



Analysis of Profit Efficiency in Rice Production in South East Nigeria: A Quantitative Approach using Translog Normalized Profit and Factor Share Models

***¹Aigbokie S. O., ²Idu M. A., ³Inyang N. N., ²Ibok A. J., ⁴Nkwachukwu D. I., ⁵Osuafor O. O.,
⁶Akpanibah C. C. and ²Ukpai O. O.**

¹Department of Agricultural Economics, Gregory University Uturu, Abia State, Nigeria.

²Department of Agricultural Economics, Michael Okpara University of Agriculture, Abia State, Nigeria.

³Department of Agricultural Education, University of Education and Entrepreneurship, Akamkpa, Cross River State, Nigeria.

⁴Agricultural Development Program, Abia State, Nigeria.

⁵Department of Agricultural Economics and Extension, Nnamdi Azikiwe University, Anambra State, Nigeria.

⁶Department of Agricultural Economics, University of Port Harcourt, Rivers State, Nigeria

*Corresponding Author: s.aigbokie@gregoryuniversityuturu.edu.ng, +2347032594743

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ABSTRACT

Despite significant human and material investment, rice production in Nigeria remains below 60%, with low profitability attributed to factors such as low-input technology, limited credit access, poor knowledge of high-input technologies, weak farm management, inadequate extension services, and the high cost and scarcity of inputs. This study focuses on analyzing profit efficiency in rice production in South East Nigeria, aiming to specifically describe the socioeconomic and farm characteristics of rice farmers and determine optimal input levels that maximize profit. A multi-stage and purposive sampling technique were employed, selecting 240 rice farmers across various states, Zones, and communities. Data were collected through structured questionnaires. The study revealed that most farmers were male (65.4%), married (50.4%), and members of farming cooperatives (94.6%), with 92.5% having access to credit. The average age of the farmers was 37, with a mean household size of 10. Most had formal education (94.17%) and an average of 10 years of experience in rice production, cultivating 1.34 hectares of land. The Maximum Likelihood Stochastic Translog Frontier model revealed that prices of labor, seeds, and fertilizers were positively and statistically significant variables affecting profit efficiency. Furthermore, interactions between the prices of seeds, fertilizers, and agrochemicals showed a positive relationship with profitability. The study concluded that the prices of labor, seeds, and fertilizers are key factors influencing the profitability of rice enterprises. Based on these findings, it is recommended that farmers optimize the use of seeds, fertilizers, and pesticides to enhance profitability of the rice sector in Nigeria.

Keywords: Profit efficiency, Rice production, Translog profit and factor share models, South East

INTRODUCTION

Agriculture is a major sector of the Nigerian economy, accounting for up to 35% of total employment (FAO, 2023). According to the Adeite, (2024) agriculture remains the foundation of the Nigerian economy providing livelihood for

most Nigerians and generating millions of jobs. Agricultural sector has been performing major roles in providing food and income to majority of people in the rural areas of Sub-Saharan Africa, including Nigeria (Ebido *et al.* 2020). It plays a dominant sector in the economy of

Nigeria and contributes about 21.91 percent to the country's GDP (CBN, 2022). Within the agricultural sector, crop production remained the fastest growing subsector at 3.64% followed by forestry, livestock and fishery which grew by 3.31%, 1.61% and 1.34% respectively (CBN, 2023).

Rice (*Oryza sativa* L.) is one of the most important food crops for more than 50% of the world population (Atera et al. 2018). It is the leading cereal crop which can be grown in the standing water of areas of flat, low-lying tropical soils. Rice cultivation is the principal activity and source of income for millions of households around the globe. Several countries of Asia and Africa are highly dependent on rice as a source of foreign exchange earnings and government revenue (Kadiri et al. 2014). It is relatively easy to produce and it is grown for sale and home consumption. Rice is primarily consumed in its parboiled form which adds value to rice in the production and consumption chain. Rice extract from the bran is rich in nutrients such as vitamin E and would not cause high blood cholesterol levels. Also, the demand for rice has increased steadily over the years, thus playing a major role in terms of strategic food security planning policies. In recent years, rice crop yield has not kept up with the population growth thus leading to shortages and higher prices with available ones (USDA, 2023)

Despite the potential for rice production in South East Nigeria, the sector faces significant challenges that impede its profitability. The current farming practices of rice farmers in Southeast are often suboptimal, leading to low yields and inefficient resource utilization. Additionally, environmental degradation, soil erosion, and water pollution further exacerbate the challenges faced by rice farmers in this region. These issues have contributed to food insecurity and limited economic opportunities for farmers, thereby hindering the overall development

of the agricultural sector in South East Nigeria ((Aigbokie et al., 2024)

Profit efficiency is the ability of a firm to achieve the highest possible profit, given the prices and levels of fixed fact Page 38 firm (Ali and Flinn, 1989). For a firm to attain level of profit efficiency, there must be optimality in the use of various input in rice production. Thus, the rice farmers must maximize their farm returns by allocating the resources in an efficient manner so as to attain optimality, which entails profit efficiency. Furthermore, the lack of comprehensive analysis to understand the factors influencing rice production and to develop optimal strategies for production has been a significant gap in the existing research. While some studies have focused on resource utilization in rice production (Simonyan et al. 2018; Simonyan et al. 2012; Nwaru et al. 2018; Rong et al. 2021; Wen-bin et al. 2021), productivity and performance of rice farmer (viz: Abdul-Gafar et al. 2017; Ameh and Lee, 2022; Anyanwu and Obasi, 2010; Aigbokie et al. 2022), there is a need for a more comprehensive approach that focus on profit efficiency in rice production in South East Nigeria: A quantitative approach using translog normalized profit and factor share models.

MATERIALS AND METHODS

Study Area

The study was conducted in South Eastern Nigeria. The Zone consists of five states, namely, Abia, Anambra, Ebonyi, Enugu, and Imo. According to NBS (2024), the population of the South East Zone is 16, 381, 729 persons, disaggregated into 8, 306,306 males and 8, 075, 423 females with a population growth rate of 2.6% per year. The South East population is now 23,053,581. The region lies in the humid tropical agro-ecological zone of Nigeria, between latitude 6° and 9°E of the equator and 4° and 7°N longitude of Greenwich Meridian. It has a total land mass of 109,524 square kilometers.

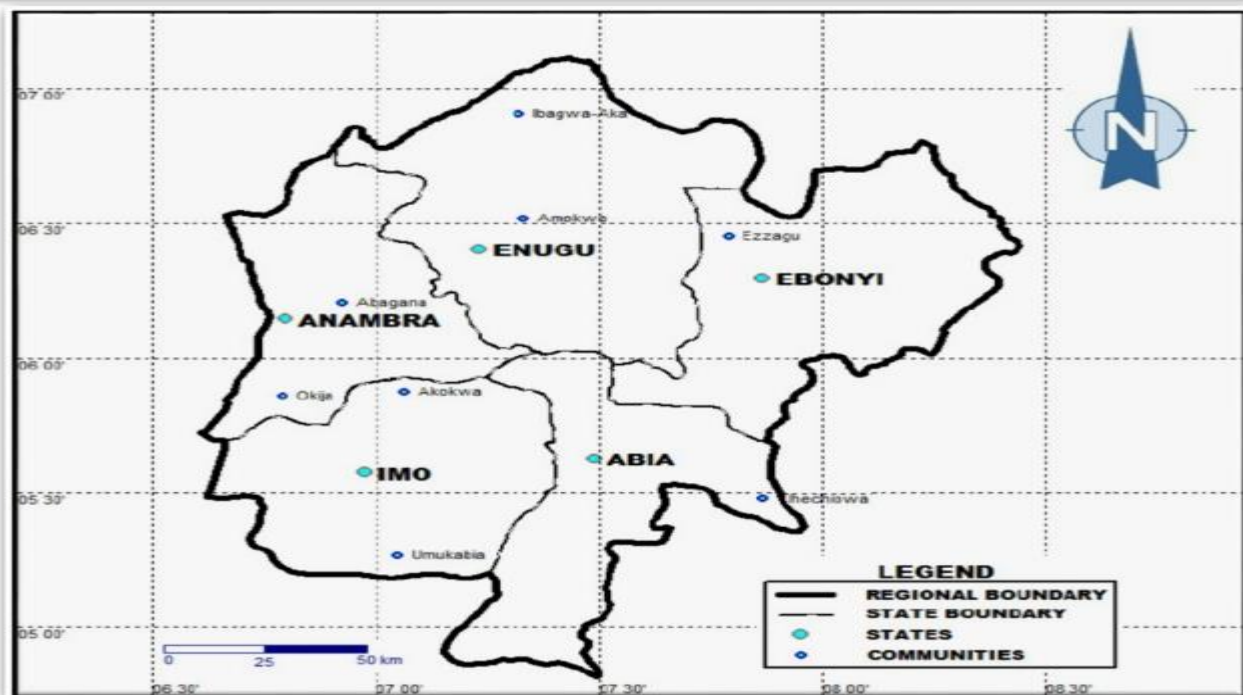


Figure 1: Map of South East, Nigeria.

Source: Office of the Surveyor General of the Federation (OSGOF), Federal Ministry of Works and Housing, Nigeria, (2023).

Sampling Techniques

A multi-stage and purposive sampling technique were used in selection of states, Agricultural Zones, Local Government Area, communities and rice farmers. The first stage involved purposive selection of three states (namely- Ebonyi, Enugu and Anambra) from the five states of the South eastern region based on the intensity of rice production. Secondly, from each of the selected states one agricultural zones was purposively selected based on the dominance of rice farming in these Zone (for Ebonyi - Ebonyi South agricultural zone, Enugu- Nsukka South agricultural zone and Anambra- Anambra Agricultural Zone). Thirdly, from each agricultural zone, two Local Government Areas (LGAs) were randomly selected. Fourth stage involve a random selection of two communities each from the selected LGA (i. e. 12 communities). The fifth stage involve a random selection of two villages each community selected (i. e. 24 villages). In the last stage, 10 farmers that produce rice from each of the villages were selected randomly, giving a sample size of 240 rice farmers. The primary data

were obtained through questionnaire and interview schedules.

Data Collection and Analysis

Data for this study were cross sectional data collected from primary sources. Structured questionnaire and oral interview were used in getting responses from the rice farmers in the study area. Descriptive statistics such as: frequency, mean and the percentage distribution were used to capture the socioeconomic and farm characteristics of rice farmers in the study area while for the optimum levels of inputs use resulting in an output that maximizes profit was achieved using the translog normalised profit and factor share functions.

The Normalized trans-log profit function for a single output is given by Diewert (1974), Christensen *et al.* (1973).

$$\ln \pi^* = \alpha_0 + \sum_{i=1}^n \alpha_i \ln P_i^* + \frac{1}{2} \sum_{i=1}^n \sum_{h=1}^n \gamma_{ih} \ln P_h^* \ln P_i^* + \sum_{i=1}^n \sum_{k=1}^m \delta_{ik} \ln P_i^* \ln Z_k + \sum_{k=1}^m \beta_k \ln Z_k + \frac{1}{2} \sum_{k=1}^m \sum_{j=1}^m \phi_{kj} \ln Z_k \ln Z_j + \varepsilon_i \quad 1$$

Where:

$\tilde{a}_{ih} = \tilde{a}_{ih}$, $\tilde{a}_{ik} = \tilde{a}_{ki}$ and $\phi_{kj} = \phi_{jk}$ for h, i and k and the function are homogeneous of

degree one in prices of all variable inputs and outputs. The definition of the variables and notation used in the profit function are as follows:

$\check{\theta}^*$ = the restricted profit (total revenue less total cost of variable inputs) normalized by P_q , the price of output.

P_i^* = is the price of variable input X_i , normalized by P_q ,

Z_k = the k^{th} fixed inputs; $i = h = 1, \dots, n$, $k = j = 1, \dots, m =$; $\ln$ is the natural logarithm; and

$\alpha_0, \alpha_i, \tilde{\alpha}_{ih}, \tilde{\alpha}_{ik}, \beta_k$ and ϕ_{kj} = Parameters to be estimated and

ε_i = random error.

From the general function (1), the normalized restricted translog profit function can be specified in actual variables as:

$$\begin{aligned} \ln \check{\theta}^* = & \alpha_0 + \alpha_L \ln P_L^* + \alpha_S \ln P_S^* + \alpha_F \ln P_F^* + \\ & \alpha_C \ln P_C^* + \frac{1}{2} \tilde{\alpha}_{LL} \ln P_L^* \ln P_L^* + \frac{1}{2} \tilde{\alpha}_{SS} \ln P_S^* \ln P_S^* + \\ & \frac{1}{2} \tilde{\alpha}_{FF} \ln P_F^* \ln P_F^* + \frac{1}{2} \tilde{\alpha}_{CC} \ln P_C^* \ln P_C^* + \\ & \frac{1}{2} \tilde{\alpha}_{LS} \ln P_L^* \ln P_S^* + \frac{1}{2} \tilde{\alpha}_{LF} \ln P_L^* \ln P_F^* + \\ & \frac{1}{2} \tilde{\alpha}_{LC} \ln P_L^* \ln P_C^* + \frac{1}{2} \tilde{\alpha}_{SF} \ln P_S^* \ln P_F^* \\ & + \frac{1}{2} \tilde{\alpha}_{SC} \ln P_S^* \ln P_C^* + \frac{1}{2} \tilde{\alpha}_{FC} \ln P_F^* \ln P_C^* + \varepsilon_i \end{aligned}$$

Where:

$\check{\theta}^*$ = the restricted profit (real value) from rice production: total revenue less total cost of labour, seeds, fertilizer and agro chemicals normalized by the farm gate price of rice;

P_L = the wage rate of labour per man day normalized by farm gate price of rice;

P_S = the price of seed normalized by farm gate price of rice,

P_F = the fertilizer farm gate price normalized by farm gate price of rice,

P_C = the pesticide price normalized by farm gate price of rice

The parameters, α_0, α_i and $\tilde{\alpha}$ are to be estimated and subscripts L, S, F , and C stand for the variable input of production labour, seeds, fertilizer and agro chemicals respectively.

RESULTS AND DISCUSSION

Socioeconomic and Farm Characteristics of Rice Farmers in South East Nigeria

Distribution of the rice farmers according to sex shows that majority of the respondents were males (65.4%) while the rest were females (34.6%). This result is in line with the report by Adeolu *et al.* (2014) who noted in their research on gender analysis of rice production efficiency in Osun state as they revealed that rice production in the study area was dominated by male which accounts for 62% of the respondents indicating that men engage more in rice production. This result suggested that gender may be a factor in enterprise selection and production in the study area.

The study further showed that 50.4% of the respondents were married. This is typical of Nigeria rural setting because family members often serve as a source of additional labor together with cultural value attached to marriage. This result agrees with the findings of Wai and Hong (2021) who noted in their work on measuring the efficiency and determinants of rice production in Myanmar as majority of the farmers were married, implying that household labour might complement production activities so as to sustain production. The implication of marital status on agricultural production can be explained in terms of the utilization of agricultural family labour. The utilization of family labour would be more where the household heads are married. This is in consonance with the findings of Saysay *et al.* (2016) on profit efficiency among smallholder rice farmers in Central Liberia. Furthermore Nwaru (2014) stated that the situation where majority of farmers classified as married, create a conducive environment for good citizenship training, development of personal integrity and rice farming which are very important for efficient use of farm resources.

From the result, 94.6% of the rice farmers in the area belong to farming cooperative.

Farming cooperative is expected to impact positively on performance as well as level of sustainability. This corresponds with the findings of Pede *et al.* (2018) who noted that majority of the sampled farmers were members of association and membership of association satisfies the social needs of rice farmers in additions to serving as an avenue for access to information on agricultural technology. Also, the extent of membership enables rice farmers acquire better skill and knowledge on farming which lead to surplus to be taken to the market for sales. Aigbokie *et al.* (2021) noted in their work on gender differentials in labour source and utilization among rural rice farmers in Enugu State, Nigeria and noted that cooperatives are vehicle for development since it provides access to different productive input, increases access to information vital to farming.

Majority (92.5%) of the rice farmers had access to credit. The implication of access to credit is aggregate level outcomes, such as technology adoption, agricultural productivity, food security, nutrition, health, and overall farmers' welfare (Chuwkuma *et al.* 2021). Credit is an important factor in agricultural production. Farmers with access to credit have a high likelihood of increasing and sustaining production. Credit is accessed by having membership in co-operative or any other financial organization. The result agrees with the findings of Idu and Sunday (2016) in their study on gender and access to agricultural credit in Abia State, that access to credit has a positive relationship with the sustainability of rice production. According to Adetiloye (2012), the introduction of sustainable credit and guarantee into agriculture will attract the youth and the educated farmers and thus make rice farming sustainable.

Majority of the rice farmers had access to extension (57.1%), this implies that farmers by virtual of their access to extension services has significant

improvements potentials in rice production. Rice farmers with access to extension services can acquire training on methods of rice production. In addition, farmers are usually informed of the existence and the effectiveness of new technologies. The extension agents act as the links between the innovators and the users of the new technology. This helps to reduce the cost of a transaction when training on the new practices. Similarly, Kinuthia (2015) noted in their study on impact of Agriculture technology adoption on farmers' welfare, that access to extension affects the productivity of new varieties. Varma (2017) noted in their study on adoption of system of rice intensification and its impact on rice yields and household income that access to extension services positively affects rice sustainability and income consecutively. Some of the implications noted for access to extension require that extension workers should move beyond simply providing farmers with information on food production and standardized technological packages but also provide farmers with issues relating to sustainability of the enterprise.

The result in the Table 2 showed that the mean age of the rice farmers was 37 years, with minimum and maximum value as 19 and 64 respectively. The minimum and maximum values show that there is youth participation in rice production. The mean age implies that the rice farmers were middle aged who are very active, dynamic and pioneer to innovation, hence could have the likelihood of having positive attitude towards rice farming.

This implies that majority of rice farmers in the study area were youth with adequate strength to perform their task for optimum yield in farming. The implication of these age bracket is abundance of young rice farmers who are energetic to carry out farming operations.

Table 1: Binary Socioeconomic and Farm Characteristics of the Rice Farmers

Variables	Frequency	Percentage (%)
Sex		
Female	83	34.6
Male	157	65.4
Marital status		
Married	121	50.4
Otherwise	119	49.58
Association		
No	13	5.4
Yes	227	94.6
Credit access		
No	18	7.5
Yes	222	92.5
Extension contacts		
No	103	42.9
Yes	137	57.1
Total	240	100.0

Source: Field Survey (2024).

This may be because younger rice farmers are flexible and have longer planning horizon than their older counterparts. Moreover, according to Obih and Baiyegunhi (2017) who noted in their study on implicit price estimation of quality attributes influencing rice prices and choice decisions of consumers in Nigeria that age influences the ability to seek and obtain farm jobs which will increase their farming capacity. The result shows that the mean household size was 10 persons per household. The result further shows that the least household size was one person while the maximum was 19 persons. Their research, focusing on return on investment in cassava processing, found that households with 6-10 members were more likely to participate in farming. This aligns with the logic that larger families, having more mouths to feed, are more likely to turn to farming to ensure sustainable food production. Furthermore, Onwumere *et al.* (2017) noted in their study that this is desirable, consistence and of great importance in farming because rice farmers may rely more on their family members than hired workers for labour on their farm. Although Aigbokie *et al.* (2023) stated that the large households have the capacity to minimize the labour constraints required during introduction of new technology. The economic implication is that it will provide the rice farmers with family labour at reduce cost of farming and increase their revenue.

Majority (94.17%) of the respondents in the study acquired one form of formal education or the other. This means that they can be easily convinced to accept better practices of their farming operations. There is high literacy level among the rice farmers in the area, this could positively influence their participation in development programme and adoption of different farming practices that could improve productivity and sustain rice production. This tally with the findings of Iheke, and Nwaru (2014), who opined that high educational attainment is a desirable condition for agricultural development, since it augured well for extension services in transferring research result for sustainable food farming. The basic objective of any form of education is to impact knowledge which would influence a change in attitude, skills, or knowledge. It therefore implies that rice farmers in the study area will not have much problems making use of improved technology in order to sustain rice production in the study area. Education increases the ability of the rice farmers to adopt Agricultural innovation and hence improve their efficiency and sustainability. High literacy level is an asset because the rice farmers would be exposed to many information sources, embrace innovations and analyze situations objectively. According to Obalola and Ayinde (2018) education provides a base for a farmer to understand changes within agriculture, affects his/her efficiency and shows how

informed they are of the new innovations and technology around them to improve their level of sustainability.

The minimum, maximum and mean farming experience were 2, 20 and 10 years respectively. This showed that rice farmers in the study area had considerable experience in farming. The result has some positive implications on increased output, and sustainability because according to Ebe *et al.* (2022) in their study on impact of ICT usage on success/failure of youth-led agribusiness activities in different agricultural value chains in Southeast Nigeria, the number of years a farmer has spent in farming business may give an indication of the practical knowledge he has acquired on how he can overcome certain inherent farm farming problems and sustain production. The implication of this is that they are equipped to overcome their farming challenges to a considerable extent.

The mean hectare cultivated was 1.34, this shows that greater percentage of the respondents in the study area had farm size between 1.0 – 2.0 hectares of land under cultivation. This thus pose a great challenge to the much desired agricultural modernization/mechanization and commercialization in Nigeria and therefore depicts the need for urgent land reform policies and programmes that would give farmers access to more contiguous land holdings for increased agricultural production; the result supports the assertion made by Simonyan, Amusa and Akpan (2018) who noted that the Nigerian agricultural sector is dominated by small-scale farmers who produce the bulk of food requirements of the country with their associated low productivity. They cultivate between one to two hectares scattered over a wide area and they constitute more than 80% of total farmers and produce up to 98% of the food consumed in the country with the exception of wheat (Nwaru, 2018). Nigeria has an arable land potential of 98.3 million hectares but only 34.2 million hectares (48 percent) are cultivated while 52 percent is yet to be exploited

(Simonyan *et al.*, 2018). As seen from Table 2, rice farmers who had above 2 hectares of land were deficient in terms of sustainability of rice production

The Table 2 revealed that major method of land acquisition was inheritance accounting for 36.7% of the population. This was followed by pledge (20.85) and borrow (17.5%) while value for purchase was low, the low percentage may be as a result of high cost of rent and purchasing power of farmland in the area. Nigeria has a total land mass of 924,768 sq.km with a population of 198 million and annual population growth rate of 2.8%. However, the level of access and title ownership is determined by the state (NPC, 2018). Therefore, the land system is characterized by several actors including government, community leaders, families, lawyers, middle men and estate agents among others. Thus, sustaining and improving rice production in the study area would require addressing the land tenure issues of both landlords and tenants. Access to land for tenants will enhance their participation in rice production and increase their chances of increasing their income and emerging from poverty. Therefore, rice farmers need more secure access to land to provide them with opportunities to manage their plots so that they will have higher yields. Farmers whose land security was not guaranteed would be more inclined towards short-term investments in land, and the sustainability of rice production would not be expected to be their priority as noted by Isaac *et al.* (2019).

Optimal Input Levels that Maximize Profit of Rice Farmers in South East Nigeria

Profit efficiency (optimum levels of inputs use resulting in an output that maximizes profit) in rice production was achieved using stochastic translog frontier and the result is presented in Table 3. The translog profit efficiency frontier function was estimated through single step procedure. The maximum likelihood estimates of the parameters of the stochastic profit frontier model are presented in Table 3.

Table 2: Non-binary Socioeconomic and Farm Characteristics of the Rice Farmers

Variables	Frequency	Percentage (%)	Min	Max	Mean
Age (years)			19.0	64.0	37.48
19 – 28	78	32.5			
29 – 38	44	18.3			
39 – 48	77	32.1			
49 – 58	27	11.3			
59 – 68	14	5.8			
Household size			1.0	18	10.16
1 – 5	48	20.0			
6 – 10	90	37.5			
11 – 15	33	13.8			
16 – 20	69	28.7			
Education					
Never attended	14	5.8			
Primary	43	17.9			
Secondary	92	38.3			
Tertiary	77	32.1			
Experience			2.0	20	10.17
1 – 5	33	13.75			
6 – 10	124	51.67			
11 – 15	29	12.08			
16 – 20	54	22.50			
Farm Size					
0.1-1.0	74	30.8	0.1	4	1.34
1.1-2.0	154	64.2			
2.1-3.0	1	0.4			
3.1-4.0	11	4.6			
Land Acquisition					
Purchase	15	6.3			
Rent	35	14.6			
Inheritance	87	36.3			
Pledge	50	20.8			
Borrow	42	17.5			
Gift	10	4.2			
Partly owned	1	0.4			
Total	240	100.0			

Source: Field Survey (2024).

. The results show that the parameter estimated coefficient sigma squared (δ^2) and gamma (γ) were statistically significant at 1% and 5% levels respectively. The parameter gamma is 0.878, which is interpreted that about 87.8% profit variation is caused by efficiency difference and the rest 12.2% is caused by external factors which were not included in the model. The variation in rice profit is due to random shocks outside the farmer's control. The gamma value is significant and close to one, indicating that the factor affecting inefficiency is essential.

The coefficients of variance-parameter for the models show that σ^2 (sigma squared) and Gamma (γ) were significantly different from

zero. According to Aigner *et al.* (1997) and Umar *et al.* (2017), statistical significance of the variance-parameter (σ^2) is an indication of a good fit for the model and confirmation of distribution assumption of the composite error term.

The result also shows that the coefficients of price of labour (X_1), price of seed (X_4) and Price of fertilizer (X_5), were positive and statistically significant, implying that increase in the magnitude of these inputs increased the performance of rice enterprise. The positive coefficient implies that an increase in the price of labour, price of seed and price of fertilizer, increases farmers' profit. Hyuha (2006) found that an increase in price of labour, price of seed

and price of fertilizer, can achieve higher output and increase profit. The indication is that price of labour, price of seed and price of fertilizer are important variables in rice production; reinforcing the evidence that rice farming in the study area is labour intensive and as well required enough price of seed and fertilizer. As more labour is applied in smallholder rice production, output will increase *ceteris paribus*, will increase profit.

The squared term for price of labour in the translog model was positive and statistically significant at 1%. This implies that continuously increasing the price of labour would at a point increase profit. The positive and statistically significant implication of the squared term for labor in the translog model for rice production suggests that there is a non-linear relationship between labor input and rice output. This indicates that the effect of labor on rice production is not constant, but rather changes as the level of labor input varies. This finding may have important implications for understanding the behavior of rice output in response to changes in labor input. This is in conformity with findings of Joseph (2016) as he reported the positive and significant relationship for Price of labour in rice production.

The squared term for price of seed in the translog model was positive and statistically significant at 1%. The positive and statistically significant implication of the squared term for price of seed for rice production suggests that there is a non-linear relationship between price of seed and rice production. This means that as price of seed increases, the impact on rice production is not constant, but rather changes at an increasing rate. This finding could have important implications for understanding the cost-effectiveness of seed investment in rice production. This implies that continuously increasing the price of seed would at a point continue to increase profit of the rice farmers as the rice farmers is adjust selling price based on price of seed. This is in conformity with findings of Joseph (2016) as he reported the positive and significant relationship for price of seed in rice production.

The squared term for price of fertilizer in the translog model was positive and statistically significant at 5%, the positive and statistically significant coefficient of the squared term for Price of fertilizer for rice production suggests a non-linear relationship between Price of fertilizer and rice production. This implies that the impact of Price of fertilizer on rice production is not constant, but rather changes at an increasing rate. This finding underscores the importance of considering non-linear effects when analyzing the relationship between Price of fertilizer and rice production, and it may have implications for optimizing fertilizer use and maximizing yields in rice farming. This implies that continuously increasing the quantity of seed would at a point continue to increase profit of the rice farmers. This is in conformity with findings of Joseph (2016) as they reported the positive and significant relationship for Price of fertilizer and profit of rice.

Two of the interaction terms were statistically significant. price of seed and price of fertilizer were positive and statistically significant at 1%. This implies that price of seed and price of fertilizer were complements in smallholder farmers' rice production in the study area, indicating that increases in price of seed will lead to increase in cost of fertilizer, which will in turn lead to an increase in performance of the rice farming in south east Nigeria. The positive and statistically significant implication of the interaction between price of seed and Price of fertilizer for rice production indicates that there is a significant joint effect of these two input costs on rice production. This suggests that the combined use of seed and fertilizer has a positive impact on rice production, and the interaction between these inputs is an important factor to consider when analyzing and optimizing production in rice farming. These findings could have important implications for understanding the synergistic effects of different inputs and for making informed decisions about input allocation in rice production.

Also, price of fertilizer and price of agro chemical were positive and statistically significant at 1%. The positive and statistically

significant implication of the interaction between Price of fertilizer and the cost of agrochemicals for rice production suggests that there is a significant joint effect of these two input costs on rice production. This indicates that the combined use of fertilizer and agrochemicals has a positive impact on rice production, and the interaction between these inputs is an important factor to consider when analyzing and optimizing production in rice farming. These findings could have important

implications for understanding the synergistic effects of different inputs and for making informed decisions about input allocation in rice production. This implies that price of fertilizer and pesticide are complements in smallholder farmers' rice production in the study area, indicating that increases in price of fertilizer will lead to increase in cost of pesticide, which will inurn lead to an increase in performance of the rice farming in south east Nigeria.

Table 3: Maximum Likelihood Estimates of Stochastic Translog Frontier Rice Production

Variable	Coefficient	Standard Error	t-ratio
Intercept	15.1767	2.7388	5.54***
Ln Price of labour	2.5845	0.4086	6.33***
Ln Price of seed	0.5863	0.2514	2.31**
Ln Price of fertilizer	3.0322	1.0382	2.92***
Ln pesticide price	-1.4503	1.6982	-0.85
½ (Ln Price of labour) ²	0.2738	0.0362	7.56***
½ (Ln Price of seed) ²	0.1777	0.0178	10.00***
½ (Ln Price of fertilizer) ²	0.1839	0.0726	2.53**
½ (Ln pesticide price) ²	0.2577	0.1577	1.63
½ Ln Price of labour * Ln Price of seed	0.2582	0.2751	0.94
½Ln Price of labour * Ln Price of fertilizer	-0.1785	0.1601	-1.11
½Ln Price of labour * Ln pesticide price	-0.1389	0.2799	-0.50
½Ln Price of seed * Ln Price of fertilizer	0.0306	0.0079	3.89***
½Ln Price of seed * Ln pesticide price	0.0156	0.1342	0.12
½Ln Price of fertilizer * Ln pesticide price	0.0416	0.0086	4.86***
Log-likelihood function	-319.5672		
Sigma square (δ^2)	0.6880	0.2590	2.66***
Gamma (γ)	0.878	0.4050	2.17**
Lambda (λ)	1.3840	0.2794	
Wald χ^2 test	68.49***		
Sample size (n)	240		

Source: field Survey (2024).

Key: * = 10%, ** = 5% and *** = 1%

CONCLUSION AND RECOMMENDATIONS

The study concluded that the prices of labor, seeds, and fertilizers are key factors influencing the profitability of rice enterprises in South East Nigeria. Given these findings, the study recommends that as follows:

1. Farmers should optimize the use of key inputs such as seeds, fertilizers, and pesticides to improve productivity and profitability.
2. Access to credit and agricultural extension services should be enhanced to support farmers in adopting better farming practices and investing in high-quality inputs.

3. The cost and availability of essential agricultural inputs should be reduced through policy interventions or collaboration with the private sector to make them more accessible to farmers.

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