Analysis of Technical Efficiency of Sunflower Oil Production in Tanzania A Case of Small Scale Processors in Singida Region

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ABSTRACT

Most developing nations, including Tanzania, consider agro processing as a key to industrialization. Despite an attractive sunflower seed yield, Tanzania's sunflower oil processing and production has been staggering over the years. Sunflower oil production is inefficient and low output. So, this study studied sunflower oil production Technical Efficiency (TE) in Singida. The study examined the social and economic factors that affect TE in small scale sunflower oil producers. The study applied cross sectional design and secondary data for year 2016/2017 were collected from central zone sunflower oil processors association and small industrial development organization based on Singida small scale sunflower oil producers. It used stochastic frontier analysis and multiple linear regressions to find the empirical economic relationship between the variables. Sunflower oil producers averaged 30.1% less TE as the average TE was 69.9%. It revealed that Labor, seed, capital and electricity also affected production. Age, experience, education and locality also mattered. Finally, processing techniques, socio economic and demographic differences affect sunflower oil production. So, producers must increase capital inputs to be technically efficient. Consider boosting producer capacity and abilities and observing a minimum number of productive staff.

Keywords: Technical efficiency, Sunflower, Singida, Stochastic frontier analysis, Electricity.

1. INTRODUCTION

Agriculture in Africa has long been the main economic activity. It employs two thirds of the continent. The sector employs 69% of sub-Saharan African workers (OECD, 2016). The rural people know its importance. According to Bachewe, et al. and Jayne, et al., 25% of urban families and 84% of rural families depend on agriculture. The sector accounts for 30% to 70% of national income and 30% of export value in each country. Only 7% of Africa's total land is arable and used for grain production (Mzali, 2019).

Sunflowers is identified as one of the main crops produced in Tanzania and quite considered as the one of the backbones in the agriculture sector alongside maize, rice, cassava, banana, peanut and sweet potato. In addition, Tanzania has been one of the world's top producers of sunflower oil seeds with an annual production of approximately 3,112,500 tons of sunflower seeds during 2017, corresponding to approximately 239,000 tons of oil (URT, 2019). Its production is mainly based on the small scale farmers, throughout the country; therefore, the sunflower oil production has tremendous potential to improve livelihoods and the wellbeing of comparatively poor households.

The central region Dodoma, Singida and surrounding areas produces almost 42% of the nation's goods (URT, 2018). Tanzania is one of three major African producers of sunflower seed oil, along with South Africa and Uganda, yet there is still a great demand for edible oil in the country (Iringo, 2013). RLDC (2016) in Tanzania evaluated annual edible oil demand at 440,000 tonnes and expected 3% annual growth. The country imports more than half of its edible oil. Large and small processors contribute 40% of the nation's edible oil needs (Ekblom, 2016).

However, Tanzania's sunflower oil seed output has declined from 1.1 million tonnes in 2017 to 767,188 tonnes in 2018, a 30.2% drop, and to 561,297 tonnes in 2019, a 26.8% drop and a staggering production process (URT, 2019). Despite the soaring production of sunflower seeds, most agro processors and small companies that process edible oil, notably sunflower oil producers, are still inefficient and incompetent. In 2019, the farms produced 561,297 tonnes of sunflower seeds but only 97,740 tonnes of oil, indicating that the industry is not fully utilizing its edible oil production potential (URT, 2019).

In developing countries like Tanzania, agriculture and agro processing inefficiency is a common complaint. The agricultural sector is inefficient since it has not fully grown into a sector that involves farm processing firms. Consequently, changing the economic return, considering the importance and demand of most agro processed products like sunflower oil Tanzania (Tisimia, 2014). Sunflower oil production faces limited output potential and chronic technical efficiency decline, resulting in a mismatch between production and consumption (Mushi, 2016).

Mpeta, et al. compared technical efficiency among Kongwa district small scale sunflower producers in the central agricultural zone. The study used the propensity score method to reduce bias from farmer characteristics. According to the study, sunflower farmers who contract farm are 7.4% more technically efficient than those who do not. Farmland size, input loans, age, off farm income, schooling, labour, and fertilizer were examined. Only two variables were significant at 5%. Hence, the study advised farmers to participate in extension programmes, farm management training, and input credit systems to improve technical efficiency and production. However, Mwalupaso, et al. found that using mobile phones to acquire agricultural information maximized technical efficiency. The report also suggests using mobile phones and technology in agriculture since it boosts production and information for rural farmers.

Ngaisset and Jia examined Lobaye's palm oil processors' technological efficiency. Descriptive and stochastic frontier analyses were used to analyze 159 randomly chosen palm oil processors. The study found 81% technical efficiency, meaning processors can enhance efficiency by 19% to reach their full capacity. Yet, producer education in the production area considerably affects palm oil processor productivity. So, the study advises measures to improve and train producers to increase knowledge, productivity and efficiency. Attipoe, et al. examined how rural and community banks affect cocoa production technical efficiency. A cross sectional survey of 500 cocoa growers was analyzed using stochastic frontier analysis and Heckman's model. The study found that rural and community banks' financial support improved cocoa growers technical efficiency. The rural and community banks' credit availability is governed by many circumstances, yet farmers' technical efficiency averaged 81%, indicating that no farmer attained the cocoa production efficiency requirement of 100%.

Kea, et al. examined Cambodia's rice production's technical efficiency and important parameters. From 2012 to 2015, panel data was collected from 25 Cambodian provinces. The stochastic frontier analysis showed that capital investment (*i.e.,* agricultural machinery), land and fertiliser application affect output. The survey also found that rice production was only 78.4% technically efficient. Additionally, Ismiasih used secondary data from the 2013 agricultural survey of 1229 palm farmers in Western Kalimantan to assess palm oil production efficiency.

The Stochastic frontier analysis showed that the farmers analyzed are technically inefficient. The study also found that plant age, number of productive trees, fertilizers, labour and pesticides affected palm oil production efficiency. However, the report suggested that farmers participate in plasma programmes and become more involved in cooperatives to learn more about palm oil farming. Sarker, et al. evaluated Bangladeshi watermelon growers' technical efficiency, efficiency factors, and dangers. The stochastic frontier analysis of 180 farmers identified a mean technical efficiency level of 86%, indicating that Bangladeshi watermelon producers can improve by 14%.

This study examined technical efficiency of sunflower oil production in the case of Singida region. In specific, the study did determine the level of technical efficiency among producers of sunflower oil as well as analyze the socio economic factors affecting the technical efficiency in the production of sunflower oil among the small scale producers. The study aims to determine the level of technical efficiency in the production of sunflower oil among the small scale producers, analyses the socio economic factors affecting the technical efficiency in the production of sunflower oil among the small scale producers.

2. MATERIALS AND METHODS

Coelli, Prasada Rao, O'Donnell, and Battese recommended SFA to be the best measure of technical efficiency estimation in agriculture studies rather than the deterministic approach and DEA, because data from agriculture are highly influenced by measurement errors and the effect of pest, weather and diseases etc. This study adopted Stochastic Production Frontier as it the most precise technique used in technical efficiency estimation.

The SFA split up the error term (deviation) into twofold parts to accommodate factors are beyond firms control. Thus, one is a technical inefficiency portion for a firm and another part includes random shocks which are also known as white noise like bad weather or climate, measurements errors, and exclusion of variables which could be included in the model. Subsequently, this study estimated and assesses the factors that influence or affect technical efficiency of sunflower oil small scale producer in Singida, Tanzania using the SFA model.

The model expressed as follows:

$$lnYi=\beta_o+\sum\beta_i lnX_{ij}+exp^{ei}$$

Where by:

ln= represent the natural logarithm

i= represent the i^{th} sunflower oil producer

Yi= represents liters of sunflower oil of the i^{th} sunflower oil producer

X_{ij}= denotes the production inputs i^{th} sunflower oil producer

$e_i=v_i-u_i$ represents the residual random term composed of two elements vi and ui.

The vi captures random deviation in output caused by factors like climatic condition, variables exclusion and other exogenous shocks, while ui denote the technical inefficiency.

Cobb Douglas functional form was used in this study to estimating the relationship between inputs of productions and output produced. This functional form is more preferred because the model of this study has more than three independent variables and is simple in specification and production frontier estimation in the literatures reviewed (Table 1). Additionally, the parameter approximation using econometric technique is very simple in terms of analysis and explanation (interpretation) because of the logarithmic production function nature.

The Cobb-Douglas functional form of stochastic frontier production expressed as follows:

$$lnY_i = \beta_o + \sum_{j=1}^{4} \beta_j lnX_{ij} + v_i - u_i$$

Where:

β_o=Constant

Y=Litres of Sunflower oil produced

X_{ij}=Independent variables

v_i=Random error

u_i=Inefficiency effect, which is non-negative

Therefore, the inefficiency model defined as follows:

$$u_i = \delta_0 + \delta_{ij} Z_{iji}$$

ui=Technical Inefficiency

δ_1-δ_5=Parameters to be estimated

Z_1-Z_5=Independent variable coefficient

Table 1. Descriptive statistics for continuous variables

Variable	Obs	Mean	Std. Dev.	Min	Max

Litres	176	39.47159	10.18174	5	60
Capital	176	8869006	7045075	855000	2.85E+07
Labour	176	9.386364	7.405684	1	30
Electricity	176	6427.841	3053.741	2000	14200
Education	176	12.77841	3.714341	2	19
Experience	176	6.982955	4.135525	2	18
Age	176	41.58523	9.902589	27	62

Source: Research findings (2023)

The variable liters were researched in Table 1 above to establish the amount of liters sunflower oil produced in the study area among the studied respondents. Furthermore, the variable was investigated as the foundation for establishing the study's technical efficiency. According to the data, 176 observations were made in the study region, and the mean or average number of liters produced on a daily basis was 39.47 liters. The small scale producers generated the most liters per day, 60 liters and the least amount, 5 liters, of sunflower oil per day. Moreover, Variable capital, determined by company investment, was specified for 176 small-scale firms. The researched small scale producers injected a maximum of Tsh. 2850000/=and a minimum of Tsh. 855000/=. The statistics also showed that the average capital invested was Tsh. 8869006/=, with small scale producers diverging by Tsh. 7045075/=.

Yet, variable labour was explored as a crucial production determinant that affected small scale producers' technical efficiency. The findings showed that among the 176 small scale producers surveyed, the largest number of labours required in the production process was 30 and the lowest was one, meaning a range of 29 laborers. The average labour was 9, while small manufacturers deviated from the norm by 7.4 (standard deviation). Variable electricity was also explored as a key production factor. To simplify production, electricity costs were analyzed. The lowest daily power or energy resource expenditure among the 176 analyzed producers was Tsh. 2000/=, while the highest was Tsh. 14200/=. The average daily electricity or energy expenditure was Tsh. 6427.8/= and producers varied from the norm by Tsh. 3053.7/=.

Among the 176 producers evaluated, education was measured in years of schooling. The maximum number of years spent in school was 19, indicating masters holders, while the lowest was 2, indicating primary school class 1. The average number of years spent at school was 12.7, which represents form leavers, while the producers' education years (schooling years) differed from the mean by 3.7, or 4 schooling years. Since more experienced producers are predicted to be technically efficient, experience was explored as a fundamental driver of producer technical efficiency. The most experienced producer had 18 years of producing experience, while the least experienced had 2. The average experience was 6.98 years, or 7 years of production, while the average variance was 4.13 years (standard deviation).

Next, all 176 producers were examined by age, with the oldest being 62 and the youngest 27. The average sunflower oil producer was 41.58 years old, and the producers surveyed were 9.9 years older.

3. RESULTS AND DISCUSSION

Empirical findings from the econometric analysis conducted for this project are shown here. The method used to do the analysis was the stochastic frontier method, and it only required a single step to complete the entire process. The method relied on statistical estimates of the Cobb Douglas function, where inputs determine outputs, and estimated inefficiency factors, or those that prevent producers in the examined area from maximizing their technical efficiency in sunflower oil production. The linear regression model of the technical efficiency levels established for each producer and the inefficiency causes was also highlighted by the empirical data (Table 2).

Table 2. Level of technical efficiency of the sunflower producers

Variable	Observation	Mean	Std. Dev.	Min	Max
Technical efficiency	176	0.699134	0.184974	0.089621	0.991978

Source: Research findings (2023)

Technical efficiency averaged 0.699%, or 69.9%, according to Table 2. The sampled population's average technical efficiency is 69.9%, or 70%. Hence, small scale sunflower oil producers in the analyzed region are 30% less efficient and may improve by 30% to attain their full potential. The data also shows that sunflower producers in the region have a minimum technical efficiency of 0.0896, which is 8.96% efficient and 91.04% below their potential. The most technically efficient corporation received a 0.9919 efficiency rating, or 99.19% technical efficiency. Producer efficiency was 0.185, 18.5% below average. Technical efficiency averaged 0.699, or 69.9%, according to Table 2. The sampled population's average technical efficiency is 69.9%, or 70%. Hence, small scale sunflower oil producers in the analyzed region are 30% less efficient and may improve by 30% to attain their full potential. Sunflower growers in the investigated region have a minimum technical efficiency of 0.0896, which is 8.96% efficient and 91.04% below their potential. The most technically efficient corporation received a 0.9919 efficiency rating, or 99.19% technical efficiency. Producer efficiency was 0.185, 18.5% below average (Table 3).

Table 3. Empirical Results of the stochastic frontier model

Variables	**Coefficients**	**Standard error**	**P>|z|**
Frontier			
Labour	-.0884616*	0.000273	0
Seeds	.0921063*	0.000608	0
Capital	.0763461*	0.000133	0
Land size	-3.15E-07	4.11E-05	0.994
Electricity	-.1283844*	0.000202	0
Constant	3.675365	.	.
Inefficiency model			
Age	-.0410882*	0.00227	0
Experience	0.00021	0.004183	0.96
Training	.0487744*	0.024186	0.044
Location	0.021723	0.025299	0.391
Constant	1.9721	0.086743	0
Usigma			
cons	-4.10462	0.117115	0
Vsigma			
Cons	-24.1056	13.82894	0.081
Sigma_u	0.128438	0.007521	0
Sigma_v	5.83E-06	4.03E-05	0.885
Lambda	22036.77	0.007521	0
Number of observations=176 Wald *chi square* (5)=6.62e+06 Prob>*chi square* =0.0000 Loglikelihood=183.8355			

Note: Dependent variable is sunflower oil in Liters
P-values with *, ** and *** imply significance level at 10 percent, 5 percent and percent respectively
Source: *Research findings (2023)*

In Table 2, all independent variables affecting the deterministic phase of the analysis, the Cobb Douglas model, are significant at 5% except land size. At 5% significance, the land size variable did not affect sunflower productivity among the examined producers in the region. Such findings concur to those of Mpeta that signified that land was the least significant variable among the others in the production process. Such that whenever other factors are significantly well efficient in the production process, a smaller land is needed in the overall process of production. Moreover, two socio economic aspects which are age and training were statistically significant and crucial to the production process, whereas others had little impact.

However, for the significant variables impacting sunflower oil production, the results show that if all other variables are maintained constant, a 1% increase in labour size (number of workers) decreases productivity by 0.08%. In a similar situation, the variable seed intake was supposed to monitor production seed processing. While other conditions are fixed, increasing seed intake by 1% increases sunflower oil output by 0.09%.

The variable capital introduced to the business increased sunflower oil production by 0.07% when other factors were held constant. While other variables are held constant, an increase in land size by 1% corresponds to a 0.000000315% rise in productivity, which is not significant at 5%. Finally, a 1% increase in electricity usage increases sunflower oil production by 0.1% when other conditions are maintained equal.

In the inefficiency section of the model, increasing age by one year increases sunflower oil production efficiency by 0.4%, decreasing inefficiency among the investigated small scale producers. While all things are held constant, a year of small scale producer experience decreases efficiency by 0.0002%. Variable experience is not statistically significant. Sunflower growers with training were 0.2% more efficient than those without. Finally, urban producers may be less efficient.

Significant variables include daily labour, seed intake, capital in shillings, machinery cost, and electricity use in production. Variable labour hurt output. This implies that a corporation will be technically efficient if it produces more with fewer labour. Yet, electricity spending reduces output and efficiency, while capital was found to increase production and producer efficiency. Lastly, the number of sunflower seeds used as source material had a favorable significant effect. So, the more kilogrammes of seeds processed, the more sunflower oil produced and the more technically efficient the manufacturer. These findings agree with Ngaisset and Jia and Ismiasih that variable capital and raw material are the most important variables in production and efficiency.

On the side of inefficiency part, Variable experience, training, and location favorably increase technical inefficiency, according to stochastic frontier model study. Experience, training and location all lower the study's technical efficiency. The variable affected technical efficiency and inefficiency differently. Age was found to negatively affect technical inefficiency and positively affect technical efficiency. Technical efficiency may rise with producer age. These findings contradict most underlying assumptions and specifically Sarker, et al., who also reported a positive relationship between age and productivity.

There are a variety of ways in which the technical efficiency might be triggered by the societal and economic context. Thus, a linear regression model is further done with regard to the technical efficiency levels derived from the stochastic frontier model to prove the effect of such factors on the level of technical efficiency. The OLS assumption that the model is built on makes it strictly linear (Table 4).

Table 4. Regression model of the socio-economic factors affecting the level of technical efficiency

Variables	Coefficient	Standard Error	P>|t|
Age	.0083645*	0.000712	0
Gender	0.004709	0.016862	0.78
Experience	-.0039877*	0.001736	0.023
Training	.026474**	0.013564	0.053
Location	-.0456363*	0.012596	0
Education	.0044728*	0.00153	0.004
cons	0.457769	0.042251	0
Number of obs	176		
F (6,169)	38.26		
Prob>F	0		
R-squared	0.576		
Adj R-squared	0.5609		
Root MSE	0.07179		

Note: Dependent variable is sunflower oil in liters

P-values with *, ** and *** imply significance level at 10 percent, 5 percent, and percent respectively

Source: *Research findings (2023)*

Table 4 demonstrates that the model was statistically significant at the 5%, 1% and 10% levels of significance, with an F-Statistic of 38.26 and a probability of F of 0.000 out of a total of 176 observations. This was the case at all three levels of significance. In addition, the model had an R-squared value of 0.5760, which indicates that the inefficiency factors evaluated (age, gender, experience, training, location and education level) account for 57.6% of the variation in technical efficiencies. These factors include: age, gender, experience, training and location and education level. It was demonstrated that age was a significant influence for all of the variables that were investigated at all three levels of significance (1%, 5% and 10%).

The study also used precise producer technical efficiencies to create a linear regression model to determine the socio economic determinants affecting sunflower oil production technical efficiency. The work employed stochastic frontier analysis to determine the linear regression model based on OLS model linear assumptions. Technical efficiencies were regressed to socioeconomic parameters such age, gender, experience, training, location and education. The data showed that producer technical efficiency increased with age. So, older producers are more productive. Such data also suggest that elderly producers are more efficient than younger ones. Yet, such studies on age can also imply the capital imposed gap, where the senior group tends to impose a huge capital due to financial stability, which can increase production efficiency. Sarker, et al. discovered a favorable relationship between age and productivity.

Male producers are 0.4% more technically efficient than female producers. The proposed model shows that women are less likely than males to produce sunflower oil in Singida. These data support Kaijage 2016's claim that men farmers are more technically proficient than female farmers.

Literature suggests that variable experience boosts production and efficiency (Attipoe et al., 2020; Ngaisset and Jia, 2020; Mpeta et al., 2020). This study found that producer experience negatively impacted technical efficiency. Those data suggest that experienced producers become less efficient. Most people get sluggish and less focused over time, which is true for most sunflower oil manufacturers in Singida. Attipoe et al. found that most cocoa producers are technically proficient.

According to the literature, trained staff performs better than unskilled staff. The study found that varied training did not affect technical efficiency. Nonetheless, the variable was positive. Trained workers were 0.2% more technically efficient than unskilled ones. Njiku and Kaijage also found that the more a producer is trained, the more efficient they will be Table 5 (OECD, 2016 and RLDP, 2010 and RLDP, 2016).

Table 5. Description and measurement of variables

Variable	Description	Measurement
Amount produced	Amount of sunflower oil produced per day	Liters
Capital	Amount of money invested in machinery for the production process	Tanzania shillings
Labour	Number of labours employed in the production process	Number of workers employed
Electricity	Amount of money spent in electricity	Tanzania shillings
Seeds	Amount of seeds used in the production process	Kilograms
Land size	Area of land occupied in the production process	Square meters
Technical efficiency	Effectiveness with which a given set of inputs is used to produce an output	Derived from a stochastic frontier model
Age	Age of the producer	Number of years
Gender	Male or female	A dummy variable
Experience	Number of years since first involved in the production process	Number of years
Training	Trained or not trained	A dummy variable
Location	Urban or rural	A dummy variable
Education	Number of years spent in school	Number of years

Source: Research Author computation (2023)

In the variable location, urban based producers especially in Singida town and adjacent township centers were less technically efficient than rural based producers. Nevertheless, urban producers produce more but also use more labour than rural producers, which adds to inefficiency. Ismiasih also found that rural firms are more likely to produce because they are closer to raw materials (Sarker, et al., 2017 and Tisimia, 2014 and URT, 2017 AND URT, 2019).

Technical efficiency increased significantly with schooling. So, better educated producers are more efficient. Kaijage, Surker et al. and Attipoe et al. found a positive correlation between education and production efficiency.

4. CONCLUSION

The small scale producers in Singida region are not fully technically efficient whereby on average their level of technical efficiency was around 69.9%, Therefore, it demonstrates that majority of the producers are in the decline and subsequently in the second and third stage of production, which yield a relative lower return in comparison to inputs used.

Furthermore, it was revealed that the variables cost capital introduced in the business and the amount of seeds used per day were the most significant factors in the production. This demonstrates that employing of quality input factors could yield a chance for an increased output as well as improving the overall efficiency of the production process.

Nevertheless, basing the study results, the study further concludes that majority of the producers are not technically efficient due to a negative effect and inefficiency of some variables such as labour. Furthermore, factors such as land were found to be insignificant for the production process, since it was revealed that most producers don't highly depend on large part of land for production. In precise it was revealed that the actual land used for production was small and most part of the land remaining was used for storage of sunflower as well as for the inspection and sorting of the sunflower seeds to be processed. Lastly, basing on the findings it can also be concluded that male producers are more technically efficient than the female and also the producers that are based on rural areas are more technically efficient than those in urban.

Therefore, the study recommends that for the producers to be technically efficient they should invest more on the capital inputs of the production process since the variable capital was found to be very significant at affecting the efficiency and the overall level of production. Furthermore, in a connection to the capital imposed, the producers should focus on employing more efficient and latest tech machines for the processing of sunflower oil. It was noted that majority of the small producers were using the oldest technologies in the processing and therefore not being quite effective enough. In similar concept of expanding the capital inputs, the study recommends that the producers should focus on acquiring loans and credits so as to broaden their capital base.

Through acquiring loan, the producers will have enough funds to buy the high-tech machines that are quite efficient and less electricity consuming.

Nevertheless, study also examined the concepts of education level as well as the training among the producers. Therefore, given the level of education and training being quite low, the government through SIDO, TFDA and other governing institutions such as CEZOSOPA can also consider improving the capacity and skills of producers through providing occasional seminars as well as special industrial training on the overall production process of sunflower oil. This is because it was revealed in the study analysis that the technical efficiency of the producers tends to improves as number of years of schooling increases. Moreover, it was also revealed that the trained producers are more technically efficient than the untrained producers.

On the other hand, since the technical efficiency of the producer of sunflower oil decreases with an increase in number of labours employed in the production process. Therefore, owners can observe a minimal number of effective employees in sunflower oil processing firms for improved output as well as improve their overall level of technical efficiencies. A large number of workers working on a similar task result in wasted time, difficulty in management, and higher labour costs. Furthermore, the producers can take initiatives of conducting training activities to their labour so as to promote the effective working capabilities.

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