Assessment of Technical Efficiency of Sorghum Production in Adamawa State, Nigeria

Jimjel Zalkuwi[1], Rakesh Singh[2], O. P. Singh[3]

[1,2,3]Department of Agricultural Economics,
Institute of Agricultural science,
BHU, Varanasi-221005, India
Corresponding author's email:jzalkwi4u {at} gmail.com

ABSTRACT---- ***The study examined the technical efficiency of sorghum production in Adamawa State, Nigeria. Data were collected from 240 farmers using purposive and simple random sampling with aid of structured schedule. The result of the stochastic frontier production function analysis shows that the variance parameters, that is the sigma squared (δ^2) and the gamma (γ) were statistically significant at 1 % level for sorghum production. The coefficient of farm size, family labor, seed and fertilizer were positive and significant at 1%, 5% and 10% levels while fertilizer was not significant. Profit level can be increased by increasing the amount of farm size, quantity of seed, labor and chemical and decreasing the use of fertilizer. Mean efficiency was 0.68; Farmers operate at 32% below frontier level due to variation in technical efficiency. The inefficiency model shows that the coefficient of Age, literacy level and credit have negative a priori sign and in consonance with the a priori expectation.***

1. INTRODUCTION

Nigeria is the largest producer of sorghum in West Africa accounting for about 71% of the total regional sorghum output. Sorghum is the 3rd cereal in terms of quantity of production in Nigeria. Agricultural industry was accorded scanty attention after the discovery of oil in commercial quantity in Nigeria. This has created a gap between the demand and supply of domestic food requirements. Consequently, the country has found it increasingly difficult to feed her teeming population and supply the local industries from the domestically produced food and raw materials. Annual widening gap between food and raw materials demand and supply in the country gave room for concern Igben (1988). In Adamawa State, sorghum is the most cultivated crop and it is grown on an area of about 70,000 hectares, with 41,000 hectares cultivated under sole and 29,000 hectares cultivated mixed cropping, (Adamawa Agricultural Development Programme (ADADP, 2010). The total production of sorghum in the State in 2012 was 72,000 tonnes with an estimated average yield of 1.18 tonnes/hectares (National Bureau of Statistics 2013) The productivity growth may be achieved through either technological progress or efficiency improvement (Coelli, 1995). Several studies indicated that the existing low levels of technical efficiency hinder efforts to achieve progress in production (Belete *et al*., 1991; Seyoum *et al*., 1997). Despite the significant growth in sorghum production, there is huge inefficiency in the production system of sorghum production. An improvement in the efficiency of production system will have direct positive impact on agricultural growth, nutritional security and rural livelihood in a country like Nigeria, where sorghum is one of the major crops.

Under these circumstances it is important to know that whether the producers have the same or different levels of technical efficiency. The study therefore, tries to measure the technical efficiency under different farm in Adamawa State of Nigeria

2. METHODOLOGY

2.1 Selection of the state and local government

Adamawa State based on their production level has been selected purposively. The state has twenty-one Local Government Areas which are categorized into four agricultural zones; South West, Central, North West and North East Zone. Twenty percent Local Government Area have been(i.e four LGA) have been purposively selected from each zone, comprise Viz; Ganye, Guyuk, Mubi south and Girei.

2.2 Selection of district

Ten percent i.e. one district from each Local government was selected purposively on the basis of highest sorghum production.

2.3 Selection of villages

A list of all villages in the four districts was prepared on the basis of sorghum production, 10 percent of the villages having the highest sorghum production in each district were selected, and then 10 percent of the farmers were selected randomly to give a total of 240 farmers

2.4 Collection of data

Primary data was collected from 240 sorghum farmers from Adamawa state, Nigeria. The main instrument that was used for collecting the data was structured schedule. Simple random sampling and purposive sampling techniques were used at various stages as the selection procedures in the selection of 240 respondents.

2.5 Analytical tools

The inferential statistics (the stochastic frontier production model) was used.

2.6 The Empirical Stochastic Frontier Production Model

The stochastic frontier production function used in this study was specified as follows:

$$\text{Log}Y_i = B_o + B_1\log X_1 + B_2\log X_2 + B_3\log X_3 + \ldots\ldots\ldots\ldots B_6\log X_6 + V_i - U_i \qquad (5)$$

Where
Y = Output of sorghum (kg)
X_1 = Farm size (hectares)
X_2 = Quantity of fertilizer applied (kg)
X_3 = Quantity of sorghum seed planted (kg)
X_5 = Quantity of herbicides used (litres)
X_5= Amount of family labour used (man-days)
X_6 = Amount of hired labour used (man-days)
X_7 = Expenses on ploughing (tractor and animal traction)
V_i = Random noise (white noise) which are $N(0,\delta^2, V)$
U_i = Inefficiency effects which are non-negative, half normal distribution $N(0,\delta^2, U)$

Operational definition of the variables of empirical stochastic production function for Sorghum Production is as follow:

i. **Output of Sorghum farmer:** This is the total yield obtained per hectare by farmers in kilogram equivalent weight.
ii. **Farm size:** This is the size of land used in producing Sorghum crop by the farmers. It is measure in hectare.
iii. **Quality of fertilizer:** This refers to the quantity of fertilizer use in kilograms.
iv. **Quantity of Seed:** This refers to the quantity of seed in Kilogram equivalent weight used for planting by the farmers.
v. **Herbicide:** this refers to the quantity of herbicide used in litres.
vi. **Family labour:** This is the total man days of labour per hectare supplied by house hold during the farm operation. The standard man day is 8 hour per day.
vii. **Hired labours:** this is the total man-days of paid labour per hectare
viii. **Expense on ploughing:** This is the expenses paid on ploughing the land either with tractor or animals.

The technical efficiency of sorghum production for i^{th} farmers, defined by the ratio of observed product as to the corresponding frontier production associated with no technical inefficiency, is expressed by;

$$TE = \text{Exp}(-U_i) \text{ so that } O \leq Te \leq 1 \qquad (6)$$

Variance parameters are δ^2 =

$$\delta^2_V + \delta^2_U \text{ and } \gamma = \delta^2_U / \delta^2 \qquad (7)$$

So that $O \leq \gamma \leq 1$

The inefficiency model is defined by,

$$U_i = \delta_o + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_5 Z_5 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 \qquad (8)$$

Where,
U_i = inefficiency effect

Z_1 = Age of farmer (in years)
Z_2 = Literacy level (in years)
Z_3 = Farming experience (in years)
Z_5 = Extension contact (1 contacted, 0 otherwise)
Z_5 = Gender of the farmer (1 female and 0 for female)
Z_6 = Family size (total number of person in household)
Z_7 = Access to formal credit (binary)

The operational definition of the empirical inefficiency parameter of the stochastic frontiers for Sorghum Production is given as:

i. **Age:** This is the age of individual farmers involved in the farm operation.

ii. **Literacy level:** This is measured as the numbers of years put in by farmers to acquired basic formal education. Specifically 'O' years denotes no formal education: 6 years denote primary education. 12 years denote secondary education. 15 years denote diploma and NCE holder: while greater than 15 years denotes graduates.

iii. **Farmer experience:** This is measured as the number of years that farmers have been into Sorghum production.

iv. **Extension contact:** This measures the frequency of meeting between the farmers and extension workers during the last cropping seasons.

v. **Family Size:** This is the numbers of house hold member who have attained the age of 15 years and above that are available for farm operation.

vi. **Access to Credit:** This is a measure as the farmers accessibility to credit facilities to finance their who have accessed credit facilities and "O"

δ^2, δ_o, γ, βs are unknown parameters that were estimated. The maximum likelihood estimate (MLE) for all the parameters of the stochastic frontier production function and the inefficiency model defined above and the technical efficiency was obtained using the Frontier

3. RESULTS AND DISCUSSION

Table 1 Maximum Likelihood Estimate of the Cobb-Douglas Stochastic Frontier Production Function Model

Variable	**Parameter**	**Coefficient**	**t-ratio**
Variable	**Parameter**		
Production factors			
Constant	β_0	2.8465***	9.7321
Farm size (X1)	β_1	0.2152***	3.3895
Labour (X2)	β_2	0.1952**	2.1981
Seed (X3)	β_3	0.2061**	2.3258
Fertilizer (X4)	β_4	-0.0091	-0.5849
Chemicals (X5)	β_5	0.0490	1.4212
Diagnostic statistics			
Sigma squared (d^2)		0.6688***	5.2574
Gamma (ϒ)		0.4530***	0.1368
Inefficiency effects			
Gender	d_1	-0.1683***	-2.7568
Marital status	d_2	-0.0220	-0.4301
Age	d_3	-0.1947**	-2.1432
Family size	d_4	-0.0087	-0.0447
Education	d_5	-0.1692***	-2.7431
Farming experience	d_6	-0.0751	-0.4737
Credit	d_7	-0.2271***	-0.3458
Extension visit	d_8	0.0188	0.2704

*** Estimates are significant at1% level,
** Estimates are significant at 5% level.
*Estimates are significant at 10% level

The maximum likelihood estimates of the stochastic frontier production function and inefficiency model results are presented in Table 1. The estimate for parameters of the stochastic frontier production function indicates that the elasticity of output with farm size was positive, approximately 0.2152. They were all statistically significant at 1 % level.

This implies that a one percent increase in area under sorghum production will raise output of sorghum by 0.2152%. This shows that land is a very important factor in sorghum production both in India and Nigeria. This finding is at tandem with the findings of; Maurice *et al.,* (2005); Odoh and Folake (2006) Gwandi et al(2010) ; Ibrahim et al (2014);Zalkuwi et al(2014), that land has positive sign and statistically significant.

The significance of labour in the study area cannot be over-emphasized as the coefficient of labour was (0.195), are significant and positively related to sorghum output. This means that an increase in man days of labour by 1% would increase sorghum output by 0.20%. The implication of this is that respondents with relatively large household size have the potential to increase their total farm output in that labour needed for the execution of important farm operations such as weeding is not expected to be a limitation. Also, farmers whose main objective is household food security would be more concerned with maximizing their output per unit of resource used, especially family labour; that is, they tend to emphasize technical efficiency (Amaza *et al*., 2006).

seed was an important factor in sorghum production, with Seed input having an elasticity coefficient of 0.2061 and positively related to total output of sorghum in the study area. This shows that a 1% increase in quantity of seeds used in production would increase output of sorghum by 0.2061%. By implication, raising the productivity of seed is expected to translate into a more than proportionate increase in the output of sorghum per hectare. This agrees with Olayide and Heady (1982) who stated that agricultural productivity can be increased through increase in the quantity of a particular input, or increase in the productivity of input, or a combination of both. So seed is a very important factor of production. The significant and positive sign of seed variable also indicated that a moderate increase in population of sorghum on the field will increase the yield provided that, the farm is not over populated beyond the recommended sorghum ration or mixture ratio capacity that will lead to competition for nutrients which will lower the yield. This finding is in consonance with the work of Shehu *et al.* (2007a) ; Ogundari (2008) ;Zalkuwi et al (2014) and Ibrahim et al (2014), who found that seed is an important factor in production

The production elasticity of fertilizer was -0.0091, it was not statistically significant, the insignificance of fertilizer use may be due to the good and fertile nature of the soil of the area which makes farmers to cultivate without much need for fertilizer. This has also encouraged more farmers in the study are to shift much of their attention to sorghum cultivation, since access to fertilizer has become prerogative of the few elite and politically connected farmers. This study is in harmony with the finding of Zalkuwi (2013)

The production elasticity for chemical was 0.0490 and was not significant This might be because of the technicality involved in using chemicals in multi-cropping system, so it requires skills. The above result reveals that the important factors of sorghum production are land, labour and seed

The estimated gamma parameter (γ) is 0.4530 and also significant at 1% level, indicating that 45% of the variation in the total output of production among the sampled farmers is due to differences in their technical efficiencies in India and Nigeria respectively. The estimated sigma square (δ^2) was (0.6688) and significantly different from zero at 1% level. This indicates a good fit and the correctness of the specified distributional assumption of the composite error

The inefficiency parameters include gender, marital status, age, family size, education, farming experience, credit, and extension agent. The inefficiency parameters are specific as those relating to farmers specific socio-economic characteristics and were examined by using the estimated d̀ coefficients. According to Adebayo, (2007), a negative d̀ coefficient indicates that the parameters have a positive effect on efficiency and vice versa.

The coefficient of gender is estimated to be negative and statistically significant at 1% level. This implies that increase in the gender by one unit will increase the efficiency of the farmers; this implies that increase in family size by one unit (Adult male) will increase the efficiency of the farmer

The coefficient of marital status is estimated to be negative and insignificant

The coefficient of farming experience is negative but insignificant, meaning that as the farming experience of sorghum farmers in the study area decreases, their technical inefficiency will decrease. This is in harmony with the study Zalkuwi (2013)

The coefficient of education variable is estimated to be negative and statistically significant at 1% level. This implies that farmers that are literate tend to be more efficient in agricultural production; this is due to their enhanced ability to acquire technical knowledge, which enhances their Agricultural productivity. It is plausible that farmers with education respond easily to the use of improved technology. This finding agrees with the study of shehu *et al.,* (2007) as cited by Maurice (2012) who also found a positive relationship between education and technical efficiency.

The coefficient of the extension variable is estimated to be positive and insignificant. This implies that increased extension visits do not accord the farmer the opportunity to learn new improved technologies and how to acquire the needed inputs and services.

The coefficient of age is significant at 5% level and positively influences farmers' likelihood to practice crop diversification, indicating that older farmers are more likely to practice or adopt crop diversification than younger farmers. Entrepreneurial ability and farm management skills increase with experience which is a function of age. Older farmers are more likely to perceive, interpret and respond to new innovation in the context of risk management than younger farmers.

Table 2 Technical Efficiency Rating of the Sorghum Farmers

Efficiency	**Frequency**	**Percentage**
<0.40	2	0.8
0.40 – 0.49	12	5.0
0.50 – 0.59	24	10.0
0.60 – 0.69	22	9.2
0.70 – 0.79	64	26.7
0.80 – 0.89	78	32.5
0.90 – 1.00	38	15.8
Total	240	100
Minimum efficiency	0.353	
Maximum efficiency	0.964	
Mean efficiency	0.775	

Source: Computed from Stochastic Frontier Result

The technical efficiency in Table 2 was derived from MLE result of the stochastic production function. The result shows that the TE of the respondents was less than 1 (100 %) hence the variation in TE exits among respondents. It means that, all the respondents produced below maximum efficiency. The minimum efficiency in India was 0.2864, while their maximum efficiency was 0.9350; and their mean efficiency were 0.6774. The distribution of the farm efficiency for sorghum production shows that, majority (69 %) of them operated above 59 % of their maximum efficiency and 31 % operated below 59% while the distribution of technical efficiency of the farmers in Nigeria reveals that about 6% had technical efficiency of less than 50 percent, while about 19% had technical efficiency of 50-69 percent, 75% of the respondents had technical efficiency of 70% and above. The magnitude of the mean technical efficiency of the farmers is a reflection of the fact that most of the sampled farmers carry out sorghum production under technical conditions, involving the use of inefficient tools, local seed varieties and so on.

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