_1- β_7 are unknown parameters to be estimated,

v_i = random error term

μ_i = technical inefficiency effect

In order to determine factors contributing to the observed technical efficiency, the following model was formulated and estimated jointly with the stochastic frontier model in a single stage maximum likelihood estimation procedure using the FRONTIER version 4.1 (Coelli, 1994):

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 \quad (6)$$

Where

Ui = Technical efficiency of the i-th farmer

Z_1 = Age of farmers (in years)

Z_2 = Educational status (in years)

Z_3 = Access to credit (Dummy; Yes = 1, No = 0)

Z_4 = Non-Agricultural income (in naira)

δ_s are unknown parameters to be estimated.

Results and discussion

Socio-economic characteristics

A summary of the socio-economic characteristics of the dry season tomato farmers is given in table 1.

Characteristics	Frequency	Percentage
Gender		
Female	23	21.9
Male	82	78.1
Total	**105**	**100**
Age of Respondents		
21-30	13	12.4
31-40	47	44.76
41-50	22	20.95
51-60	17	16.19
>60	6	5.71
Total	**105**	**100**
Marital status		
Married	78	74.29
Single	21	20
Widow/separated	6	5.71
Total	**105**	**100**
Educational status		
No formal education	33	31.43
Quranic education	28	26.67
Primary education	26	24.76
Secondary education	14	13.33
Post secondary education	4	3.81
Total	**105**	**100**
Household size		
1-5 members	24	22.86
6-10 members	62	59.05
11-15 members	17	16.19
>15	2	1.9
Total	**105**	**100**

Table 1: Summary of the socio-economic characteristics of the dry season tomato farmers.

Farming experience		
1-5 years	23	21.91
6-10 years	59	56.19
11-15 years	17	16.19
>15 years	6	5.71
Total	**105**	**100**

Table 1: Summary of the socio-economic characteristics of the dry season tomato farmers - continuation

As shown in Table 1, dry season tomato production in the study area is male dominated (78.1%). This indicates dominance of male folk in dry season tomato production in the study area. This could be in view of the fact that the area is a Muslim dominated area and men have greater access to land than women. The mean age of the respondents was 38.27 years, revealing the presence of young and middle aged individuals who are known to be active with the youngest farmer being 26 years and the oldest 67 years. The study revealed that more than 74% of the respondents are married. The mean family size was 7 persons per household and the modal family size was 6 to 10 persons. The relatively large family size could be as a result of the practice of polygamy in the study area and the need for family labour. The study also revealed that 31.43% of the respondents had no formal education with only 13.33% and 3.81% having secondary and post secondary education respectively. The low level of education of the farmers could affect their adoption of appropriate technology. The average farming experience of the farmers was 8.68 years and about 63% of the respondents had more than 7 years experience in dry season tomato production. This is an indication that a good number of the farmers are highly experienced in dry season tomato production and could affect their productivity.

Costs and Returns Analysis

Table 2 gives a summary of the costs and returns analysis. The total value of output (TVO) in Naira per hectare less total variable cost (TVC) also in naira per hectare gave a positive value. This shows that dry season tomato production is a worthwhile venture with high returns. The total output produced was valued at the prevailing market price.

From the analysis of costs and returns to dry season tomato production, a gross margin of N 18, 956.75 ($US 120.74, at an exchange rate of N157 to a dollar) per ha per farmer was obtained. This therefore, implies that dry season tomato production is a profitable business in the study area. The implication of this is that given the rising unemployment in the country, more people can take dry season tomato production as their primary source of livelihood by getting involved in large scale production of it and as a result improve their livelihood.

Variables	**Value in N/ha**
Total Value of Output	**149,969.56**
Less	
Total Variable Cost	**131,012.81**
Labour	67,096.85
Water	24,715.58
Seed	7,599.30
Fertilizer	9,603.33
Herbicide	2,380.38
Pesticide	4,217.30
Fuel	15,400.02
Equals	
Gross Margin	**18,956.75**

Table 2: Summary of Gross Margin Analysis in Dry Season Tomato Production.

Technical Efficiency of the Dry Season Tomato Farmers

The maximum-likelihood estimates of the parameters in the stochastic production frontier model and those in the technical inefficiency effect model are presented in Table 3. The results obtained indicate that technical inefficiency effects are significant for the dry season tomato farmers with σ^2 being significantly different from zero. hence, indicating that Cobb-Douglas production function is a representative model and that the majority of error variation is due to the inefficiency error u_i (and not due to the random error v_i). The magnitude and significance of the estimate for the variance parameter, γ, also supported the results from the likelihood-ratio tests. The maximum-likelihood estimate for the parameter γ is 0.844. This indicates that 84.4% of the variation in output of tomato production is probably due to the inefficiency of the dry season tomato farmer. Farm size, Labour and herbicides were statistically significant at 1% level of significance, while seed was significant at 5% level of significance. Since Cobb Douglas type production function was used, the estimator directly represents elasticity of independent variables. The estimated Maximum Likelihood (ML) coefficient

Variables	Co-efficient	Standard-error	t-ratio
Production function			
Constant	0.728	0.381	0.191
Farm size (ha)	0.667***	0.181	3.686
Labour (manday)	0.123***	0.0419	2.921
Water (litres)	0.127	0.225	0.565
Seeds (kg)	0.701**	0.355	1.98
Fertilizer (bags)	-0.305	0.246	-0.136
Herbicides (litre)	0.114***	0.022	5.18
Pesticides (litre)	0.125	0.27	0.462
Inefficiency model			
Constant	0.459	0.262	0.176
Age	-0.113*	0.064	-1.76
Education	-0.405**	0.206	-1.98
Access to credit	-0.490**	0.228	-2.15
Non-farm income	0.146	0.452	0.323
Sigma squard (d2)	0.332	0.416	0.799
Gamma (g)	0.844	0.106	0.794
Log likelihood function	0.3004		
One sided error	0.5003		

* Significant at 10% ** significant at 5 % ***significant at 1%

Table 3: Maximum Likelihood Estimates of the stochastic frontier production model.

Technical efficiency (%)	Minimum (%)	Maximum (%)	Frequency	Percentage
Less than 60	32.3	54.58	9	8.57
60.00 – 69.99	60.24	69.96	12	11.43
70.00 – 79.99	70.19	79.97	19	18.1
80.00 – 89.99	80.04	89.77	47	44.76
90.00 – 99.99	90.64	99.91	18	17.14
Total			105	100
Mean efficiency: 78.94%				

* Significant at 10% ** significant at 5 % ***significant at 1%

Table 4: Efficiency Distribution of Dry Season Tomato Farmers.

of farm size showed positive value of 0.667, and was significant. Therefore increments of farm size by one percent will increase output by 0.667%. This implies that farmers with greater access to farm land are likely to be more efficient. Similarly, the estimated ML coefficient for labour showed positive and significant value. Therefore increment of labour usage by one percent will increase the output by 0.123%. The implication of this is that farming households with larger household size are likely to be more efficient. The positive impact and significance of seed and herbicides indicates that improved seed varieties and usage of herbicides are highly responsive and tends to give higher productivity in dry season tomato production.

The estimated coefficients of the explanatory variables in the model for technical inefficiency effects are of interest and have important implications as shown in Table 3. Given the specifications of the preferred model with inefficiency effect, it is noted that the age of farmers has a negative effect on inefficiency and significant at 10%. This indicates that older farmers have higher technical efficiency than younger farmers. Older farmers may take benefit of their experience to use inputs more efficiently for tomato production; hence age of farmers is a decisive factor in improving the efficiency of farms. The coefficient of education is negative and statistically significant at 5%. Kumbhakar, Biswas and Bailey (1989) and Battese and Coelli (1993) also identified farmers' level of education as a determinant of technical inefficiency effects. This could be due to better access to information and good farm planning also, farmers with more education respond more readily in adopting new technology and produce closer to frontier output.

The coefficient of access to credit was negative and statistically significant at 5%. This implies that farmers with better access to credit are more efficient. This could be in view of the fact that they would have better access to the needed production inputs.

Table 4 shows the efficiency distribution of dry season tomato producers. The table explains how efficient the tomato farmers are in their dry season tomato production.

The mean technical efficiency of 78.94% obtained in this study is rather high. However, a gap still exists between the efficiency of the least technically efficient farmer 32.3% and that of the mean technical efficiency. This suggests that considerable amount of productivity is lost due to inefficiency. The result therefore indicates that potential still exists for the farmers to increase output using the available resources. A pie chart representation of the efficiency distribution of the dry season tomato farmers is given in figure 1.

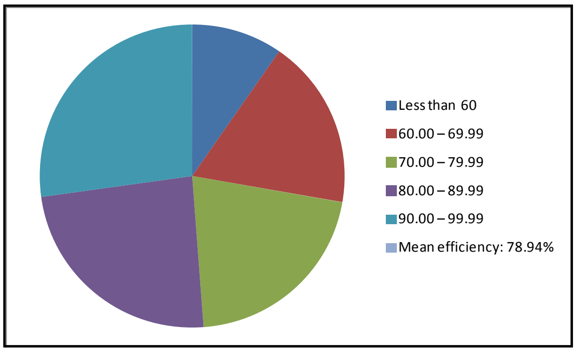

Figure 1: Efficiency Distribution of the Dry season Tomato Farmers.

Conclusion

This study has shown that the dry season tomato farming is a profitable business.

Within the limit of partial productivity analysis, farm size, availability of labour, type of seed, and usage of herbicide are important factors in dry season tomato production. Thus, to increase efficiency in dry season tomato production, availability of improved seed and other inputs as shown by the results of the study may be appropriate for the improvement of productivity in dry season tomato production. The inefficiency effects is explained by age, education of the farmer and access to credit and are decisive factors in determining the efficiencies of the dry season tomato producers.

In line with the results of the study, it is recommended that, government should invest in public education and review agricultural loan policies in government banks, private banks and microfinance institutions (MFIs) to increase credit access to smallholder tomato farmers. This will reduce the burden of high cost of production on the farmers and encourage the farmers to expand their farm size and increase production. Also, improved seed should be made available to the farmers to raise their productivity. Given the rising unemployment rate in the country, people should be encouraged to go into dry season tomato production. Increased awareness on the need to increase average yield of the farmers through the adoption of appropriate technological change and wise use of chemicals is also recommended.

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