Identification Of Factors That Influence Technical Efficiency Of Cash Crops Production (Sesame And Groundnut) In North Kordofan State, Sudan

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Abstract: This paper was aimed to measure technical efficiency and identifies eeficiency determinants in groundnuts and sesame crops production in rainfed sector area of North Kordofan State of Sudan. Random sampling technique was used to select 205 crop farmers from which input-output data were collected based on 2011-2012 cropping season. Technical efficiency has been estimated using stochastic frontier production function analysis. The results revealed that the technical efficiency of crop production range from 3% to 100% with mean of 40% for groundnuts, and from 11% to 100% with a mean of 84% for sesame. The average technical efficiencies indicate that there are scopes for increasing groundnuts and sesame production by 60% and 16%, respectively, from a given mix of production inputs via adopting the existing technologies used by the more efficient farmer's. Also the results indicate that farmers in North Kordofan state are more efficient in technology and resources utilization for sesame production compared to groundnut. Contrary to expectations, all the inefficiency model parameters for both sesame and groundnut production were found to be insignificant with exception of the framer age for sesame crop. It could be concluded that there is a possibility of technical gain from enhancing sesame and groundnut farmers' technical efficiency in the study area.

Index Terms: Technical Efficiency, Production inefficiency, Groundnut, Sesame, Stochastic Frontier, North Kordofan, Sudan.

1 Introduction

Rainfed agriculture produces much of the food consumed globally and by poor communities in developing countries. It accounts for more than 95% of farmed land in sub-Saharan Africa; 90% in Latin America; 75% in the Near East and North Africa; 65% in East Asia; and 60% in South Asia [1]. In several regions of the world rainfed agriculture generates the world's highest yields. These are predominantly temperate regions, with relatively reliable rainfall and inherently productive soils. Even in tropical regions, particularly in the sub-humid and humid zones, agricultural yields in commercial rainfed agriculture exceed 5–6 t/ha [2], [3],[4], [5]. The agricultural sector is the core of Sudanese population and the primary source of livelihoods for a majority of its citizens. The Sudanese economy is predominately rural with 70 percent of the population deriving their livelihoods in rural areas. The agricultural sector contributes one third to GDP and about 80% to labor force [6].

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In Sudan the traditional rain-fed agriculture is one of the three major production systems in Sudan, representing more than 50% of the national cultivated land. This sector is characterized by small holdings, manual farming operations, little or no external inputs, limited farmers' resources and low and erratic rainfall. Traditional rain-fed crop production is predominant in western Sudan, southern Sudan and over vast areas in Gezira, Sennar, Blue Nile, White Nile, Kassala and Red Sea States. The average contribution of this sector to the national total production of millet, sorghum, sesame and groundnut is about 93%, 27%, 39% and 60%, respectively [7]. According to Ahmed and others the economy of Northern Kordofan state is based on agricultural production, which is mainly traditional rain-fed crop farming. The main staple food crops grown are millet and sorghum, while the main cash crops are sesame and groundnut. Forest products include Gum Arabic, fuel wood, charcoal, and construction materials [8]. Livestock keeping is also practiced in villages where they raise camel, sheep, goat and cattle. Milk and milk products made locally specially by rural women are sold in the nearby markets as means of income generation activities [8]. Among the main cash crops produced in the North Kordofan area are groundnut, sesame and rosella. Groundnut and sesame are mainly used for oil production [9]. The main aim of this paper was to measure groundnut and sesame technical efficiency, identifies technical inefficiency determinants and to quantify the technical gain from enhancing the technical efficiency of sesame and groundnut farmers in rainfed sector area of North Kordofan State of Sudan.

2 Methodology

2.1 Data collection

This study depends on both primary data and secondary data. The sources of secondary data include reports from relevant institutions and references. While the primary data were collected from a sample of 205 farmers. Those farmers were selected from four localities in North Kordofan state using random sampling technique.

2.2 Method of data analysis

2.2.1 Stochastic Frontier Production Functions:

Technical efficiency is defined as the ability to produce a given level of output with a minimum quantity of inputs under certain technology. Early studies focused primarily on technical efficiency using a deterministic production function with parameters computed using mathematical programming techniques. However, with inadequate characteristics of the assumed error term, this approach has an inherent limitation on the statistical inference on the parameters and resulting efficiency estimates. Aigner, Meeusen, Van den Broeck and Forsund independently developed the stochastic frontier production function to overcome this deficiency[10], [11],[2] .

2.2.2 Model Specification:

The stochastic frontier production function model for estimating farm level technical efficiency is specified as:

$$\ln Y_i = f(X_i;\beta) + \varepsilon_i \qquad (1)$$

Where

i= 1,2,……..n

$\ln Y_i$ is the logarithm of output, X_i denotes the actual input vector, β is vector of production function and ε is the error term that is composed of two elements, that is:

$$\varepsilon_i = V_i - U_i \qquad (2)$$

Where v_i is the symmetric disturbances assumed to be identically, independently and normally distributed as N (0, $\sigma^2 v$) given the stochastic structure of the frontier. The second component ui is a one-sided error term that is independent of v_i and is normally distributed as (0, $\sigma^2 u$), allowing the actual production to fall below the frontier but without attributing all short falls in output from the frontier as inefficiency

2.2.3 Model building

The explicit Cobb-Douglas stochastic frontier production function for estimating farm level technical efficiency is specified as:

$$\ln y_i = \beta_0 + \sum_{j=1}^{8} \beta_j \ln x_{ij} + v_i - u_i \qquad (3)$$

Where:

ln = the natural logarithm; Yi = total output in kantar; X_1 = farm size under groundnut and sesame crops (feddan); X_2 = number of sowing; X_3 = number of weeding; X_4 = amount of labor (man-day); X_5 = quantity of seeds kg/ fed; X_6 = quantity of rainfall (dummy) 1 = sufficient, 0 = not sufficient; X_7 = fertilizer applied in kg/fed; and X_8 = pesticides applied in kg/fed. v_i account for the effect of measurement errors on the production variable y, and the combined effect of the omitted explanatory variables [13],[14]. The presence of the vi indicate that the output vary randomly across the farms or over time for the same farm [10]. ui is a non-negative random variable, represents the technical inefficiency term, associated with technical inefficiency of the farmers in the sample. It is assumed to be independently distributed by truncation at zero of the normal distribution with the mean μi, and the variance δ^2. The level of inefficiency model of the farmers in traditional rainfed sector in term of other explanatory variables will be specified according to Battese and Coelli [15], where μi , mean of technical inefficiency term. the inefficiency model can be written as:

$$\mu_i = \sum_{s=1}^{8} \delta_{si} \ Z_{si} \qquad (4)$$

Z_{1i} = age of farmers; Z_{2i} = farming experience (years of active farming); Z_{3i} = sex (dummy) 1= male, 0= female; Z_{4i} = educational level of farmers (years spend in school); Z_{5i} = marital status of farmers; Z_{6i} = household size (number); Z_{7i} = credit access (dummy) 1= Access, 0 = no access; Z_{8i} = extension services contact (dummy) 1 = contact, 0 = non-contact; δo and δs coefficient are unknown parameters to be estimated, together with the variance parameters which are expressed in terms of $\sigma^2 = \sigma^2 u + \sigma^2 v$ and $\gamma = \sigma^2 u / \sigma^2$, Where the γ-parameters has value between zero and one. If γ has a value of one this will indicate that differences in farmers output due to technical inefficiency. A value of zero for, γ, indicates that the differences mainly due to statistical errors [16].

3. Result and Discussion:

3.1 Stochastic Production Function Results

The maximum likelihood parameter estimates of the stochastic production function were obtained using FRONTIER 4.1 [17] and the results were presented in Table 1. Table (1) illustrated the results of groundnuts and sesame maximum-likelihood estimate for the parameters of the stochastic frontier production function and technical inefficiency effect model. The technical efficiency is computed for each crop according to stated equations on Frontier 4.1 program. As shown in Table (1) the mean technical efficiency for groundnuts and sesame were 0.40 and 0.84, respectively. This means, there are ranges for increasing groundnuts and sesame production by 60% and 16% respectively, from a given mix of production inputs if the farmers are technically efficient. In other words, on average, about 60 % and 16 % of production are lost due to technical inefficiencies. Sesame mean technical efficiency (84%) exceeds that of groundnut (40%) in the study area. This result indicates groundnuts farmers in North Kordofan state are more efficient in technology and resources utilization for sesame production compared to groundnut production. The value of γ = 0.99 and is statistically significant implies that all of the residual variations is due to the inefficiency effect. This implies that the inefficiency effects are significant in determining the level and variability of outputs of crops producers in the study area. These results express that about 99% of groundnuts and sesame output are explained by inefficiency. The significant estimates of γ and δ^2s imply that the assumed distribution of ui (truncated) and vi (normally) is accepted. This result is consistent with others researchers findings that imply that the conventional production function is not an adequate representation of the data [13], [16], [17],[18], [19]. The coefficients of the estimated parameters showed different signs and level of significance for both sesame and groundnut production in study area. While some parameters proved to be insignificant for both crops. For instance, amount of seeds (kg), rainfall sufficiency and pesticides application are the groundnut insignificant hypothesized variables. . Whereas the number of weeding, number of labor in man-days, amount of seeds were found to have no significant effect on sesame productivity in North Kordofan State. The estimated coefficients of farm area were found to be positive and significant at 1% level of significant for groundnuts and sesame. This result is in line with the findings of Gabriel, in study of resource use efficiency in urban farming in Nigeria: an application of stochastic frontier production function [20]. The results revealed that in North Kordofan State sesame and ground productivity has a positive relation with holding size. This could be attributed to the fact that farmers with large holding have access to formal and informal finance than small holding famers. The obtained result is in contrary to that of Chirwa and others in a study of maize production in Malawi using a national survey data, where a negative relationship between local maize yield and land holdings was found [21]. The number of sowing coefficient was found to be significant for

Table 1: Maximum-likelihood Estimate for the Parameters of the Stochastic Frontier Production Function and Technical Inefficiency Effect Model

Crops		Groundnut	Sesame
Variables	Parameter	Estimate	Estimate
Constant	β_0	0.300 (0.773)	0.478 (0.511)
Area (fed)	β_1	2.0288*** (0.503)	1.0413*** (0.153)
Sowing	β_2	1.925** (0.891)	-0.845* (0.444)
Weeding	β_3	2.102**	0.668 (0.8134)
Labor (man-day)	β_4	-3.300*** (0.963)	0.393 (0.561)
Seeds/kg	β_5	0.462 (0.309)	-0.321 (0.235)
Rainfall	β_6	-0.0326 (0.638)	0.0168 (0.635)
Fertilizer/kg	β_7		-4.598*** (0.986)
Pesticides/kg	β_8	0.537 (0.779)	-0.00053 (0.0188)
Inefficiency Model			
Constant	δ_0	-0.061 (0.917)	-0.0893 (0.968)
Age	δ_1	-0.0132 (0.0521)	0.0345** (0.968)
Experiences	δ_2	0.0284 (0.087)	-0.0319 (0.0418)
Sex	δ_3	-0.068 (0.890)	-0.385 (0.921)
Education	δ_4	0.147 (0.841)	-0.00245 (0.418)
Marital status	δ_5	0.0583 (0.972)	-0.0119 (0.864)
Household size	δ_6	0.1778 (0.491)	0.263 (0.209)
Credit	δ_7	-0.089 (0.755)	-0.580 (0.829)
Extension	δ_8	-0.0566 (0.837)	-0.737 (0.709)
Sigma-squared	$\sigma_s^2 = \sigma_v^2 + \sigma^2$	1.383* (0.727)	0.204** (0.0717)
Gamma	$\gamma = \sigma^2 / \sigma_s^2$	0.999*** (0.00007)	0.999*** (0.00040)
Mean efficiency		0.40	0.84
Log likelihood function		-213.89	280.49

***, ** and * asterisks on the value of the parameters indicate its significant at 1,5, and 10 percent level of significance respectively. The estimated standard errors are presented in parenthesis bellow the corresponding parameter estimate both sesame and groundnut at 10 and 5% level of significant, respectively. However the coefficient sign was negative for sesame and positive for groundnut. Negatively significant parameter of sowing means that sesame productivity increases with decrease in number of sowing. The possible justifications of this inverse relationship could attributed to the fact that as number of sowing increased, differences in reaching the harvesting time is there and sesame crop is very sensitive to harvesting time. Any delay in the harvesting process will lead to a great loss in yield due to shattering process. A positive relationship between groundnut yield and number of sowing was found. The reasons for this positive relationship among others will include: (1) re-sowing of groundnut will result in good established of the vegetative stage and hence higher productivity will be achieved as the crop is not so sensitive to harvesting time and (2) In the study area groundnut produced under rainfed conditions, during which the crop may subjected to flood and/or rainfall shortage during the sowing and seed germination periods. This may result in poor germination and hence re-sowing will be inevitable. Weed growth restrict the crop production as it negatively influence crop yield, quality and increase production costs. This implies a positive relationship between the number of weeding and crops productivity and quality, given the weed threshold for weeding process for the different crops. Crops weedings number depend in many factors, among which are: type of crop, weed and soil; sowing method and the environmental conditions Weeding parameter was found to be positively significant for groundnut and insignificant for sesame production. This could be attributed to the differences in sowing type and crop population density. Sesame crop sown using either broadcasting or raw planting method, which will result in a higher population density compared to groundnut. According to Dayal, weed causes much damage to the groundnut crop production during the first 45 days of its growth. The most critical period for weed competition is from the third week to six week after sowing. The average yield loss due to weed was estimated to be about 30% and it reached 60% under poor management situation [22]. The labour coefficient was found to be negative and significant at 1% level of significance for groundnut and not significant for sesame production. Amount of fertilizer coefficient was statistically significant at 1% level of significance for sesame production.

3.2 Inefficiency Model Results

Worldwide many researchers have identified different factors which are associated with production technical inefficiency level. These factors among others include, years of schooling land size [19],[23],[24],[25],[26],[27]; family size and per capita net income [23]; education of farmers and hours of extension among farmers [28],[29]. The effect of socio-economic characteristics for technical inefficiency model was studied and analyzed according to their coefficients' value and signs. A negative sign indicates a reduction in technical inefficiency which means an increase technical efficiency and the reverse is true for the parameters with positive signs. As depicted in Table (1), the value of parameter γ = 0.99 and is statistically significant implying that all of the residual variations is due to the inefficiency effect. However and contrary to expectations, all the inefficiency model parameters for both sesame and groundnut production were found to be insignificant with exception of the framer age for sesame crop. The results revealed a negative relationship between the farmer's age and sesame productivity under rainfed condition in North Kordofan State.

3.3 Distribution of Farmers According to the Technical Efficiency level

The distribution of farmers' technical efficiency and inefficiency effect model indices derived from the analysis of the stochastic production function was presented in Table 2. The percentage distribution of technical efficiency reveals that groundnut and sesame farmers' technical efficiency varied between 3% -100% with a mean of 40% and 11% - 100% with a mean of 84%, respectively. The picture that emerges from the analysis is one of the a generally high technical efficiency in traditional rainfed sector farming in study area as most of the farmer 87.6% produce above 50% efficiency index for sesame crops, while 56.2% of farmer produce below 50% efficiency index for groundnuts crop. This result provides information for decision makers and helps them to investigate the main factors behind technical inefficiency and to design policies to improve farms technical efficiency. The distribution of the technical efficiency suggests that potential gain in technical efficiency among the sample farmers is large.

Table 2: Distribution of the sesame and groundnut farmers according to the level of efficiency

Efficiency level	Groundnut	Sesame
20-10	29.6	2.43
30-20	4.87	4.87
40-30	21.91	4.87
50-40	7.31	0
60-50	21.7	2.43
70-60	4.87	4.87
80-70	0	7.32
90-80	4.87	4.87
100-90	4.87	68.29

3.4 Technical Inefficiency Hypotheses Testing:

As shown in Table 3, the test of hypotheses of groundnut and sesame likelihood ratio test (LR), which test the null hypothesis for the technical inefficiency effect for crops production in North Kordofan state is rejected. The value of the test is calculated as:

$$LR = -2\{\ln[L(H_0) / L(H_1)]\} = -2\{\ln[L(H_0)] - \ln[L(H_1)]\}$$

Where L (H_0) and L (H_1) are the values of the likelihood function under the null hypothesis and alternative hypothesis, respectively [16],[17], [30]. Table 3, reveals that there are significant technical inefficiency effects, groundnut and sesame production, because the null hypotheses Ho are fully efficient given the specification of (SPF) in Cobb-Douglas form. Then the (H_0: $\gamma = \mu = 0$): null hypothesis are rejected. To test the first null hypothesis, a nested hypothesis is performed to determine whether the Cobb-Douglas specification is an adequate representation of the frontier production function. This test uses the log Likelihood ratio test. Table outlines the results of the null hypothesis. The null hypothesis, H_0=β_{ik}= 0 is rejected in favor of the production function. The second null hypothesis explores the test that specifies each farm is operating on the technically efficient frontier and that the systematic and random technical efficiency in the inefficiency effects are zero. This is rejected in favor of the presence of inefficiency effects. The final null hypothesis determines whether the variables included in the inefficiency effects model have no any effect on the level of technical inefficient, the null hypothesis is rejected confirming that the joint effect of these variables on technical inefficiency is statistically significant

Table 3: Groundnut and sesame models, test of hypotheses for the parameters of stochastic frontier production function and inefficiency effect model

	Model Groundnut	Sesame	Decision
H_0=β_{ik}=0	213.9***	42.5***	Ho: Rejected
H_0: $\gamma = \mu = 0$	1.9*	2.8**	Ho: Rejected
LR H_0: No Technical inefficiency	66.1	280.5	Ho: Rejected

***, ** and * asterisks on the value of the parameters indicate it is significance at 1, 5 and 10 percent level, respectively

4 Conclusion and Recommendations

The objectives of this manuscript are to measure groundnut and sesame technical efficiency, identify technical inefficiency determinants and quantify the technical gain from enhancing the technical efficiency of sesame and groundnut farmers in rainfed sector area of North Kordofan State of Sudan. The study used the stochastic frontier analysis model to estimate technical efficiency and inefficiency determinants. The results revealed that the mean technical efficiency was found to be 40 for groundnut and 84% for sesame production. Also, the study found that farm size; number of sowing, number of weeding, fertilizer; labor of farmers is the major factors that are associated with changes in sesame and groundnut yield. The policy implication of the study is that technical efficiency in both cash crops production could be increased by 60% for groundnuts and 16% for sesame through improved use of available resources, given the current state of technology. This can be achieved through improved farmer specific efficiency factors, which include improved farmer education, access to credit, access to improved extension services and less crop diversification. If the government and the farmers address the inefficiency determinants sesame and groundnut production will be maximized in the rainfed sector in North Kordofan state.

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