Analysis of Technical and Allocative Efficiencies of Groundnut Producers in Benue State, Nigeria

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Abstract
Despite the recognized need for efficiency improvements in agricultural production, there is a paucity of empirical studies focusing on the dual dimensions of technical and allocative efficiencies among groundnut producers in Benue State, Nigeria. Thus, this study analyzed the technical and allocative efficiencies of groundnut producers in Benue State, Nigeria. The study utilized data collected from 180 groundnut farmers from three local government areas of the State using multistage sampling technique. The collected data were analysed using descriptive statistics and stochastic production and cost functions. The findings revealed that the mean technical and allocative efficiencies of groundnut farmers in the study area were 0.68 and 0.99 respectively and that these farmers could improve input use by 32% to operate at the production frontier and save up to 0.8% of input costs by adopting cost-minimizing strategies while maintaining the same output levels. Analysis of results also showed that the cost of herbicides increases production costs by 0.054% and reduces groundnut output by 0.0027% while costs of fertilizer, seeds, pesticides, dressing, empty bags, and transportation contribute to production cost increases by 0.16%, 0.023%, 0.047%, 0.059%, 0.037%, and 0.16%, respectively. The study further revealed that educational attainment and extension service contact reduce technical inefficiency among farmers, whereas years of farming experience exacerbate allocative inefficiency. It was recommended that the use integrated pest and fertilizer management practices be promoted so as to minimize the overuse of herbicides, pesticide, and fertilizer among groundnut farmers; and groundnut farmers in the State should seek more affordable sources for inputs through bulk purchasing or cooperative arrangements; and that Benue State government should strengthen groundnut farmers' access to extension services, and encourage continued education among them.
Key words: *Technical Efficiency; Allocative Efficiency; Groundnut Producers; Benue State; Nigeria*

Introduction

Groundnut (*Arachis hypogaea*) is considered a critical legume crop cultivated across many regions in Nigeria (Gabasawa *et al*., 2017), serving as a source of food, income, and raw materials for industries in the country. Groundnut production plays a pivotal role in the livelihoods of smallholder farmers in Benue State, Nigeria, contributing to household food security and income generation. Despite this economic and nutritional significance of groundnut in Benue State, Ani et al. (2013) reported that the productivity and efficiency of groundnut farming in the State remain below optimal levels. Therefore, insight into the factors affecting production efficiency is crucial to addressing the challenges faced by groundnut farmers in the country.

Technical and allocative efficiencies are two critical dimensions through which efficiency in agricultural production is often analyzed. According to Felix *et al*. (2024), technical efficiency refers to a farmer's ability to maximize output given a set of inputs, while allocative efficiency reflects the ability of a farmer to use inputs in proportions that maximize production costs (Shanmugam and Venkataramani, 2006). For smallholder farmers who often operate under resource constraints, improving these efficiencies is important in enhancing their productivity.

The socio-economic characteristics of farmers such as their age, education, farm size, access to credit, and farming experience, are widely recognized as influential factors in agricultural productivity and efficiency. For instance, Ogunniyi *et al*. (2012) revealed that access to education and extension services enhance farmers' decision-making abilities and adoption of improved farming techniques. Similarly, Okeke *et al*. (2019) and Salisu *et al*. (2024) showed the link between gender, household size, and marital status to resource use and efficiency levels in agricultural production. However, the extent to which these socio-economic characteristics affect technical and allocative efficiencies in groundnut production remains unclear in the context of Benue State.

Previous studies on efficiencies of groundnut production in Nigeria include but not limited to Ani *et al*. (2013) that examined the profitability and economic efficiency of groundnut production in Benue State; Onuwa *et al*. (2022) that investigated groundnut productivity and return to scale among smallholder farmers in Plateau State; and Salisu *et al*. (2024) that explored economic efficiency of groundnut production in Kano State. Yet, there is limited empirical evidence on how socio-economic variables shape efficiency levels in groundnut production, particularly in Benue State. This gap thus underscores the necessity of this study, which sought to evaluate the technical and allocative efficiencies of groundnut farmers while exploring the influence of their socio-economic characteristics on these efficiencies.

Methodology

The Study Area

The study was conducted in Benue State, Nigeria. The State is located in the north central region of Nigeria, which is the transition zone from the northern and southern ecologies. It lies between longitudes $6^{0}31$'E and 10^{0}E and between latitudes $6^{0}30$'N and $8^{0}10$N (Benue Agricultural and Rural Development Authority, BNARDA, 2015).

The State has favorable agro-climatic ecologies for arable crops, tree crops and livestock production and enjoys two distinct seasons; rainy season, beginning from April to October and dry season, from November to March. Annual rainfall records vary from 1700mm in the southern part to 1250mm in the northern ecology of the state with annual temperature variations of 30^{0}C and 35^{0}C (Benue Agricultural and Rural Development Authority, BNARDA, 2015).

Population of the Study

The population for this study consisted of 1800 smallholder groundnut farmers from Oju, Konshisha and Guma Local Government Areas (BNARDA, 2015).

Sampling Technique and Data Collection

The study adopted purposive and multi-stage sampling technique to select a sample of 180 groundnut farmers randomly selected form Konshisha, Guma, and Oju LGAs. Structured questionnaire was used for the data collection.

Analytical Techniques

The Stochastic Frontier Production Function Specification

The stochastic frontier production function was specified as follows:

$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + V_i - U_i$…………(1)

Where,
Y = Groundnut output (kg)
$\ln$ = natural logarithm
β_0= constant term or intercept
X_1=farm size (ha)
X_2= single super phosphate (Naira)
X_3=nitrogen phosphate potassium (Naira)
X_4=urea (Naira)
X_5=seeds (Naira)
X_6=herbicide (Naira)
X_7=pesticide (Naira)
$\beta_1 - \beta_2$= the regression coefficients
V_i = random error term
U_i = technical inefficiency effect predicted by the model

The stochastic frontier cost function estimation

The Cobb-Douglas type frontier cost function was specified as follows:

$\ln C = \alpha_0 + \alpha_1 \ln F_i + \alpha_2 \ln S_i + \alpha_3 \ln H_i + \alpha_4 \ln P_i + \alpha_5 \ln D_i + \alpha_6 \ln B_i + \alpha_7 \ln T_i + V_i + U_i$ …………………… (2)

Where:
C = total cost (Naira)
α_0 = intercept
F_i = fertilizer cost (Naira)
S_i = seed cost (Naira)
H_i = herbicide cost (Naira)
P_i = pesticide cost (Naira)
D_i = dressing cost (Naira)
B_i = empty bags cost (Naira)
T_i = transportation cost (Naira)
$\alpha_1 - \alpha_7$ = regression coefficients
V_i = random error term
U_i = technical inefficiency effect predicted by the model

The technical and allocative inefficiency effects specification
The inefficiency effect (U_i) was specified as follows:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where,
U_i = technical inefficiency effect
δ_0 = constant or intercept
$\delta_1 - \delta_8$ = scalar parameters estimated
Z_1 = Age (years)
Z_2 = Marital status (single = 0, married = 1)
Z_3 = Household size (number)
Z_4 = Sex (male =0, female = 1)
Z_5 = Educational level (years)
Z_6 = Membership of cooperative (member = 0, non-member = 1)
Z_7 = Extension contact (had contact = 0, no contact = 1)
Z_8 = Experience (years)

Results and Discussion

Distribution of the Technical Efficiency Estimates of Groundnut Producers

The distribution of groundnut producers' technical efficiency is presented in Table 1. The technical efficiency of the sampled groundnut farmers was less than 100% (or 1) indicating that the entire groundnut producers were operating below frontier. The least efficient groundnut farmers in the study area was 63% inefficient (37% efficient), while the most efficient farmer was 0% inefficient (i.e. 100% efficient). On the average, the groundnut producers were 32% inefficient (68% efficient). This implies that 32 % of the value of revenue from the farm is lost due to inefficiency. Distribution of efficiency groups showed that most (61.1%) of the groundnut producers had efficiency level greater than or equal to 70%. This is in consonance with Udoh and Falake (2006) that used the stochastic function to estimate output oriented technical inefficiency of crop mix of farmers in Odukpani Local Government area of Cross River State, Nigeria, and reported a mean output-oriented efficiency of 73%.

The most efficient farmer has technical efficiency of 0.99 or 99%, household size of 4, and active age of 39 years, and had frequent contact with extension agent. He had 12 years of farming experience, higher educational background, higher annual income of ₦500000 and was a member cooperative society for the past 10years. These qualities made him to stand out from every other farmer and achieved higher level of technical efficiency in groundnut production in the study area.

Table 1: Distribution of the Technical Efficiency Estimates of Groundnut Producers (n = 180)

Efficiency class	Frequency	Percentage (%)
≤ 0.5000	59	32.8
0.5001 -0.7000	11	6.1
≥0.7001	110	61.1
Mean Efficiency	0.68	

Minimum	0.37
Maximum	1.00

Source: Field survey data, 2023.

Estimation of Stochastic Frontier Production Function

The maximum likelihood estimates of parameters in stochastic frontier function are presented in Table 2. The elasticity parameters are contained in the upper segment of the table while the determinants of inefficiency are contained in the lower segment of the table. The significance of the estimates of gamma (γ) (0.99) at 1 % level showed that the inefficiency effects jointly estimated with the production frontier function were not simply random errors. This implied that socio-economic characteristics had significant influence on efficiency of groundnut producers in the study area.

The value of sigma squared was 0.41 and statistically significant at 1 % level of probability indicating a good fit and correctness of the distribution. It also implies that the Cobb Douglas stochastic production frontier is the adequate representation of the data.

The estimated elasticity parameter for farm size (-0.0070), urea (-0.0011) and pesticides (-0.0015), were negative but not significant. This could be because the farmers never see increase in farm size, uses of urea and pesticides as a means to enhance their output, which can as well lead to increase in their profit level. The coefficient of herbicide (-0.0027) also was negative and statistically significant at 1%. This reveals that the higher the quantity of herbicide used, the less the output. These outcomes are at variance with the finding of Taphee *et al*. (2015) who reported that the quantity of agrochemicals applied is directly related to groundnut output.

However, the parameter estimates for Single Super Phosphate (SSP) (0.00084), Nitrogen Phosphate and Potassium (NPK) (0.00020) and seeds (0.0063) were positive but not significant, indicating that uses of fertilizer and seeds are under-utilized and hence, increasing quantity of the inputs use will enhance output and profit level. These findings are in agreement with the report of Taphe *et al*. (2015) who observed that resources were inefficiently utilized in groundnut production.

Inefficiency Model Analysis

Analysis of Table 2 shows that the coefficient of extension contact was significant at 5% and negatively related to technical inefficiency. The negative sign of coefficient agrees with the a priori expectation, implying that if a farmer had contact with extension agents, his/her level of technical inefficiency decrease because the farmer will be exposed to good agricultural practices. This will in turn lead to increase in productivity. This implies that extension contact had a positive effect on groundnut production technical efficiency. As such, farmers who received more extension contacts were better and technically efficient in groundnut production than those who received less extension contacts in the study area.

The negative relationship between extension contacts and the level of technical efficiency implies that farmers with more contact are more technically efficient. This is in line with the findings of Sulaiman *et al*. (2015) in their study of resource use efficiency in sugarcane production in Kaduna state, Nigeria which revealed that the coefficient of extension contacts to be (-0.069) negative and statistically significant at 10%. He added that, a 10% increase in extension contacts increases production by less than proportionate margin of 0.69%.

Table 2 also shows that the coefficient of education was significant at 10% and negatively associated with technical inefficiency. This is in conformity with the a priori expectation, implying that as the level of education of the farmer increases, his/her inefficiency in groundnut production decreases. Farmers with formal schooling tend to be more efficient in food crop production due to their enhanced ability to acquire technical knowledge which makes them closer to the frontier output (Okeke *et al*., 2019). This finding conforms to Ogunniyi *et al*. (2012) who reported a negative relationship between education and inefficiency among groundnut farmers in Saki Agricultural Zone of Oyo State, Nigeria.

Table 2: Stochastic Frontier Production Function Results for Groundnut Farmers

Variable	Coefficient	Standard error	t-ratio
Production Function			
Constant	2.79	0.030	92.04***
Farm size (X_1)	-0.0070	0.0053	-1.34^{NS}
SSP (X_2)	0.00084	0.0011	0.77^{NS}
NPP(X_3)	0.00020	0.00093	0.21^{NS}
Urea (X_4)	-0.0011	0.0020	-0.53^{NS}
Seed cost (X_5)	0.0063	0.0065	0.096^{NS}
Herbicide cost (X_6)	-0.0027	0.00076	-3.60***
Pesticide cost (X_7)	-0.0015	0.0014	-1.07^{NS}
Inefficiency Model			
Constant	0.25	0.32	0.76^{NS}
Age (Z_1)	-0.0071	0.0064	-1.10^{NS}
Marital status (Z_2)	0.054	0.11	0.47^{NS}
Household size (Z_3)	0.0076	0.027	0.47^{NS}
Sex (Z_4)	-0.0085	0.11	-0.079^{NS}
Education (Z_5)	-0.023	0.014	-1.64*
Membership of cooperative (Z_6)	0.16	0.11	1.42^{NS}
Extension contact (Z_7)	-0.33	0.13	-2.48**
Experience (Z_8)	0.027	0.036	0.75^{NS}
Diagnostic statistics			
Sigma squared Γ^2	0.41	0.081	4.97***
Gamma γ	0.99	0.000000044	2.28×10^{7}***
Log likelihood function	-37.59		
LR test	67.19		

Source: Field survey data, 2023. * Significant at 1% and ** Significant at 5%. NS =not significant**

Distribution of the Allocative Efficiency Estimates of Groundnut Producers

The distribution of allocative efficiency estimates of groundnut producers in the study area is presented in Table 3. The farmers' allocative efficiency scores vary between 96.8% and 99.9%, with a mean of 99.2%. This implies that there is a possibility for the farmers to reduce production cost by 0.8% on average if they allocate available resources efficiently. About 78.3% of the farmers display an allocative index greater than or equal to 0.988, 15.6% display an allocative index between 0.976 and 0.987, while 6.1% display allocative index less than or equal to 0.975. This shows that the farmers display a good level of allocative efficiency. This finding is at variance with Salisu *et al*. (2024) who reported an average allocative efficiency index of 0.37 for groundnut farmers in Kano State, Nigeria.

Table 3: Distribution of Allocative Efficiency Estimates of Groundnut Producers (n = 180)

Allocative efficiency	Frequency	Percentage (%)
≤ 0.975	11	6.1
0.976 -0.987	28	15.6
≥0.988	141	78.3
Mean Efficiency	0.992	
Minimum	0.968	
Maximum	0.999	

Source: Field survey data, 2023.

Estimation of Stochastic Frontier Cost Function

The maximum likelihood estimates of parameters in stochastic frontier cost function are presented in Table 4. The elasticity parameters are contained in the upper segment of the Table 4 while the determinants of inefficiency are contained in the lower segment of the table. The insignificance of the gamma (γ) parameter (0.0046) shows that the inefficiency effects jointly estimated with the frontier cost function were simply random errors. This implies that groundnut farmers' socio-characteristics had no significant influence on cost efficiency of groundnut farmers in the study area. The value of sigma squared was 0.0041 and statistically significant at 1 % level of probability indicating a good fit and correctness of the distribution. It also implies that the Cobb Douglas stochastic cost function is the adequate representation of the data.

The elasticity coefficient presented in the upper segment of Table 4 shows that the parameter of fertilizer cost was positive (0.16) and statistically significant at 1 %. This implies that a 100 % increase in the use of fertilizer increased the value of total cost by 16%. This is however expected as the quantity of fertilizer applied increases, the cost of groundnut production will likely increase. The coefficient of seed cost (0.023) was positive and significantly related to value of cost at 1 %. The result showed that 100 % increase in the quantity of seed planted would increase cost of groundnut production 2.3 %. This could be as a result of increase in the hectare of land cultivated due to more purchase seed could increase the cost of production. The coefficient of herbicides cost (0.054) was positive and significantly related to value of total cost value at 1 %. The result showed that 100 % increase in the quantity of herbicides used would increase the cost of groundnut production by 5.4 %.

The result further showed that the coefficient of the quantity of pesticides used (0.047) was positive and significantly related to value of total cost at 1 %. The result showed that 100 % increase in the quantity of herbicides used would increase the cost of groundnut production by 4.7 %. The coefficient of dressing cost (0.059) was positive and significantly related to value of total cost at 1 %. The result showed that 100 % increase in dressing cost would increase the cost of groundnut production by 5.9 %. The coefficient of empty bags cost (0.087) was positive and significantly related to value of total cost at 1 %. The result showed that 100 % increase in the empty bags cost would increase the cost of groundnut production by 8.7 %.

The coefficient of transportation cost (0.16) was positive and statistically significant at 1 % level. The result showed that 100% increase in cost of transportation would increase the cost of groundnut production by 16%. This implies that as a farmer, more output could only be transported when there is bumper harvest.

Groundnut producers' specific variable influencing inefficiency of the respondents are contained in the inefficiency model of the lower section of Table 4. Farm experience (0.0048) was positive and statistically significant at 5 % level. This showed that increase in farming experience increases groundnut producers cost inefficiency. This is because the more experience a groundnut producer is, the more likely to become cost inefficient. Experienced farmers are exposed to new technologies and improved techniques over the years thereby making them to enjoy economies of scale. This finding agrees with Salisu *et al*. (2024) who reported a negative relationship between farming experience and inefficiency among groundnut farmers in Kano State, Nigeria.

Table 4: Stochastic Frontier Cost Function Results for Groundnut Farmers

Variable	Coefficient	Standard error	t-ratio
Cost Function			
Constant	6.63	0.30	22.25***
Fertilizer cost (X_1)	0.16	0.020	8.36***
Seed cost (X_2)	0.023	0.011	2.00**
Herbicide cost (X_3)	0.054	0.010	5.13***
Pesticide cost (X_4)	0.047	0.010	4.57***
Dressing cost (X_5)	0.059	0.011	5.25***
Empty bags cost (X_6)	0.037	0.011	3.37***
Transport cost (X_7)	0.16	0.018	9.15***
Inefficiency Model			
Constant	-0.0050	0.070	-0.071
Age (Z_1)	-0.00041	0.00066	-0.61
Marital status (Z_2)	0.012	0.012	0.98
Household size (Z_3)	0.0014	0.0053	0.26
Sex (Z_4)	0.0069	0.016	0.42
Education (Z_5)	-0.0013	0.0024	-0.54
Membership of cooperative (Z_6)	0.0051	0.0061	0.84

Extension contact (Z_7)	-0.0087	0.014	-0.60
Experience (Z_8)	0.0048	0.0018	2.58***
Diagnostic statistics			
Sigma squared Γ^2	0.0041	0.00031	13.28***
Gamma γ	0.0046	0.038	0.12
Log likelihood function	287.78		
LR test	2.17		

Source: Field survey data, 2023. *** **Significant at 1% and** ** **Significant at 5%.**

Conclusion and Recommendations

Evidence from the study shows that on average, groundnut farmers in the study area could improve their inputs use by 32% if they are to produce at frontier level as well as save could save up to 0.8% of the input cost if they are to use inputs in cost-minimizing level and achieve the same output level. The cost herbicide increases cost of groundnut production by 0.054% and decreases groundnut output by 0.0027% while cost of fertilizer, seed, pesticide, dressing, empty bags, and transportation increases groundnut production cost by 0.16%, 0.023%, 0.047%, 0.059%, 0.037%, and 0.16% respectively. The level of educational attainment and contact with extension services of groundnut farmers in the study area decrease their technical inefficiency while their years of farming experience increases their allocative inefficiency.

Based on the findings of the study, the following were recommended:

- There should be concerted effort to promote the use integrated pest and fertilizer management practices so as to minimize the overuse of herbicides, pesticide, and fertilizer among groundnut farmers while maintaining or improving yields;
- Groundnut farmers in the State should seek more affordable sources for inputs like herbicides, fertilizers, seeds, and other inputs, potentially through bulk purchasing or cooperative arrangements;
- Benue State government should strengthen groundnut farmers, access to extension services in the State by conducting training sessions focusing on addressing technical and allocative inefficiencies in groundnut production;
- The Government of Benue State should improve these farmers access to market by enhancing the infrastructures and logistics required for transporting groundnut produce so as to reduce transportation costs, which significantly affect production expenses; and
- The Benue State Government should also encourage continued education among groundnut farmers in rural areas of the State through adult education or workshops so as to enhance their educational attainment and thereby improving their ability to make informed farming decision.

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