Mustafa Kemal Üniversitesi Tarım Bilimleri Dergisi, 29 (3), 695-706
Mustafa Kemal University Journal of Agricultural Sciences, 29 (3), 695-706
https://dergipark.org.tr/tr/pub/mkutbd
e-ISSN: 2667-7733

ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Socio-economic evaluation and technical efficiency of soybean (*Glycine max* L. Merrill) production in North-West Nigeria: A parametric approach

Kuzey-Batı Nijerya'da soya fasulyesi (*Glycine max* L. Merrill) üretiminin sosyo-ekonomik değerlendirmesi ve teknik verimliliği: Parametrik bir yaklaşım

Olugbenga Omotayo ALABI[1], Ibrahim MAHARAZU[2], Jeremiah Samuel ALUWONG[3], Paul Akinwumi ATTEH[4], Augustine OBIDA[5]

[1]*University of Abuja, Faculty of Agriculture, Department of Agricultural Economics, PMB 117 Gwagwalada-Abuja, Federal Capital Territory, Nigeria.*
[2]*Kaduna State University (KASU), Faculty of Agriculture, Department of Agricultural-Economics, Kaduna State, Nigeria.*
[3]*Nuhu Bamali Polytechnic, School of Agricultural Technology, Department of Agricultural-Extension and Management, Zaria, Samaru Kataf Campus, Kaduna State, Nigeria.*
[4]*Federal University of Lafia, Faculty of Agriculture, Department of Agricultural Economics and Extension, PMB 146 Lafia, Nasarawa State, Nigeria.*
[5]*Federal University of Agriculture, Department of Agricultural Economics, Zuru, Kebbi State, Nigeria.*

ARTICLE INFO

Article history:
Recieved / Geliş: 30.05.2024
Accepted / Kabul: 12.07.2024

Keywords:
Technical efficiency
Soybean production
Parametric approach
North-west Nigeria

Anahtar Kelimeler:
Teknik verimlilik
Soya fasulyesi üretimi
Parametrik yaklaşım
Kuzeybatı Nijerya

Corresponding author/Sorumlu yazar:
Olugbenga Omotayo ALABI
omotayoalabi@yahoo.com

ABSTRACT

This aim of study examined socioeconomic evaluation and technical efficiency (TE) of soybean (*Glycine max*) production with a parametric approach in North West, Nigeria. The multistage sampling method was used to select 160 soybean farmers. Primary data were used. Data were analyzed using descriptive statistics and the stochastic production efficiency frontier model (SPEFM). The result shows that the mean age of a soybean farmer was 46 years. Soybean production was profitable with an estimated Gross Margin and Net Farm Income of 899,237.80 and 824, 468.22 Naira respectively. The Gross Margin Ratio and Rate of Return on Investment was calculated at 0.583 and 1.15 respectively. The significant socio-economic factors that increase the TE of soybean production include household size, age, years of experience, level of education, members of cooperatives, and number of extension contacts. The mean TE scores of soybean farmers was 53.77%, leaving a gap of 46.23% for improvement. This study recommends that credit with single-digit interest rates should be made available to soybean farmers.

ÖZET

Bu çalışmanın amacı, Kuzeybatı Nijerya'da soya fasulyesi (*Glycine max*) üretiminin sosyoekonomik değerlendirmesini ve teknik verimliliğini (TE) parametrik bir yaklaşımla incelemektir. 160 soya fasulyesi çiftçisini seçmek için çok aşamalı örnekleme yöntemi kullanılmıştır. Birincil veriler kullanılmıştır. Veriler tanımlayıcı istatistikler ve stokastik üretim verimliliği sınır modeli (SPEFM) kullanılarak analiz edilmiştir. Sonuçlar, bir soya fasulyesi çiftçisinin ortalama yaşının 46 olduğunu göstermektedir. Soya fasulyesi üretimi, sırasıyla 899.237,80 ve 824.468,22 Naira tahmini Brüt Kar Marjı ve Net Çiftlik Geliri ile karlıydı. Brüt Kar Marjı Oranı ve Yatırım Getirisi Oranı sırasıyla 0,583 ve 1,15 olarak hesaplanmıştır. Soya fasulyesi üretiminin TE'sini artıran önemli sosyoekonomik faktörler arasında hanehalkı büyüklüğü, yaş, deneyim yılı, eğitim seviyesi, kooperatif üyeleri ve uzatma temaslarının sayısı yer almaktadır. Soya fasulyesi çiftçilerinin ortalama TE puanları %53,77 olup, iyileştirme için %46,23'lük bir boşluk bırakılmıştır. Bu çalışma, soya fasulyesi çiftçilerine tek haneli faiz oranlarıyla kredi sağlanmasını önermektedir.

Cite/Atıf: Alabi, O.O., Maharazu, I., Aluwong, S.J., Atteh, A.P., & Obida, A. (2024). Socio-economic evaluation and technical efficiency of soybean (*Glycine max*) production in North-West Nigeria: A parametric approach. *Mustafa Kemal Üniversitesi Tarım Bilimleri Dergisi, 29* (3), 695-706. https://doi.org/10.37908/mkutbd.1492376

INTRODUCTION

Soybean (*Glycine max*) is the 4th major cereal crop in the world after wheat (1st), maize (2nd), and rice (3rd) (Grassini et al., 2021). Nigeria is the largest producer of soybean in Central and West Africa (Umar, 2020). In 2022, Nigeria produces 1, 060, 000 metric tons of soybean with a total land area of 1,200,000 hectares (FAO, 2022). As of 2022, global soybean production stood at 348,856,427.48 metric tons (FAO, 2022). Thanks to its rich vitamin B content, it stands out as a nutritious food (Kaya and Ateş, 2024). Soybean is a good source of inexpensive high quality protein and oil. In terms of protein content, soybean is the highest among all food crops, and in terms of oil content, it is second to groundnut among food legumes, with an average oil content of 20% and protein content of 40% (Umar, 2020). Soybeans can be used to produce edible oils, milk, and animal feed. Soybean is a versatile crop that can be used to derived products like soybean oil, soy-milk, soy-cheese, soy-flour, soybean fufu, soy-sauce, livestock feed, and Baby foods such as Babeena, Golden morn, Cerelac, and Nutrend (Omoigui et al., 2020). In the industry, soybean is used in the manufacture of infant food supplements, edible oils, pharmaceuticals, cosmetics, paints, soap making, and animal feed (Biam et al., 2015). In addition, soybean is used in industries to make printing ink, wood veneer, adhesive, paper coating, and alkyd resins (Mairabo et al., 2023).

The consumption of soybean is estimated to be 1.275 million tons in Nigeria between 2021 and 2022 (Donley, 2021). Even with increases in domestic soybean production, local soybean demand cannot be met. There is huge supply gap of soybean in Nigeria. The research gap is more of technical inefficiency (TIE) among smallholder soybean farmers, the viable option is to close the supply gap and for farmers to maximize the use of available production and socio-economic resources. Agricultural growth which means increasing or enhancing agricultural productivity, plays a key role in reducing food insecurity and rural poverty in Africa (Okello et al., 2019). Sakurai et al. (2006) reported that agricultural productivities do` not only depend on crop yield, but also on efficiency. It is important to know that ways of increasing agricultural productivity in sub-Saharan Africa, Nigeria inclusive, must be geared toward improving the efficiency of smallholder soybean farming activities and the allocation of resources to different enterprises (AGRA, 2014). Efficiency of smallholder farms and its predisposing factors are key issues for better farm planning and policy makers decision- making. Tung (2013) reported that smallholder soybean farmers need to develop new farm plans or change their existing ones and that their output will expand due to the increased or enhanced efficiency in soybean production. According to Amaza and Maurice (2005), efficiency is defined as the possibility of farms, (or firms) producing at a given optimal level of output (product) from a certain bundle of inputs or at a given level of output at minimum cost. Efficiency is an important or significant factors in productivity growth of an economy, especially in Africa, where resources are scarce and opportunities for new technologies are lacking. Therefore, studies on soybean efficiency will show that it is possible to raise productivity by improving or enhancing efficiency without increasing the resource base or developing new technology.

According to Miassi et al. (2023), efficiency can also be defined or explained as the ability or potential of soybean producers to produce the maximum quantity of output with the minimum production. TE according to Miassi et al. (2023) can be defined as ways to measure the ability or potential of a soybean production unit to obtain the maximum possible output or yield from a combination of production inputs. Adeyemi et al. (2017) defined a technically efficient firm or farm as one that produces the maximum output or yield for a certain amount of inputs, on the condition that production technology is available to it. TE (Technical Efficiency) is a very important instrument or tool in estimating the technical performance of soybean farms and those producing grains or cereals (Miassi et al., 2023). TE estimates the efficiency of the use of farm resources and factors of production. This implies that it is concerned with allocation of farm inputs (resources) involved in the production process of a given level of output. In order to improve the efficiency of smallholder soybean farmers, resource allocation levels must be known. According to Adeyemi et al. (2017), soybean production can be improved by increasing the efficiency of resources allocation. Therefore, soybean production systems should be focused on estimating the model by

combining production inputs, estimating the determinants of TE in soybean production and acting upon them to enhance the performance of the sector. Bhatt and Bhat (2014) reported that it is important to develop agricultural policies that optimize farmers efficiency to improve crop yields and soybean supply.
Several studies have reported that certain factors or parameters have significant effect on the efficiency level of farms (Miassi et al., 2023). These socioeconomic factors include the age of farmers, the level of education received, the membership of a farmer group, the size of the farm, and access to credit (Nuama, 2006). The methods for estimating productive efficiency are based on a non-parametric approach using DEA (Data Envelopment Analysis) and a parametric approach using a stochastic production frontier efficiency model. Several studies have focused on studying the TE of farms using DEA and little using the stochastic production frontier method because DEA allows for the development of a production frontier without any restriction on the functional form (Hayran and Gul, 2020; Bhatt and Bhat, 2014).
Evidence has suggested that very small is known about the general level of inefficiency of most smallholder farms, very small is known about the exact level of inefficiency in allocation of resources among smallholder farms in Africa (AGRA, 2014). The study fill a research gap existing in the literature and adds to the discussion of soybean production efficiency. The major objective of this study is to examine the socioeconomic evaluation and technical efficiency of soybean (*Glycine max*) production in North West, Nigeria: a parametric approach. The specific objectives include; identify the socioeconomic, institutional and farm-specific characteristics of soybean farmers; analyzing the profitability of soybean production, evaluating the factors influencing soybean production TE, estimating the TE scores of soybean farmers, and determining the constraints facing soybean farmers.

MATERIALS and METHODS

This work was conducted in Kaduna and Kano States, Nigeria. Kaduna State lies between the Longitudes 06˚ 15ǀ and 08˚ 50ǀ East and Latitudes 09˚ 02ǀ and 10˚ 36ǀNorth of the equator. Kaduna state has total land area of 4.5 million hectares. The mean rainfall was approximately 1,482mm. The population of Kaduna state was 8.9 million as of 2021. Kano State lies between Longitudes 08˚ 30ǀ E and Latitudes 12˚ 02ǀN. The state has total land area of 20, 230 Km^2, the population of Kano State is 15,462, 200 people with an annual population change of 3.2% (NPC, 2022). The people of the 2 states engaged in farming activities. A multistage method of sampling method was employed in this study. The total sample size of soyabean farmers selected within the 2 states was 160 respondents comprising 80 soybean farmers from Kaduna State and 80 soybean farmers from Kano State. Primary sources of data were obtained. A structured and correct questionnaire was administered to the respondents using well-trained agricultural extension officers. The structured questionnaire was subjected to validity and reliability tests. This research work used the estimating formula reported by Yamane (1967) in the calculation of the sample size. The formula is given as:

$$n = \frac{N}{1+N(e^2)} = 160 \ldots\ldots (1)$$

Where,
n = The Calculated Sample Size (Number)
N = The Sample Frame of Soybean Farmers (Number for the 2 States)
e = Margin of Error (Maximum) Acceptable and as Determined by the Researcher (5%)
Data were estimated using the following descriptive statistics and econometric tools as stated below:

Descriptive statistics

This includes the use of mean, percentage, frequency distribution, and standard deviation. This information will be used to summarize the socioeconomic, institutional and, farm specific characteristics of soybean farmers.

Farm budgetary technique

Gross margin model (GM) according to Alabi et al. (2022) is stated thus:

$$GM = TR - TVC \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The net farm income(NFI) is defined as:

$$NFI = \sum_{i=1}^{n} P_i Q_i - \left[\sum_{j=1}^{m} P_j X_j + \sum_{k=1}^{k} GK\right] \ldots\ldots\ldots\ldots . (3)$$

Where

P_i = Price of Soybean ($\frac{N}{Kg}$),

Q_i = Quantity of Soybean (Kg),

P_j = Price of Factor Inputs ($\frac{N}{Unit}$),

X_j = Quantity of Factor Inputs (Units),

TR = Total Revenue (The Sales of Soybean) (N),

TVC = Total Variable Cost (N),

GK = Cost of all Fixed Inputs (Naira)

NFI = Net Farm Income (Naira)

Financial analysis

The GMR (Gross Margin Ratio) following to Alabi et al. (2020), is given as:

$$Gross\ Margin\ Ratio = \frac{Gross\ Margin}{Total\ Revenue} \ldots\ldots\ldots\ldots . (4)$$

The RORI (Rate of Return per Naira Invested) is calculated as:

$$RORI = \frac{NFI}{TC} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where,

NFI = Net Farm Income from Soybean Production (Naira),

TC = Total Cost (Naira)

Stochastic production efficiency frontier model (SPEFM)

The parametric and non-parametric approaches are generally used to measure TE. If the production model can be represented explicitly by a function and parameters such as the Cobb-Douglas production function, the approach used is called parametric (Houngue and Nonvide, 2020).

According to Alabi *et al*. (2022), the SPEFM is stated thus:

$$Y_i = f(X_i, \beta_i) e^{v_{i-} u_i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

$Ln\ Y_i = Ln\ \beta_0 + \sum_{j=1}^{5} \beta_i\ LnX_i + (v_i - u_i) \ldots\ldots\ldots\ldots (7)$

Technical efficiency (TE_i) would be estimated as follows:

$$TE_i = \frac{Y_i}{Y_i^*} \ldots\ldots\ldots\ldots\ldots\ldots\ldots . (8)$$

$$TE_{ij} = \frac{F(X_i, \beta) \exp\,(v_i - u_i)}{F(X_{i,} \beta) \exp\,(v_i)} \ldots\ldots\ldots\ldots . . (9)$$

$$TE_{ij} = \exp(-u_{ij}) \ldots\ldots\ldots\ldots . . (10)$$

Since the actual production is usually < the frontier production ($Y_i \leq Y_i^*$), the values for TE lies between 0 and 1, with a TE of 1 indicating that the actual production = to the frontier production and farm is said to be technically efficient (Ahmed and Melesse, 2018).

where,

Y_i = Output of Soybean (Kg)

Y_i^* = Unobserved Frontier Output of Soybean (Kg)

X_i = Vectors of Variable Inputs

β_i = Vectors of Estimated Parameters
V_i = Random Variations in Soybean Output
U_i= Error Term due to TIE (Technical Inefficiency)
X_1 = Seed (Kg)
X_2 = Fertilizer (Kg)
X_3 = Farm Size (Ha)
X_4 = Labour Input (Mandays)
X_5 = Chemical (Litres)

$$U_i = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (11)$$

where,
Z_1 = Age (Years)
Z_2 = Household Size Measured in Number
Z_3 = Level of Education in Years
Z_4 = Years of Farm Experience in Years
Z_5 = Members of Cooperatives (1, Member; 0, Otherwise)
Z_6 = Extension Contact (Number per Month)
α_0 = Constant Term
$\alpha_1 - \alpha_6$ = Estimated Parameters
U_i= Error Term due to TIE

RESULTS and DISCUSSION

Socioeconomic, institutional and farm specific characteristics of soybean farmers

The summary statistics of the socioeconomic, institutional and farm-specific characteristics of the soybean farmer are presented in Table 1. The average age of soybean farmers is 46 years, indicating that they are young, strong, and energetic in their productive years. The farmers have spent an average of 11 years in soybean production. In terms of gender, approximately 78% of soybean farmers are male. Household sizes are large, with a mean value of 9 persons per household. This result is in consistent with the outcomes of Saliu et al. (2017), who reported an average household size of 9 persons among smallscale soybean farmers in Kaduna State. Soybean farmers have acquired formal education, and have spent an average of 12 years in school. Education plays a significant role in enhancing the adoption of new practices, innovations and technologies, which in turn increases the TE of soybean production. The result is in consistent with Mairabo et al. (2023), who observed that 92.7% of soybean farmers had formal education and were literate in Niger state, Nigeria. Soybean producers are smallholder farmers with an average farm size of 1.75 ha. The total revenue from one hectare of a soybean farm was 1, 540, 000 Naira, with a mean output of 2,200 kg ha^{-1}. In terms of institutional variables, approximate 56% of soybean farmers are members of cooperatives, implying that soybean farmers can access credit, purchase necessary farm inputs and, dispose of their farm products in bulk through cooperative associations. The mean credit value accessed per soybean farmers was 250, 000 Naira.

Table1. Descriptive statistics of socioeconomic,iInstitutional and production variables
Çizelge 1. Sosyoekonomik, kurumsal ve üretim değişkenlerinin tanımlayıcı istatistikleri

Variables	Unit of Measurement	Mean Statistics
Age	Years	46
Gender	Percentage Male	78%
Household Size	Number	9
Farm Experience	Years	11
Level of Education	Years	12
Farm Size	Hectares	1.75
Output	Kg ha^{-1}	2,200
Revenue	Naira/ha	1,540,000
Extension Contact	Number of Contact/Month	4
Amount of Credit Accessed	Naira	250,000
Membership of Cooperatives	Percentage	56
Number of Farmers	Number	160

Source: Field Survey (2024)

The costs and returns analysis (profitability) of soybean production per hectare

The costs involved and revenue obtained in soybean production were estimated based on the prevailing market price at the time this field survey was conducted, and the result are presented in Table 2. The total cost (TC) is the addition of TVC (Total Variable Cost) and the total fixed cost (TFC). The TVC was calculated at 640, 762.20 Naira per hectare accounting for 89.56% of TC. The TFC was estimated at 74, 769.58 Naira per hectares, accounting for 10.44% of TC. The TVC includes seed input (5.26%), agrochemicals (4.56%), fertilizer input (31.96), labour input (41.51%), loading and offloading cost (2.27%), transportation (1.99%), fees and commission (1.12%), and bags/sacks/sewing (0.88%). The fertilizer input and the labour input accounted for the highest percentage of the TVC. The TFC includes depreciation on farm implements (3.90%), land rent (3.15%), taxes (2.75%), and capital interest (0.64%). The TC was calculated at 715, 458.78 Naira per hectare. The TR (Total Revenue) and GM (Gross Margin) was estimated at 1, 540, 000 Naira and 899, 237.80 Naira per hectare. This gives a net farm income (NFI) of 824, 468.22 Naira per hectare. This indicates that soybean production is profitable in the area. The GMR (Gross Margin Ratio) was calculated at 0.583, this implying that for every naira invested in soybean production approximate 58 kobo covered expenses, profits, depreciation, and taxes. The RORI was calculated at 1.15, indicating that for every one Naira invested in soybean production, 15 kobo was earned. This finding is in consistent with Olorunsanya et al. (2009), who documented that soybean production was profitable in Kwara State, Nigeria.

Table 2. The costs, returns and profitability analysis of soybean production per hectare
Çizelge 2. Hektar başına soya üretiminin maliyetleri, getirileri ve karlılık analizi

Variables	Units	Value (N)	% TC
Variable Cost (VC)			
Seed	Kg	37,655.30	05.26
Agrochemicals	Litre	32,657.93	04.56
Fertilizer	Kg	228,678.94	31.96
Labour	Mandays	296,993.65	41.51
Loading and Offloading	Naira	16,231.32	02.27
Transportation	Naira	14,235.87	01.99
Fees and Commission	Naira	7,987.21	01.12
Bags/Sacks/Sewing	Naira	6,321.98	00.88
Total Variable Cost (TVC)	Naira	640,762.20	89.56
Fixed Cost (FC)			
Depreciation on Farm Implement	Naira	27,892.18	03.90
Land Rent	Naira	22,563.87	03.15
Taxes	Naira	19,673.21	02.75
Interest Paid on Capital	Naira	4,567.32	00.64
Total Fixed Cost (TFC)		74,769.58	10.44
Total Cost (TC)		715,458.78	100.00
Quantity Sold	2,200 Kg		
Price	700Naira Kg^{-1}		
Total Revenue (TR)	Naira	1,540,000	
Gross Margin (GM)	Naira	899,237.80	
Net Farm Income (NFI)	Naira	824,468.22	
Gross Margin Ratio (GMR)	Number	0.5839	
Rate of Return on Investment(RORI)	Number	1.15	

Source: Field Survey (2024)
Exchange rate is 950 Naira = 1USD

Factors influencing TE of soybean production

The MLEs (Maximum Likelihood Estimates) using the SPEFM for analyzing factors influencing soybean TE are presented in Table 3. The various factors considered in the model include seed, fertilizer, farm size, labour, and chemical. The seed and fertilizer inputs significant in influenced TE of soybean production at ($P < 0.01$). The farm size and chemical input were significant at ($P <0.05$), whereas labour input significantly influenced TE ($P < 0.10$). A 1% increase in fertilizer input, with all other variables fixed gives rise to 53.12% increase in soybean output. In addition, a 1% increase in labour input, fixing all other variables will give rise to 27.13% increase in soybean output. The RTS (Return to Scale) is the summation of the elasticities of production for all variables included in the TE component. The calculated RTS was 1.7017, which implies an increasing RTS. An increased RTS signifies that an increase in the variable inputs included in the TE components of soybean production will lead to more than proportional increase in the output. In the diagnostic statistics component, the coefficient of variance ratio (γ) was 0.8249, indicating that 82.49% of variations in the yield of soybean were due to differences in TE. The coefficient of total variance (σ^2) was 2.8310, which was statistically significant at $(P < 0.01)$. This signifies that the data and model are well fitted. The Log-Likelihood function was -417.23. The results of this study agree with Mairabo et al. (2023), who reported that farm size, seed, and labour were significant factors influencing soybean TE in Niger State, Nigeria.

Socioeconomic factors influencing TE and TIE of soybean production

The maximum likelihood estimates (MLE) using the SPEFM for evaluating the socioeconomic factors influencing TE and TIE of soybean production are presented in Table 3. Socioeconomic factors under consideration in the TIE component include age, household size, years of experience, level of education membership in cooperatives, and number of extension contacts. Socioeconomic factors with negative coefficients increase TE of soybean production, whereas those with positive coefficients increase TIE. All socioeconomic factors included in the TIE component have negative coefficients. Age, level of education, household size,cooperative membership, and number of extension contacts were statistically significant socioeconomic factors that increase TE or decrease TIE of soybean production at ($P < 0.05$). The years of experience was a statistically significant socioeconomic factor that increase TE or decrease TIE of soybean production at ($P < 0.01$). A 1% increase in the level of education of soybean farmers by fixing all other factors will give rise 24.13% increase in TE or decrease in TIE for soybean production. In addition, a 1% increase in the number of extension contacts among soybean farmers with all other factors fixed will give rise to a 28.19% increase in TE or decrease in TIE for soyabean production. This finding is in conformity with Yusuf et al. (2022), who observed that age was a significant socioeconomic factor that increase the TE of soybean production in Sabon Gari Local Government Area, Kaduna State, Nigeria.

Table 3. Maximum likelihood results of the SPEFM

Çizelge 3. Stokastik üretim verimliliği sınır modelinin maksimum olasılık sonuçları

Variables	Parameters	Coefficient	Standard Error	t-Value
Constant	β_0	2.1245**	0.7153	2.97
Seed	β_1	0.4530***	0.1416	3.20
Fertilizer	β_2	0.5312***	0.1348	3.94
Farm Size	β_3	0.2043**	0.0687	2.97
Labour	β_4	0.2713*	0.1195	2.27
Chemical	β_5	0.2419**	0.0837	2.89
RTS		1.7017		
TIE Component				
Constant	α_0	1.8201**	0.7398	2.46
Age	α_1	-0.2338**	0.1003	-2.33
Household Size	α_2	- 0.2718**	0.1037	-2.62
Education Level	α_3	-0.2413**	0.0868	-2.78
Years of Farm Experience	α_4	-0.3564***	0.0968	-3.68
Members of Cooperatives	α_5	-0.3219**	0.1118	-2.88
Number of Extension Contact	α_6	-0.2819**	0.0952	-2.96
Diagnostic Statistics	σ^2			
Total Variance (Sigma Squared)	γ	2.8310***		
Variance Ratio (Gamma)		0.8249		
Log-Likelihood Function		-417.23		

Source: Data Analysis (2024) *-Significant at ($P < 0.10$), **-Significant at ($P < 0.05$), ***-Significant at ($P < 0.01$)

TE (technical efficiency) scores of soybean producers

Table 4 summarizes statisti of soybean producers TE scores. About 74.66 % of soybean farmers had efficiencies between 21 to 80 %. The mean TE was 53.77%, leaving an inefficiency gap of 46.23 % for improvement. Therefore, soybean farmers can obtain 53.77% of the potential output from a given mixture of production inputs. Thus, opportunity still exists for increasing soybean productivity and net farm income by increasing the efficiency using available resources and by adopting new farm technologies and techniques used by the best performing soybean farmers. In addition, the lowest TE score was 7%, whereas the best performing soybean farms had the highest TE score of 97%. If average soybean producers were to achieve the level of TE like most of their efficient counterparts, then average soybean producers could make 44.57% cost savings calculated as $\left[\left[1-\frac{53.77}{97.00}\right]\times 100\right]$. The calculated value for the most technically inefficient soybean farmers revealed a cost savings of 92.78% calculated as $\left[\left[1-\frac{7.00}{97.00}\right]\times 100\right]$. This result agrees with findings of Mohammed et al. (2016) who obtained an average TE score of 61% among soybean farmers in Northern Region of Ghana. In addition, Moses (2017) obtained an average TE score of 90% among soybean farmers in the Mubi North Local Governement Area of Adamawa State, Nigeria.

Table 4. Summary statistics of TE scores

Çizelge 4. Teknik verimlilik puanlarının özet istatistikleri

Efficiency score	Frequency	Percentage
0.00 to 0.20	19	12.67
0.21 to 0.40	23	15.33
0.41 to 0.60	41	27.33
0.61 to 0.80	48	32.00
0.81 to 1.00	19	12.67
Mean	0.5377	
Standard deviation	0.2435	
Minimum	0.07	
Maximum	0.97	

Source: Field Survey (2024)

Constraints faced by soybean producers

The frequency distribution of constraints faced by soybean farmers is presented in Table 5. Soybean farmers were allowed multiple responses. Lack of improved seeds had the highest frequency of 154 which accounted for 22.71% of all constraints encountered and was ranked 1st(first). Lack of credit was ranked 2nd with frequency of 127 and this accounted for 18.73% of all constraints encountered. Inadequate extension officers with a frequency of 116, which accounted for 17.11% of all constraints encountered by soybean farmers was ranked 3rd.

Table 5. Constraints faced by soybean farmers
Çizelge 5. Soya fasulyesi çiftçilerinin karşılaştığı sorunlar

Constraint	*Frequency	Percentage	Rank
Lack of Improved Seeds	154	22.71	1st
Lack of Credit	127	18.73	2nd
Lack of Extension Officers	116	17.11	3rd
High Cost of Fertilizers	109	16.08	4th
Bad Road Infrastructures	87	12.83	5th
High Cost of Labour	85	12.53	6th
Total	678	100.00	

Source: Field Survey (2024) *Multiple Responses

In conclusion, this research established that soybean production in the study area is profitable. Soybean producers were young, strong, agile, energetic, and resourceful. The mean age of soybean producers was 46 years, and they had formal education with an average of 12 years of school education. The GM (Gross Margin) and NFI (Net Farm Income) was computed at 899,237.80 and 824, 468.22 Naira, respectively. Significant factors influencing soybean TE include seed, fertilizer, farm size, labour, and pesticide. Socioeconomic factors that increase the TE of soybean production include age, household size, education level, cooperative membership, years of experience, and number of extension contacts. The estimated RTS was 1.7017, indicating an increase in the RTS. The average TE score of soybean farmers was estimated at 53.77% leaving a gap of 46.23% for improvement. The major constraints faced by soybean farmers include a lack of improved seeds (1st), lack of credit (2nd), and inadequate extension officers (3rd). Based on the outcomes, the following recommendations were made:

(i) Credit at a low interest rate (single digit) devoid of cumbersome administrative procedures should be made available to soybean farmers by government and private institutions to increase productivity.

(ii) Fertilizer input, improved seed, chemical inputs and other farm inputs should be made available to soybean farmers by government and private institutions to increase TE and productivity.

(iii) Extension officers should be deployed to disseminate innovations, research findings, and new farm technologies and techniques to soybean farmers.

(iv)Feeder road infrastructures should be constructed to move soybean produce from production areas to nearby market centres.

(v) Labour saving technologies, equipments and machines should be given to soybean farmers to increase efficiency and productivity.

STATEMENT OF CONFLICT OF INTEREST

The author(s) declare no conflict of interest for this study.

AUTHOR'S CONTRIBUTIONS

The contribution of the authors is equal.

STATEMENT OF ETHICS CONSENT

Ethical approval is not applicable, because this article does not contain any studies with human or animal subjects.

REFERENCES

Adeyemi, B.B., Okoruwa, V.O., & Ikudaisi, A. (2017). Cost efficiency among rice millers in Southwest, Nigeria. *International Journal of Social Economics, 44* (12), 2450-2464. https://doi.org/10.1108/IJSE-06-2015-0137

Ahmed, M., & Melesse, K. (2018). Impact of off-farm activities on technical efficiency: Evidence from maize producers of Eastern Ethiopia. *Agricultural and Food Economics, 6* (3). DOI: https://doi.org/10.1186/s40100-018-0098-0

Alabi, O.O., Oladele, A.O., & Maharazu, I. (2022). Economies of scale and technical efficiency of smallholder pepper (*Capsicum species*) production in Abuja, Nigeria. *Journal of Agricultural Sciences (Belgrade), 67* (1), 63-82. https://doi.org/10.2298/JAS2201063A

Alabi, O.O., Oladele, A.O., & Oladele, N.O. (2020). Economic market decisions among marginal maize farmers in Abuja, Nigeria: Applications of double hurdle model and factor analysis. *Russian Journal of Agricultural and Socio-Economic Sciences, 8* (104), 114-125. https://doi.org/10.18551/rjoas.2020-08.14

Alliance for a Green Revolution in Africa, AGRA (2014). Africa Agriculture Status Report 2014, Climate Change and Smallholder Agriculture in Sub-Saharan Africa. Alliance for a Green Revolution in Africa (AGRA), Nairobi, Kenya.

Amaza, P.S., & Maurice, D.C. (2005). Identification of factors influencing technical efficiency in rice-based production systems in Nigeria. *Workshop on Rice Policy and Food Security in Sub-Saharan Africa,* WARDA, Cotonuou, November, 7-9,70p.

Biam, C.K., Okorie, A., & Nwibo, S.U. (2015). Economic efficiency of smallscale soyabean farmers in central agricultural zone, Nigeria: A cobb-douglas stochastic frontier cost function approach. *Journal of Development and Agricultural Economics, 8* (3), 52-58.

Bhatt, M.S., & Bhat, S.A. (2014). Technical efficiency and farm size productivity micro-level evidence from Jammu & Kashmir. *International Journal of Food and Agricultural Economics, 2* (4), 27-49.

Donley, A. (2021). Nigerian soybean demand on the rise. Available at: https://www.world-grain.com/articles/15474-nigerian-soybean-output-demand-on-the-rise

FAO. (2022). Food and Agriculture Organization, Statistical Data Base, Rome, Italy.

Grassini, P., La Menza, N.C., Edreira, J.I.R., Monzon, J.P., Tenorio, F.A., & Specht, J.E. (2021). Soybean. In: Sadras, V.O & Calderini, D.F (Eds), *Crop Physiology Case Histories for Major Crops*, pp 282-319, Academic Press.

Haryan, S., & Gul, A. (2020). Technical efficiency of green pepper production in greenhouses. The case of Mersin Province Turkey. *Tarim Ekonomisi Dergisi, 25,* (1), 33-40. https://doi.org/10.24181/tarekoder.516795

Houngue, V., & Nonvide, A.M.G. (2020). Estimation and Determinants of efficiency among rice farmers in Benin. *Cogent Food & Agriculture, 6* (1), 1819004. https://doi.org/10.1080/23311932.2020.1819004

Kaya, A. & Ateş, M. (2024). The change of soybean production in Türkiye and its place in the world. Avrasya 11th International Conference on Applied Sciences, August 1-5, Tashkent.

Mairabo, A., Jibrin, S., Audu, H., Salihu, M.Y., & Elisha, Y. (2023). Technical efficiency of soyabean production in Niger State, Nigeria. *FUDMA Journal of Sciences, 7,* (1), 201-206. https://doi.org/10.33003.fjs-2023-0701-1286

Miassi, Y.E., Akdemir, S., Dossa, F.K., & Omotayo, A.O., (2023). Technical efficiency and constraints related to rice production in West Africa: The case of Benin Republic. *Cogent Food and Agriculture, 9* (1), 2191881. https://doi.org/10.1080/23311932.2023.2191881

Moses, J.D. (2017). Technical efficiency of soyabean production in mubi north local government area of Adamawa State, Nigeria. *International Journal of Environmental & Agricultural Research, 3* (6), 36-42.

Mohammed, S.A.R., Al-hassan, S., & Amegashie, D.P.K. (2016). Technical efficiency of soyabean farmers in the Northern Region of Ghana. *ADRRI Journal of Agriculture and Food Sciences, 11* (2), 20-38.

NPC. (2022). National Population Commission of Nigeria, Data Base.

Nuama, E. (2006). Mesure de l'efficacité technique des agricultrices de cultures vivrières en Côte-d'Ivoire. *Économie Rurale, 269* (296), 39-56. https://doi.org/10.4000/economierurale.1892

Okello, D.M., Bonabana-Wabbi, J & Mugonola, B (2019). Farm level allocative efficiency of rice production in Gulu and Amuru Districts Northern Uganda. *Agricultural and Food Economics, 7,* 19. https://doi.org/10.1186/s40100-019-0140-x

Olorunsanya, E.O., Babatunde, R.O., Orebiyi, J.S., & Omotesho, J.O. (2009). Economic analysis of soybean production in Kwara State, North Central, Nigeria. *Global Approaches to Extension Practice (GAEP), 5* (2), 45-53.

Omoigui, I.O., Kamara, A.Y., Kamai, N., Dugie, I.Y., Ekeleme, F., Lava Kumar, P., Ademulegun, T., & Solomon, R. (2020). *Guide to soyabean production in Northern Nigeria-Revised edition.* Ibadan, İnternational İnstitute Of Tropical Agriculture (IITA), 23pp.

Sakurai, T., Furuya, J., & Futakuchi, K. (2006). Rice millers cluster in Ghana and its effects on efficiency and quality improvement. *International Association of Agricultural Economics*, 34-45 pp.

Saliu, I.A., Abdulrazaq, S.A., & Yette, F.E. (2017). Socio-economic analysis of soyabean production among smallscale farmers in Kaduna State, Nigeria. *Conference Proceedings of the 18th Annual National Conference of the Nigerian Association of Agricultural Economics held at Federal University of Agriculture,* Abeokuta, Nigeria 16th – 19th October.

Tung, D. (2013). Changes in the technical and scale efficiency of rice production activities in the Mekong Delta, Vietnam. *Agricultural and Food Economics, 1* (16). https://www.agrifoodecon.com/content/1/1/16

Umar, S.A. (2020). The competitiveness of Nigeria's sesame and soyabean export in international trade: 1986-1997. Unpublished PhD Thesis Department of Agricultural Economics, University of Abuja, Nigeria.

Wilson, D., Etwire, P.M., Martey, E., Etwire, J.C., Baba, I.I.Y., & Salise, A. (2013). Economics of soyabean production, evidence from Saboba and Chereponi Districts of Northern Region of Ghana. *Journal of Agricultural Science, 5* (12), 28-46.

Yamane, T. (1967). *Statistics: An ıntroductory analysis*. 2nd Edition, New York: Harper and Row. Pp. 33-50.

Yusuf, H.O., Omokore, D.F., Olawoye, R., Yusuf, H.A., & Shuaibu, H. (2022). Analysis of production efficiency among small scale soybean farmers in Sabon Gari Local Government Area of Kaduna State, Nigeria. *International Journal of Agricultural Economics, Management and Development, 8,* 195-205.