

Smallholder Tomato Production in Mwanza Region: A Technical Efficiency Analysis Approach

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ABSTRACT--- *This study measured technical efficiency and its determinants in maize production by small-scale producers in Mwanza region, using a stochastic frontier production function approach. A randomly selected sample of participants in the two districts was used. The Maximum Likelihood estimation procedure was followed to obtain the determinants of technical efficiency and technical efficiency levels of small-scale tomato producers. The minimum and maximum values of technical efficiency were between 20% and 91%, indicating that the least practices of specific producer operates at a minimum level of 20%, while the best practice producers operate at 91% technical efficiency level respectively. The summary results of the mean technical efficiency was 57%. The results indicate that farmers were not fully technically efficient with a mean technical efficiency score of 0.58. The study also revealed that most of the farmers irrespective of the size of the holdings have shown technical inefficiency problems. Experienced farmers were observed to have good measures of technical efficiency. The findings also indicated that significant variables of technical efficiency included household size, labour, fertilizer, seed, educational level, household size, farming experience, and access to extension services were statistically significant by positively impacted on producers' technical efficiency in the study area.*

Keywords--- Stochastic frontier analysis, tomato, Cobb-Douglas production function, technical efficiency, Mwanza

1. INTRODUCTION

Agriculture in Tanzania is a vital sector involving about 80% of the country's poor and contributing about 30% of the Gross Domestic Product (GDP) (Molua & Lambi, 2006). The sector contributes about 45% to the national GDP and about 80% of population is employed in agriculture (Peterson, 2003). It also contributes about 70% to foreign exchange earnings of the country with traditional export crops such as coffee, sisal, tea and cashew as the most important crop. In 2005 the sector contributed about 45% to the national GDP of the country and employed about 80% of the population (Peterson, 2003). The country has a suitable area for agricultural production of about 43,000,000 ha, which is 45% of the total surface. Of this total area, about 14% is used for arable and permanent cropland, which is about 6,500,000 ha (de Putter et al, 2007). Tomato, also known as *Lycopersicon esculentum* is one of the main open field vegetables cultivated and consumed in Tanzania. It has dietary economic importance and it is a key input in agro-allied industrial products. Tomato is an important food component consumed in Tanzania and in the world, and for this reason is apparent in the fact that most Tanzanian dishes have tomatoes as a component ingredient. Tomato provides income to farmers and all other agents involved in its production and marketing (Tabe-Ojong & Molua, 2017). Tanzania is one of the largest producers of tomatoes in Africa. There exist more than four tomato varieties grown across various five regions in the south and north of Tanzania. The most common varieties include Tanya and Tengeru (de Putter et al, 2007). The production areas for tomato are located in the country's southern regions of Iringa, Njombe, Morogoro, and Mbeya, where approximately 70% of tomatoes output are produced in these regions. The remaining 30% is produced in the northern and coastal areas of Arusha, Tanga, Mwanza, and Kilimanjaro regions (de Putter et al, 2007). Tomato harvesting seasons in these regions varies respectively from August to November, July to September and May to August. According to Mtaita (1994), labour input required in tomato production is about 124 – 150 man days per hectare. Following Lynch (1999), different constraints in tomato farming exist. They are different constraints such as requirement in different fertilizers to be used at different stages of the tomato plant, and the need to produce tomatoes in order to harvest the output at the peak in the market prices (Lynch, 1999; de Putter et al, 2007). However, it was observed that the yield of tomatoes production in the region was estimated to be about 5,589 kg/ha with a total of about 187,957 tones, suggesting much lower yield figures (Tabe-Ojong & Molua, 2017). The number of households growing tomatoes in the region during both long and short rainy seasons were 5,400 and 5,016 respectively. This represents 4.5 percent of the total crop growing households in the region during the long rainy season and 1.6 percent during the short rainy season. Missungwi district had the largest planted area of tomatoes (23.5% of the total area planted with tomatoes in the region), followed by Sengerema (22.7%), Ilemela (17.5%), Magu (14.3%), Geita (11.3%), Kwimba (6.9%) and Ukerewe (3.9%) (URT, 2007). Based on the current production technology, this study, therefore, is aimed at examining how tomato producers can progress in Mwanza region, by using Cobb-Douglas stochastic frontier approach.

1.1 The problem

Tomato production in Tanzania is predominated produced by small-scale producers who use traditional methods of production. Because of low yields, up to 80% of all tomato produced is consumed by the producing households (FAO, 2015; Hayatullah, 2017). Changes are needed to help millions of small-scale farmers who currently make little or no profit from production to become profitable. Generally, small-scale maize production yields are low. To achieve optimum production level, resources available must be used efficiently (World Bank, 2015). Scarce resources are underutilized in addition to the use of low yielding varieties, poor extension services, inadequate incentives and amenities giving rise to low output leading to low farm income (Abdulai et al., 2018). An important step towards achieving higher lever of tomato output and food security in the region is by increasing productivity through enhancing efficiency in production (Wudineh & Endrias, 2016). The lower levels of yields in tomato production in the region may be attributed to the inefficient production by farmers. Also because most of the tomato produced in the region comes from small-scale producers including gardens, where the major tools applied is the traditional cutlass and hoe technology, that can be blamed for the low output levels of output of the farmers. Improving production efficiency of the producers would be a possible way to increase tomato productivity given both limited resource allocation, and the creation and adoption of new technologies (Haji & Andersson, 2006). Another reasons for low yield in tomato production in the region is the inability of farmers to fully take advantage of the available technologies and production techniques that have rendered it impossible to increase productivity (Kavoi et al., 2016).

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 (Onyenweaku & Nwaru 2005). Rahji (2005) posits that by being exposed to a less than optimal performance in the agricultural sector, this implies the need for more studies to investigate technical efficiency of this sector, particularly the smallholder tomato producers who are vital for food security. Increased tomato productivity requires improvements in technology to increase technical efficiency. It helps also to increase both food security, food supply, high incomes and improved living standards as this can assist in reducing dependency on imports of tomatoes (Murthy et al. 2009; Ogada et al., 2014). According to Abu et al., (2011), three main related issues exist in this case of inefficiency of smallholders tomato producers; first, there is an issue of limited land used in tomato production in order to improve the output. Second, the available labour is less trained and lack the necessary experience to take production to the next level. Third is the issue of inadequate institutional support given to tomato farmers including a very little access to credits and improved inputs. Given a growing demand for tomato output in the region, improving the efficiency of resource use would be the only way of increasing tomato production in the study area. Hence, for smallholder producers to succeed and progress in tomato production, they should try to achieve a high level of efficiency which is essential for competitiveness and profitability. For this reason, the issue of efficiency in agricultural production should not be over reemphasized because the overall scope of agricultural production depends on expanded and sustained efficiency in resource use (Abu et al 2011).

The results of this study will provide vital information that will enhance increased tomato production in the region. It will also determine the extent to which it would be possible to increase the efficiency levels of tomato farmers with the existing resource base and the available technology. This helps to tackle the problem of increased tomato production in Mwanza region in general. By examining the technical efficiency of small-scale tomato farmers in Mwanza, this study adds to the existing literature on technical efficiency in various approaches, in: (i) determining the production function of tomato farms, (ii) identifying the factors that influence the technical efficiency of tomato farms and (iii) assessing the technical efficiency of the farmers and make recommendations based on the findings of the study. The rest of the article is structured as follows: The theoretical framework is presented in section 2, followed by the empirical model with data description in section 3. Empirical results and discussion are presented in section 4.

2. REVIEW OF RELATED STUDIES

Technical efficiency is a way through which individual farmer can transform inputs into outputs given set of technology and economic factors. Two farmers using the same kind of inputs and technology may produce considerably different levels of output (Abdul-Rahaman, 2016). Technical efficiency concept relates to individual farmer's production performance which can be compared to the best practice input-output relationship. The best-practice frontier is assumed to be stochastic, with a corresponding two-sided error term, in order to capture exogenous shocks beyond the control of the farmers. Since all farms are not able to produce the frontier output, an additional one-sided error term is introduced to represent technical inefficiency (Battese & Coelli, 1995). Although there has been literature on technical efficiency in production, however, there is still few available literature on productive and technical efficiency in Africa, particularly in Tanzania. There are many factors that may influence farmer's productive efficiency. Van Passel (2007) briefly summarized these factors into two, namely: agent and structural factors. Agent factors include those associated with the farm management such as educational age level, and social capital. Structural factors are those that are either on-farm like farm location, farm type, farm size, fertility and drainage) or off-farm such as policy, infrastructure, upstream and downstream relations (Ogada et al., 2014). Different studies have proxied how these factors can influence technical efficiency. Several empirical studies on productivity and efficiency have also attributed demographic, socio-

economic, institutional and environmental factors to cause efficiency differentials among farmers (Abebe, 2014; Battese & Coelli, 1995; Bravo-Ureta & Pinheiro, 1997). For instance, Kavoi et al. (2016) analysed factors influencing the technical efficiency of open tomato production in the Kiambu region of Kenya, and found that educational level of the household, experience in tomato farming and family size to positively impact on technical efficiency. However, gender and farm size showed a negative relationship. In the same way, a study by Malinga et al. (2015) in Swaziland discovered that age, educational level, experience and access to credit impact significantly on the level of technical efficiency of tomato growers in the area.

Despite this, only very few studies have documented technical efficiency of Tanzania's agriculture, despite good progress made by this sector in terms of productivity and its contribution to the economy (Binam et al., 2005). A stochastic production function approach was used by Ngoe et al. (2016) in their study on smallholder cocoa producers in the Meme area of Cameroon. The study was conducted to examine the way in which cocoa sector impacts on the country's economy and, consequently a mean technical efficiency of 0.86 was found confirming that extension services and access to credits were the significant determinants of the technical efficiency. Cooper et al. (2011). Meanwhile, Hayatullah (2017), pointed out that technical efficiency estimates obtained from nonparametric approach (DEA) are generally lower than those obtained under the parametric (SFA) alternative (Coelli et al., 2005; Hayatullah (2017). The main advantage of the econometric / parametric stochastic frontier analysis (SFA) approach is that it incorporates a composed error structure with a two-sided symmetric term and a one-sided component which allows to distinguish between inefficiency and exogenous shocks (Aigner et al., 1977; Hayatullah (2017). The degree of technical inefficiency reflects an individual farmer's failure to attain the highest possible output level given the set of inputs and technology represented by the production frontier (Hayatullah (2017). Finally, Binam et al. (2005) examined the technical efficiency in smallholder maize and peanut farmers in Cameroon and found average technical efficiency levels averaging between 0.79 and 0.80 respectively. The findings found suggested that schooling and membership of farmer's associations were important determinants of technical efficiency.

3. METHODOLOGY

The study methodology was carefully designed to maximize the use of available quantitative information (Corbin & Strauss, 2008). Quantitative research designs was used in this study to achieve its objectives. This study adopted stochastic frontier approach following agricultural production's tendency to exhibit random shocks. Hence, there was a need to separate the influence of stochastic factors (random shocks and measurement errors) from the effects of other inefficiency factors by assuming that deviation from the production frontier may not be entirely under the control of farmers (Hayatullah, 2017). The study was conducted in Mwanza, one of Tanzania's 31 administrative regions. The region has 8 districts namely: Nyamagane, Ilemela, Magu, Kwimba, Misungwi, Geita, Sengerema, and Ukerewe, with a total population of about 3,125,995 and, it is the second largest region after Daressalaam (Gongwe & Kongolo, 2020). The regional capital Mwanza lies in the northern part of the country, located between latitude 1° 30' and 3° south of the Equator. Longitudinally the region is located between 31° 45' and 34° 10' east of Greenwich. The region shares borders with Lake Victoria in the North, Kagera and Geita in the West, Mara Region in the East, while Shinyanga and Simiyu regions are located on the South and South-eastern side of the region (URT, 2017). Mwanza is a relatively small region occupying 2.3% of the total land area of Tanzania mainland. The region occupies a total of 35,187 sq km., out of this area 20,095 sq km is dry land and 15,092 sq km is covered by Lake Victoria. The Region's 43% of surface area is covered by water, the remaining 57% of surface is a dry land (Gongwe & Kongolo, 2020). The United Republic of Tanzania is situated on the Indian Ocean just south of the equator in East Africa. The country has a surface of 945,087 sq km compared to The Netherlands with a surface area of 41,526 sq km, and consists of the mainland Tanganyika and the Island Zanzibar. The population in 2006 is estimated at about 37,187,939 people with predominantly Bantu Africans (95%).

3.1 Sample and data collection

The sampling frame was drawn from small-scale households in two selected districts. They included Nyamagana and Ilemela districts which were purposively selected because of their maize production potential. From the sampled two districts, three (3) wards were randomly selected per district and 13 small-scale tomato producers randomly chosen from each of the three selected wards. It resulted in a total of seventy eight (78) participants randomly sampled during the study period. The three wards included Usagara, Misungwi and Kisesa. Through review of literature, quantitative secondary data was gathered from various sources, namely: (1) Tanzania annual agricultural sample survey report (2014/2015); (2) Tanzania smallholder surveys report (2016); (3) Tanzania annual agricultural sample survey (2016/2017); and (4) Tanzania National Bureau of Statistics (2016/2017) annual survey. This allowed the author to make effective use of information already available while conceptualizing the assessment, thus being able to focus on quantitative data to fill the key information gaps (Astalin, 2013). Important socio-economic variables gathered included age, sex, level of education, farm size and farming experience. Socio-economic characteristics were widely believed in the literature to influence efficiency (Hayatullah, 2017).

3.2 The model

This study adopts the stochastic frontier function because following the reason given previously in (3). Stochastic frontier production function is estimated following Boundeth et al., (2012); Kongolo (2021). One advantage of this approach is that it accounts for measurement error in the specification and estimation of the frontier production function (Boundeth et al., 2012). The stochastic frontier production model used follows Adzawla et al. (2013), Abdul-Rahaman (2016), Hayatullah, (2017) and it is specified as:

$$Y_i = f(X_i; \beta) - U_i + V_i, \text{ given that } i = 1, 2, \dots, n \quad (1)$$

where Y_i is output of i th maize producer; X_i is a (1 Xk) vector of farm inputs used in maize production; β is a (kX 1) vector of parameters to be estimated. V_i is a random error variation in maize output) associated with random factors not under the control of the farmer while U_i is inefficiency effects. The assumptions that the model includes random error V_i is assumed to be independently and identically distributed with mean zero and constant variance $N(0, \sigma_v^2)$ and independent of U_i , and that the non-negative error U_i is distributed as the absolute value of a normal distribution, $N(0, \sigma_u^2)$ (Mango et al, 2015; Hayatullah, 2017). The technical efficiency of an individual producer can be defined in terms of the ratio of the observed output to the corresponding frontier output, given the available technology (Boundeth, 2012).

3.3 Tests model specification

There exist various ways to tests the null hypotheses of the frontier production functions. The Maximum likelihood estimates (MLE) for all parameters of the stochastic frontier production and inefficiency were also estimated including the variance parameters in terms of parameterization (Boundeth et al., 2012). The variance parameters were specified as follow:

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

and

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

to have $0 \leq \gamma \leq 1$

From equation (3) it can be noticed that γ ranges from 0 to 1 taking the values close to 1, indicating that the random component of the inefficiency effects contributes positively to the analysis of the production system (Hayatullah, 2017). Thus, according to (Abdul-Rahaman, 2016), technical efficiency (TE_i) of the i -th producer can be expressed in terms of the levels of inputs used, and be estimated using the expectation of U_i conditional on the random variable ϵ_i , as expressed in the following equation:

$$TE_i = \text{Exp}(-U_i) \quad (4)$$

The Technical Efficiency (TE) of a small-scale producer was between 0 and 1 and is inversely related to the level of the technical inefficiency effects (Boundeth et al., 2012). The TE is also predicted using the Frontier 4.1 package, used to calculate the ML estimate of the predictor for equation (6), that is based on its conditional expectation, given the observed value of ($V_i - U_i$). If U_i is equal to 0, the production is on the frontier, suggesting that the producer is technical efficiency. If U_i is greater than 0, the production will lie below the frontier, suggesting that the producer is technical inefficiency (Mango et al, 2015). The technical inefficiency can only be estimated if the inefficiency effects are stochastic and have a particular distribution specification (Boundeth et al., 2012). It follows that the technical inefficiency determinants of small-scale producers where Y_i is output of i th tomato producer; X_i is a (1 Xk) vector of farm inputs used in tomato production; β is a (kX 1) vector of parameters to be estimated. V_i is a random error variation in tomato output) associated with random factors not under the control of the farmer, while U_i is the inefficiency effects. The assumptions that the model includes random error V_i is assumed to be independently and identically distributed with mean zero and constant variance and independent of U_i , and that the non-negative error U_i is distributed as the absolute value of a normal distribution (Mango et al, 2015; Hayatullah, 2017). The technical efficiency of an individual producer can be defined in terms of the ratio of the observed output to the corresponding frontier output, given the available technology (Boundeth et al., 2012). Consequently, the tomato producers were expressed as expressed in equation (5):

$$\ln(U_i) = \delta_0 + \delta_1(C_i) + W_i \quad (5)$$

where U_i is technical inefficiency; $\delta_0, \dots, \delta_1$ are the parameters to be estimated; C_i is a vector of farmer and household socio-economic characteristics; W_i is a random error.

3.4 Empirical model

The study used a stochastic frontier approach to estimate the level of technical efficiency of small-scale tomato producers including the levels of the determinants of inefficiency of producers. The Binam et al., (2004) model was used to specify a stochastic frontier production function with the behaviour inefficiency component to be used in data analysis. As a result, the use of Binam et al., (2004) Cobb-Douglas function framework for tomato farmers in Mwanza was expressed as given in equation (6).

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \beta_8 \ln X_8 + \beta_9 \ln X_9 + \dots + V_i - U_i \quad (6)$$

where Y_i represents tomato output, b is 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:

$$\mu_i = d_0 + \sum d_k Z_k \quad (7)$$

where: Z_k = Farm-specific variables assumed to affect technical, and they included variables such as: Z_1 = farmers' age; Z_2 = educational level; Z_3 = experience; Z_4 = access to extension service, Z_5 = household size and d_k is an unknown parameters. The maximum likelihood estimates of the parameters of the Cobb-Douglas deviation minimum and maximum of each variable used in stochastic frontier model is given in Table 1.

Table 1: Descriptive statistics of variables used in the analysis

Variable	Mean	Standard Dev	Minimum	Maxideviation
Farm size (hectare)	0.81	0.60	0.12	3.10
Fertilizer (kg)	29.73	34.12	0.01	148.01
Seed (kg)	0.96	0.76	0.11	3.10
Labour (man days)	274.00	78.91	90.10	450.01
Pesticides (litre)	1.30	1.50	0.01	7.01
Age (year)	37.00	10.76	28.00	70.00
Household size	8.64	4.21	1.00	23.00
Education (year)	8.34	5.41	0.01	16.00
Farming experience (year)	7.90	6.27	2.10	29.02
Access extension service (1 = yes; 0 = No)	0.21	0.40	0.00	1.00

The unknown parameters of the model, i.e b 's and d 's and the variance parameter, $d^2 = d_u^2 + d_v^2$ and $g = d_u^2 / (d_u^2 + d_v^2)$ were respectively calculated. g describes relative magnitude of the variance associated with the distribution of the inefficiency effects, u_i . The mean age of tomato farmers was 37.00 years with the standard deviation of 10.76. The mean size of the family of the respondent farmers was recorded as 8.34 people per family with the standard deviation of 4.21. The mean farming experience was 7.90 with standard deviation of 6.27. Educational level of the farmers (or the mean value of years of schooling of the farmer was 8.36 years with a standard deviation of 5.41, suggests that educational level of the respondents was low.

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

Variable	Parameter	Coefficient	t-ratio
Production function			
Constant	β_0	9.10	8.36*
ln (Farm size) (ha)	β_1	1.24	7.24*
ln (Labour) (mandays)	β_2	-0.38	-1.66***
ln (Seed) (kg)	β_3	0.16	1.14***
ln (Fertilizer) (kg)	β_4	0.07	2.04**
Pesticide (Lt)	β_5	-0.05	-0.69
Inefficiency Model			
Constant	d_0	1.70	1.16
Age (years)	d_1	-0.23	-0.44
Education (years)	d_2	-0.076**	-2.03**
Household size	d_3	0.38**	2.23**
Farming experience (years)	d_4	-0.46**	-2.06**
Access to extension service	d_5	-0.51***	-1.94***
Variance parameter			
Sigma squared	$s^2 = 0.84^*$	5.89*	
$s^2u + s^2v$			
Gamma $\gamma = 0.47^*$		10.06*	
$s^2u / s^2v + s^2u$			
Log likelihood function (LLF)		-122.30	

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

The estimated coefficients of the production function for farm size, labour, seeds, and fertilizer, were all significant at the 1%, 5% and 10% respectively, suggesting their influence on tomato production in the region. However, the coefficient of pesticides did not have any positive effect on tomato production. In line with economics of production, the values of the coefficients represent the elasticity of the various inputs to the output. For instance, the coefficient of farm size of 1.24 indicates that an increase of 1 percent in farm size leads to an increase in tomato yield of 12.4 percent (other things being constant). This is the same for labour, seed and fertilizer, if increased by 1 percent, will experience an increase of 3.8 percent, 1.6 percent and 0.7 percent respectively. The negative coefficient of labour of (-0.38) will be transformed into 3.8 with an increase of 1 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 (Abu et al., 2011). Hence, in order to increase the output, producers will need to increase the utilization of seed, farm size, and fertilizer (Tabe-Ojong & Molua, 2017). With regards to the parameter estimates of the influence of socio-economic factors on technical inefficiency, the results showed that factors such as educational level, farming experience and access to extension services positively impacted on technical efficiency of the producers. Overall, both the signs and significance of the estimated coefficient of the inefficiency model have important implications on technical efficiency. Hence, the result in Table 2 suggest that both farmer's educational level, farming experience, and access to extension service were negative, but significant at the 5 percent level. Meaning that although negative they significantly impacted positively on producer's technical inefficiency (Sharma et al., 1999; Rahman, 2002; Ogundari, 2008). That is, as producers become more educated, they reduce technical inefficiency by increasing efficiency (Bianam et al., 2004; Abu et al., 2011). In other words, when education increases the ability to perceive, interpret and react to new ideas lead to improvement in farmers' managerial skills (Ogundari, 2008). The estimated coefficient of household size was significant and had a positive impact on technical inefficiency. It implies that, this factor led to increase in technical inefficiency of the producers. The estimated sigma square (s^2) of the tomato farmers was 0.84 and was significant at 1 percent level. It indicates a good fit and the correctness of the specified distributional assumptions of the model. The result implies that the usual production function was not an adequate representation of the data (Rahman, 2002; Tijan et al., 2006; Ogundari, 2006). The estimated gamma (γ) parameter was 0.47, implying that about 47 percent of the variation in the output of tomato farms in the study area is due to the differences in their technical efficiencies.

3.5 Technical Efficiency Estimates

The results of efficiency analysis indicated that technical efficiency score of tomato producers in Mwanza region ranged from 0.20 to 0.97 with an average of 0.58 (Table 3)

Table 3: Returns to scale

Variable	Coefficient
Farm size	1.27 (1.24)
Labour	-0.34 (-0.36)
Seed	0.18 (0.16)
Fertilizer	0.10 (0.08)
Pesticide	-0.07 (0.04)
Return to scale (RTS)	1.06 (1.08)

In other words, it can be argued that in the short run, there would be a scope for increasing tomato production by 22 percent with the adoption of the best practice technology could be used in tomato producers in the region. The same 22 percent indicates that on average about 22 percent of tomato could be lost as a result of farmers' inefficiency. In terms of the frequency analysis of efficiency levels, it can be said that about 22.4 percent of the tomato producers sampled had a technical efficiency score greater than 62 percent, while 38.4 percent had technical efficiency levels between 40 percent and 50 percent. The remaining of producers had a technical efficiency levels between 22 percent and 36 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	18.0	21.2
0.40-0.59	32.0	36.6
> 0.60	37.0	42.2
Total	87.0	100.0
Mean efficiency	0.50	
Minimum efficiency	0.24	
Maximum efficiency	0.87	

4. CONCLUSION

This paper aimed at investigating the way in which small-scale tomato producers in Mwanza region could progress, using a stochastic frontier analysis approach with a Cobb-Douglas functional form to estimate all the parameters of the technical efficiency. Data used was collected from various sources with identified factors related to technical efficiency from a sample of 78 small-scale maize producers. The findings indicated that estimated coefficients of farm size, labour, fertilizer, seed, educational level, household size, farming experience, and access to extension services were statistically significant by positively impacted on producers' technical efficiency in the study area. However, the coefficient of pesticide was not significant. That is, it was not a source of technical efficiency of the small-scale tomato producers, but a potential source of inefficiency (Boundeth et al, 2012). The negative coefficient of labour of (-0.38) will be transformed into 3.8 with an increase of 1 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 (Abu et al., 2011). Hence, in order to increase the output, producers will need to increase the utilization of seed, farm size, and fertilizer (Tabe-Ojong & Molua, 2017). Variations in minimum and maximum technical efficiency were 20% and 97% respectively with an average of 0.58. The mean technical efficiency of the total sample of producers was 58% of maximum attainable output for a given set of input levels and the technology. This implies that the output per producer can be increased on average by 37% of tomato producers under the current conditions. The findings of this study are in line with the findings of Abedullah and Ahmad, (2006); Boundeth et al, (2012); Mango et al, (2015) technical efficiency analysis of smallholder tomato production in Pakistan, maize production in Zimbabwe and Laos respectively. The Maximum Likelihood Estimate (MLE) evidences the need for efficient use of available means of production. The MLE estimates were based on the coefficient of gamma (γ), the ratio of the variance of technical inefficiency effects (U_i) to the variance of random errors (u_i).

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