J Agri Sci, 2(2): 77-82 (2011)
PRINT: ISSN 0976-6898 ONLINE: ISSN 2456-6535
DOI: 10.31901/24566535.2011/02.02.02

Can Small-scale Tomato Farmers Flourish in Benue State, Nigeria?

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KEYWORDS Food Basket. Tomato. Flourish. Stochastic Frontier Analysis. Cobb-Douglas

ABSTRACT This study employed Cobb-Douglas stochastic frontier analysis to examine the ability of small-scale tomato farmers to flourish in Benue state, Nigeria from technical efficiency point of view. Evidence shows that tomato output was significantly influenced by farm size, labour, seeds, and quantity of fertilizer used. Technical efficiency among the tomato farmers varied considerably ranging between 0.20 and 0.99 with a mean technical efficiency of 0.58, implying that an estimated 42 percent of tomato output is lost due to inefficiency. Thus, suggesting the presence of considerable inefficiency among the tomato farmers in the state. In order words, if current resources available to the farmers were used efficiently, tomato output would increase by about 42 percent, resulting in an increase large enough to meet the demand of the state as well as neighbouring states. Consequently, going by this result, there is a huge potential for tomato farmers in the state to flourish. Furthermore, education, experience and extension were found to impact significantly on tomato output.

INTRODUCTION

Tomato (*Lycopersicon esculentum*) is one of the most widely grown vegetables in the world. Tomato is an important food component consumed in Nigeria and this is apparent in the fact that most Nigerian dishes have tomatoes as a component ingredient. It provides income to farmers and all other agents involved in its production and marketing (Tambo and Gbemu 2010). Notwithstanding the high popularity tomato has assumed, its total production in Nigeria in general and Benue state in particular is grossly inadequate. This is because most of the tomato produced in Nigeria comes from small farms and gardens where the major tools applied is the traditional cutlass and hoe technology which has been blamed for the low output levels of farmers.

Although Benue state is the acclaimed "food basket" of the nation, it has not been able to meet its annual tomato demand. The failure of tomato farms to meet demand in the state has raised concern over the ability of these farms to thrive. In view of the growing demand for tomato in the state, improving the efficiency of resource use would be the key to increased tomato production in the state. Thus, for the state to flourish in tomato production, it needs to achieve a high level of efficiency which is essential for competitiveness and profitability. The question of efficiency in agricultural production can not be over emphasized because the scope of agricultural production can be expanded and sustained by farmers through efficient resource use (Udoh 2000). One of the major reasons for low productivity in agriculture all over the world has been ascribed to the inability of farmers to fully exploit the available technologies resulting in lower efficiencies of production (Murthy et al. 2009). According to Rahji (2005), the efficiency with which farmers use resources and technologies available to them are important in Nigeria agricultural production since the major problem in the country still revolves around low productivity. The implication is that there is scope for additional increase in output from existing hectares of food crop if resources are properly exploited (Rahji 2005). Besides low productivity, the poor performance of Nigerian agriculture can also be attributed to a system of production characterized by small unprofitable production units, fragmentation of landholdings and predominance of poor management of production techniques (Onyenweaku and Nwaru 2005). The term efficiency of a firm can be defined as its ability to produce the largest possible amount of output from a given set of inputs. Thus, the level of technical efficiency of a particular firm is therefore characterized by the relationship between observed output and achievable output.

This study is aimed at examining the ability of tomato farms to flourish in Benue state of Nigeria given the current technology using Cobb-Douglas stochastic frontier analysis. Results of this study will provide vital information that will enhance increased tomato production in Benue state by determining the extent to which it is possible to raise the efficiency levels of tomato farms with the existing resource base and the available technology in order to tackle the problem of diminishing tomato production in Benue state in particular and Nigeria in general.

METHODOLOGY

Study Area and Data Collection

The study was conducted in Makurdi Local Government Area of Benue State**.** Makurdi is located on the north-western part of Benue State and made up of eleven council wards or districts. It is one of the 23 local government areas of the state. It lies between latitude 7.2° to 8° north and latitude 8.2 to 9° west. It is located in the middle belt area of the country, Nigeria. It serves as a major link between east, south-eastern parts and northern parts of the country. Makurdi is characterized by 2 seasons; the rainy season (begins from April and ends in October) and dry season (starts from late October to March).

Primary data was collected during the 2009 cropping season with the aid of a structured questionnaire. First, nine council wards were purposively selected based on the high population of tomato farmers in the areas. The council wards are Agan, Clerk Mission, Mbalagh, Modern Market, North Bank I, North Bank II, Fiidi, Walamayo, Bar (Apir-Kanshio). Secondly, ten farmers from each council ward were randomly selected for interview. The input data include quantity of fertilizer used, farm size, seeds, labour and pesticide used. Data were collected also on the socio-economic variables such as the age of the farmer, household size, years of education, farming experience and access to extension service.

Stochastic Frontier Model

Parametric and non-parametric approaches have been used in empirical estimations of efficiency. The parametric approach makes assumptions about the error terms and also impose functional forms on the production functions, while non-parametric approach neither impose any functional form nor make assumptions about the error terms. The parametric approach in essence implies that structural restrictions are imposed and the effects of misspecification of functional form might be confounded with the inefficiency. The non-parametric approaches are free from misspecification but they do not account for the effect of other factors that are normally not under the control of the farmer and consequently are not good for studying efficiency at the smallholder level where conditions are highly varied. This study uses the parametric stochastic frontier approach because of the numerous variations underlying smallholder production in developing countries. The stochastic frontier models attributes part of the variation to random errors (for example, measurement errors and statistical noise) and farm specific inefficiency (Battese and Coelli 1995; Coelli et al. 1998).

Aigner et al. (1977), Meeusen and van den Broeck (1977) and Battese and Coelli (1995) defined stochastic production frontier model for the cross-sectional data as:

$$y_i = f(X_i, \beta) + \varepsilon_i \quad (1)$$

Where: y_i is output of the ith farmer in the sample, X_i is vector of input quantities used by the ith farmer, β_i parameters to be estimated, $f(X_i, \beta)$ is an appropriate parametric form for the underlying technology, ε_i is the stochastic error term consisting of two independent components u_i and v_i. The symmetric component v_i accounts for random variation in output due to factors outside the farmer's control, such as weather and plant diseases. It is assumed to be independently and identically distributed as $N(0,\sigma^2 v)$ independent of u_i. The asymmetric component u_i is a non-negative random variable, associated with technical inefficiency. It is assumed to be independently distributed with truncations (at zero) of the normal distribution with mean, μ_i and variance, σ_u^2 [$N(\mu_i, \sigma_u^2)$]. Under these assumptions the technical inefficiency effects, μ_i can be specified as follows:

$$\mu_i = \Sigma \delta_k Z_{ik} \quad (2)$$

Where Z is farm-specific variables hypothesized to be associated with technical inefficiency, δ is the unknown parameters to be estimated.

Technical efficiency is defined as the ratio of observed output to the maximum potential output. Thus, technical efficiency can be expressed as:

$$TE_i = \frac{f(X_i, \beta) exp(v_i - u_i)}{f(X_i, \beta) exp(v_i)} = \exp(-u_i) \quad (3)$$

Yi attains the maximum value of $f(Xi, \beta)$ and $TEi = 1$ if $u_i = 0$. Otherwise $u_i \neq 0$ provides the deficit of observed output from the maximum potential output. The above equation can be estimated by the Maximum Likelihood (ML) method. Given that TE can not be observed directly, Jondrow et al. (1982) showed that the technical efficiency measure of individual farm level can be obtained from the point estimator of *ui*, i.e.,

$$E(U_i / \varepsilon_i) = \frac{\sigma_u \sigma_v}{\sigma}\left[\frac{\phi \varepsilon_i \lambda}{1-\Phi(\varepsilon_i \lambda / \sigma)} - \frac{\varepsilon_i \lambda}{\sigma}\right] \quad \text{.......................... (4)}$$

Where: ϕ (.) and Φ (.) are the standard normal density function and the standard normal distribution function evaluated at (åë/ó). Estimated values for ε, $\lambda = (\sigma_u / \sigma_v)$ and σ are used to evaluate the density and distribution functions.

Model Specification

To analyze the data, the Battese and Coelli (1995) model was used to specify a stochastic frontier production function with the behaviour inefficiency component. Consequently, following the adoption of Battese and Coelli (1995) framework for the analysis of the data, the explicit Cobb-Douglas functional for the tomato farms in the study area is therefore specified as:

$$\ln Y_i = \beta_o + \beta_{1i} + \beta_{2i} \ln X_{2i} + \beta_{3i} \ln X_{3i} + \beta_{4i} + \ln X_{4i} + \beta_{5i} \ln X_{5i} + (V_i - U_i) \quad \text{.......... (5)}$$

Where Y_i represents tomato output, $\beta_i s$ represents parameters to be estimated, $X_i s$ represents inputs (farm size, labour, seeds, fertilizer and pesticide). While technical inefficiency effects, μ_i is defined as:

$$\mu_i = \delta_o + \Sigma \delta_k Z_k \quad \text{.......... (6)}$$

Where: Z_k = Farm-specific variables assumed to affect technical, and they included variables such as: Z_1 = Age of farmers; Z_2 = educational status of farmer; Z_3 = farming experience; Z_4 = access to extension service and Z_5 = household size. δ_k = Unknown parameters. The unknown parameters of the model, i.e β's and δ's and the variance parameter, $\delta^2 = \delta u^2 + \delta v^2$ and $\gamma = \delta u^2/(\delta u^2 + \delta v^2)$ were simultaneously estimated. The value of γ indicates the relative magnitude of the variance associated with the distribution of the inefficiency effects, u_i. The maximum likelihood estimates of the parameters of the Cobb-Douglas stochastic frontier production function model in equation (5) and the specification for technical inefficiency effects in equation (6) were estimated jointly using the computer programme, frontier 4.1, developed by Coelli (1996).

RESULTS AND DISCUSSION

Summary Statistics

The mean, standard deviation, minimum and maximum of each of the variables used in the stochastic frontier model is presented in Table 1. The mean age of tomato farmers was 37.10 years with the standard deviation of 10.78. The mean size of the family of the respondent farmers was recorded as 8.67 people per family with the standard deviation of 4.19. The educational level of the farmers denotes the mean value of years of schooling of the respondent farmer which was 8.36 years with the standard deviation of 5.39, implying that the educational level of the respondent farmers was low.

Table 1: Descriptive statistics of variables used in the analysis

Variable	*Mean*	*Standard deviation*	*Minimum*	*Maximum*
Farm size (hectare)	0.79	0.57	0.10	3.00
Fertilizer (kg)	29.71	32.14	0.00	150.00
Seed (kg)	0.98	0.76	0.10	3.00
Labour (man days)	275.00	77.93	90.00	450.00
Pesticides (litre)	1.31	1.51	0.00	7.00
Age (year)	37.10	10.78	28.00	70.00
Household size	8.67	4.19	1.00	23.00
Education (year)	8.36	5.39	0.00	16.00
Farming experience (year)	7.90	6.25	2.00	29.00
Access extension service (1=yes; 0=No)	0.22	0.42	0.00	1.00

Estimates of the Stochastic Frontier Production Function

The maximum likelihood estimates of the Cobb-Douglas stochastic frontier production model are shown in Table 2. The estimated elasticity of farm size, labour, seeds, fertilizer, were found to significantly influence the production of tomato farms at P≤ 0.1. However, pesticides had no significant influence on tomato production. The values of the coefficients indicate the elasticity of the various inputs to the output. Considering farm size, the value indicates that if farm size is increased by 1 percent, the yield of tomato would increase by 12.4 percent. If quantity of seed, fertilizer increases by 1 percent, yield of tomato would increase by 1.6 percent and 0.8 percent respectively. Furthermore, the coefficient of labour was negative (-0.36), this implies that increase in labour by 1 percent decreases total output by 3.6 percent. This is true because the more labour employed on the same farm size will lead to over use of labour or excess labour which in turn leads to reduction in income obtained. This corroborates Stephen et al. (2004) and Tambo and Gbemu (2010). Consequently, to increase output, there is the need for the farmers to increase the utilization of seed, farm size, and fertilizer.

Table 2: Maximum Likelihood Estimates of the Cobb-Douglas Stochastic Frontier Production Function

Variable	*Parameter*	*Coefficient*	*t-ratio*
Production function Constant	β_0	10.13	8.27*
ln (Farm size) (ha)	β_1	1.24	8.18*
ln (Labour) (mandays)	β_2	-0.36	-1.64***
ln (Seed) (kg)	β_3	0.16	1.14***
ln (Fertilizer) (kg)	β_4	0.08	2.06**
Pesticide (Lt)	β_5	-0.04	-0.72
Inefficiency Model			
Constant	δ_0	1.68	1.14
Age (years)	δ_1	-0.23	-0.44
Education (years)	δ_2	-0.06**	-2.01**
Household size	δ_3	0.36**	2.24**
Farming experience (years)	δ_4	-0.44**	-2.04**
Access to extension service	δ_5	-0.49***	-1.96***
Variance parameter			
Sigma squared	$\sigma^2 = \sigma^2 u + \sigma^2 v$	0.86*	5.90*
Gamma	$\Upsilon = \sigma^2 u / \sigma^2 v + \sigma^2 u$	0.49*	10.08*
Log likelihood function	*LLF*	-122.30	

Note: *** = significant at 10 percent level; ** = significant at 5 percent level; * = significant at 1 percent level.

Based on the parameter estimates of the influence of socio-economic factors on technical inefficiency, results revealed that factors such as educational status, farming experience and access to extension services had a significant impact on technical efficiency. The signs and significance of the estimated coefficient in the inefficiency model have important implication on technical efficiency. The result showed that farmer's educational level negatively and significantly affected technical inefficiency (Table 2), implying that as farmers become more educated, technical inefficiency is reduced. This agrees with findings of Bianam et al. (2004), Zavela et al. (2005) and Ogundari (2008). This is because education increases the ability to perceive, interpret and react to new events and improves farmers' managerial skills (Schultz 1964). The significant and negative sign of the coefficient of experience mean that experience had a significant influence on technical inefficiencies of the tomato farms surveyed consistent with Sharma et al. (1999). The coefficient of access to extension service was negative and significant, implying that farmers with regular access to extension workers were better in reducing technical inefficiency (Table 2). Similar result was reported by (Rahman 2002; Bianam et al. 2004; Ogundari 2008). Although the estimated coefficients of household size was significant, it was found to have a positive impact on technical inefficiency, implying that, this fac-tor led to increase in technical inefficiency. This is contrary to a priori expectation regarding the role of this factor.

The estimated sigma square (σ^2) of the tomato farmers is 0.86 and is significant at 1 percent level. This indicates a good fit and the correctness of the specified distributional assumptions of the model. The result implies that the usual production function is not an adequate representation of the data. This agrees with the reports of Rahman (2002), Tijan et al. (2006) and Ogundari (2006). The estimated gamma (γ) parameter is 0.49, implying about 49 percent of the variation in the output of tomato farms in Benue state is due to the differences in their technical efficiencies.

Returns to Scale

The total sum of elasticities of the Cobb-Douglas production model gives the returns to scale. The returns to scale was 1.08 (Table 3), indicating an increasing returns to scale. This suggests that tomato production in the study area had positive increasing returns to scale and in stage I of the production region which clearly indicates inefficiency in the allocation of resources and production. Hence, efforts should be made to increase the current scope of production to actualize the potential inherent in it.

Technical Efficiency Estimates

The results of efficiency analysis revealed that technical efficiency score of tomato farmers in

Table 3: Returns to scale

Variable	*Coefficient*
Farm size	1.24
Labour	-0.36
Seed	0.16
Fertilizer	0.08
Pesticide	-0.04
Return to scale (RTS)	1.08

Benue state ranged from 0.20 to 0.99 with an average of 0.58 (Table 4). The inference of this statistics is that in the short run, there is a scope for increasing tomato production by 42 percent by adopting techniques used by the best practice tomato farmers. This further suggests that on average about 42 percent of tomato out is lost as a result of inefficiency. Furthermore, frequency analysis of efficiency levels showed that 42.2 percent of the sampled tomato farms had technical efficiency score greater than 60 percent, whereas 36.7 percent of the farms had technical efficiency levels between 40 percent and 59 percent. The rest of the farms had a technical efficiency levels between 20 percent and 39 percent (Table 4).

Table 4: Distribution of technical efficiency scores for tomato farms in Benue state

Efficiency Level	*Frequency*	*Relative efficiency (%)*
0.20-0.39	19	21.1
0.40-0.59	33	36.7
> 0.60	38	42.2
Total	90	100
Mean efficiency	0.58	
Minimum efficiency	0.20	
Maximum efficiency	0.99	

CONCLUSION

This paper employed the stochastic frontier analysis with a Cobb-Douglas functional form to examine the ability of tomato farms to flourish in Benue state, Nigeria from technical efficiency standpoint. Results revealed high level of inefficiency among tomato producers in the state. The mean technical efficiency was 0.58 suggesting that an estimated 42 percent of the tomato output is lost due to inefficiency in production. Thus, sufficient potential exist for increased production of tomato in the study area. Output was significantly influenced by farm size, labour, seeds, and quantity of fertilizer used. Consequently, efforts should be made to increase the present capacity in order to realize the available potential. Similarly, about 49 percent of the variations in the total output of tomato produced in the study area resulted from the differences in their technical inefficiencies. Based on the findings of the present study, education of farmers through accurate agricultural extension services should be encouraged in other to increase efficiency levels among tomato farmers and boost yield in the study area.

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