Journal of Agriculture, Environmental Resources and Management
ISSN2245-1800(paper) ISSN 2245-2943(online)
8(2)1-800;**February**.2026; pp21- 27

www.saerem.com

Economic (Profit) Efficiency of Smallholder Cassava Producers in Aninri Local Government of Enugu State, Nigeria: A Stochastic Frontier Normalized Profit Approach

Onu, Donatus Onwuha and Amusa, Taofeeq Ade
Department of Agricultural Economics, Michael Okpara University of Agriculture, Umudike, Abia State**Corresponding author:** onu.donatus@mouau.edu.ng

Abstract: This study analyzed the economic efficiency of smallholder cassava production in Aninri Local Government Area of Enugu State, Nigeria, using primary data collected from 120 farmers through a multistage sampling technique. The study employed the stochastic frontier normalized profit function to estimate efficiency levels and identify determinants of inefficiency. Descriptive statistics results showed that the average farm size was 1.58 ha, with a mean output of 15,240 kg (15.24 tons) per production season. Labour use was intensive, with 79.18 mandays of family labour and 54.62 mandays of hired labour, while average expenditures on fertilizer (₦41,350), agrochemicals (₦23,480), and capital inputs (₦68,540) reflect moderate input utilization levels. The maximum likelihood estimates showed that the model was well fitted, with a statistically significant sigma-squared ($\sigma^2 = 3.9184$, $p < 0.01$) and a high gamma value ($\gamma = 0.9146$). Results also showed that the major factors that influenced normalized profit included family labour ($p < 0.05$), fertilizer ($p < 0.01$), cassava cuttings ($p < 0.01$), farm size ($p < 0.01$) and annual depreciation ($p < 0.10$). Determinants of inefficiency showed that education ($\delta_2 = -0.0614$), farming experience ($\delta_3 = -0.0283$), credit access ($\delta_6 = -0.2478$), and cooperative membership ($\delta_7 = -0.2063$) significantly reduced inefficiency, while age increased inefficiency ($\delta_1 = 0.0317$). The mean economic efficiency was 0.73, implying that farmers operate at 73% efficiency, with a potential cost-saving margin of 23% if optimal resource allocation is achieved. Efficiency levels ranged from 0.36 to 0.95. The study recommends that cassava farmers in the study area should form cooperative societies so as to enable them have access to productive inputs that will enable them expand their resource base and consequently their scale of operation

Key words: stochastic frontier, normalized profit, economic efficiency, profitability, smallholders.

Introduction:

Cassava (*Manihot esculenta Crantz*) remains one of Nigeria's most critical staple crops, significantly contributing to rural livelihoods, food security, and agrarian economic activity (Onu et al, 2023a). In the Southeast, states such as Enugu contribute significantly to national cassava output, with cassava cultivation and associated value chains accounting for substantial rural employment and economic activity (Eze et al., 2023). Cassava production is noted to be a small scale phenomenon in Nigeria as it is dominated by over 60% of small-scale farmers who are basically poor in resource endowments (Onu et al, 2023). Their production activities have always been restricted to less productive crude tools in the light of multifarious problems. This has resulted in relative decline in output and productivity over time with resultant decline in overall agricultural growth In southeastern Nigeria, especially in Aninri Local Government Area of Enugu State, cassava is typically cultivated either as a sole crop or in intercropping systems alongside crops such as maize, yam, cocoyam, and vegetables, reflecting the complex and resource-constrained nature of smallholder farming systems (Udealor et al., 2019; Nweke, 2017). While these systems enhance risk diversification and food security, they may also contribute to inefficiencies in resource allocation when production decisions are not optimized. Empirical evidence suggests that many smallholder farmers operate below the production frontier, indicating the presence of both technical and allocative inefficiencies (Akinola et al., 2020; Awerije & Rahman, 2014). Economic efficiency in agriculture encompasses technical, allocative, and profit efficiency, reflecting how well farmers convert inputs into output and allocate these inputs relative to their costs (Ogundari & Ojo, 2006). Technical efficiency assesses the ability of farmers to achieve maximum output from a given set of inputs, while allocative efficiency examines the cost-effective use of inputs relative to their prices. Profit efficiency integrates both aspects to indicate how close a producer's profit is to the maximum achievable under given conditions (Ogundari & Ojo, 2006). Despite Nigeria's position as the world's largest cassava producer, productivity and farm-level returns remain below potential, especially among smallholder farmers who dominate production systems in states such as Enugu (Nwadiolu et al., 2024). Cassava production is frequently constrained by limited access to improved inputs, inadequate extension support, credit scarcity, and weak market linkages, all of which influence how farm resources are deployed and the extent to which producers realize optimal economic outcomes (Onu et al, 2023b).

In southeastern Nigeria, especially in Aninri Local Government Area of Enugu State, cassava production is predominantly small-scale and characterized by limited access to improved inputs, inadequate extension services, and poor access to credit facilities. These constraints hinder optimal decision-making and reduce farmers' ability to respond efficiently to input and output price signals, ultimately affecting profit outcomes (Liverpool-Tasie et al., 2023; Ogundari, 2021). Consequently, many farmers operate below the production frontier, leading to significant economic losses (Onu and Okoronkwo, 2019). Studies in Nigeria have documented mixed results regarding efficiency in cassava production. For instance, in Ogun State, cassava farmers showed moderate technical (0.8054), allocative (0.8414), and economic (0.6835) efficiencies, suggesting substantial room for improving resource use and cost management (Akinola, et al; 2020). Similarly, in the southwestern Yewa communities, technical efficiency gaps of approximately 21% have been identified, suggesting opportunities to enhance production through improved input use and management practices (Nwakpu, 2024). Broader research across Delta State using Data Envelopment Analysis reported notably low technical and cost efficiencies around 40% and 29% respectively suggesting pervasive inefficiency in resource use and the potential for significant productivity gains (Awerije & Rahman, 2014). Previous empirical studies in Nigeria have largely focused on technical or allocative efficiency, often employing production or cost frontier models (Akinola et al., 2020; Awerije & Rahman, 2014). Though these studies are relevant, but they did not fully capture profit efficiency, which integrates both technical and allocative dimensions and directly reflects farmers' economic performance under market conditions (Ogundari & Ojo, 2006). More importantly, there is limited empirical evidence on economic (profit) efficiency using a stochastic frontier normalized profit approach in localized contexts such as Aninri Local Government Area of Enugu State. Given the heterogeneity in agro-ecological conditions, institutional arrangements, and socio-economic characteristics across regions, localized studies are essential for understanding context-specific efficiency dynamics and designing targeted interventions. In Enugu State, prior work has examined profit efficiency among smallholder cassava producers, reporting mean profit efficiency of about 73%, with inefficiencies linked to both technical and allocative factors (Okorie et al, 2021). While this study provides valuable insights into farm-level profitability, it primarily focuses on profit efficiency without a comprehensive simultaneous assessment of technical, allocative, and economic efficiency within a localized context such as Aninri Local Government Area. Moreover, many existing studies (Nwadiolu et al., 2024; Oluwasola, et al, 2025; Okorie, et al, 2021) are geographically dispersed or concentrated in other states, leaving a knowledge gap regarding the specific efficiency dynamics of cassava production in southeastern locales where agro-ecological conditions, market structures, and socio-economic environments may differ substantially. Additionally, while research such as that by Nwadiolu et al. (2024) and Akinola et al. (2020) explores broader efficiency determinants, there is limited localized evidence on how specific socio-economic, institutional, and production factors uniquely affect efficiency among smallholder cassava producers in Aninri. This gap is critical to address because localized studies are essential for designing tailored interventions that reflect community-level realities and production constraints. Also, in Aninri LGA, where cassava production is a major livelihood activity, there is a paucity of empirical evidence on how efficiently farmers allocate resources to maximize profit and the factors influencing inefficiency. This study would fill these gaps by providing a comprehensive economic efficiency analysis of smallholder cassava producers in Aninri Local Government Area of Enugu State. Specifically, it estimated profit (economic) efficiency using a stochastic normalized profit frontier and identified the socio-economic and institutional determinants of inefficiency within this localized farming context. By doing so, the study would generate evidence to inform targeted policies and extension strategies that can enhance resource use, improve profitability, and strengthen cassava value chains, thereby promoting rural development and sustainable agricultural growth in Enugu State, Nigeria.

Methodology:Study Area: The study was conducted in Aninri Local Government Area (LGA) of Enugu State, situated in the southeastern geopolitical zone of Nigeria. Aninri lies at approximately 6°03′N latitude and 7°35′E longitude, with an elevation of about 60 m above sea level, and is characterized by a typical tropical savanna climate suitable for staple crop cultivation including cassava. The LGA covers an area of approximately 364 km² and comprises five major towns: Oduma, Nenwe, Ndeabo (the administrative headquarters), Mpu, and Okpanku. Agriculture is the dominant economic activity, with most residents engaged in the production of yam, cassava, cocoyam, melon, and other food crops (with cassava being especially important), followed by trading activities in local markets such as Oduma Central Market and Afor Okpanku Market (Onu et al, 2023a). Geographically, Aninri's location along accessible road networks such as the Enugu–Port Harcourt expressway enhances its linkages with urban hubs and input/output markets for agricultural commodities. The Local Government Area is blessed with abundant and fertile farmland. The major source of livelihood in this area is agriculture and the bulk of agricultural production is undertaken by smallholder farmers. Major crops grown in the area include cassava, yam, maize, rice, cocoyam, groundnut, potatoes and vegetables among other crops (Onu and Onu, 2024).

Sampling Technique: The study utilized primary data elicited from the smallholder cassava farmers using structured questionnaire administered to the farmers. A multi-stage sampling technique involving purposive and random sampling procedures was adopted in the selection of the respondents. In the first stage, Aninri Local Government Area was purposively selected due to the intensity of cassava

22

production. In the second stage, all the five cassava-producing communities (Mpu, Ndeabo, Nenwe, Oduma, and Okpanku) were purposively selected due to the wide spread cultivation of cassava across all the five communities in the Local Government Area. In the third stage, two villages were randomly selected from each community, resulting in a total of ten villages. In the final stage, twelve cassava farmers were randomly selected from each village using farmer lists obtained from village heads, extension agents, and the Agricultural Development Programme (ADP), giving a total sample size of 120 farmers. Well trained enumerators as well as agricultural extension agents residing in each of the villages in the study area assisted the researcher in data collection.

Methods of Data Analysis: The stochastic frontier normalized profit function was used in the analysis of data. It was used to empirically determine the economic efficiency in resource utilization of the cassava farmers in the study area

Empirical Model for Economic Efficiency in cassava farmers: Following Simonyan and Onu (2023); Tanko et al (2020) the stochastic frontier normalized profit function model used is explicitly specified as:

$$In\pi_i = \beta_0+\beta_1 Inq_1+\beta_2 Inq_2+\beta_3 Inq_3+\beta_4 Inq_4+\beta_5 Inq_5+\beta_6 Inq_6+\beta_7 Inq_7+\beta_8 Inq_8+V_i - U_i \text{ ....(1)}$$

Where,

π_i= Normalized profit of ith farmer (in ₦ per cassava enterprise)

q_1 = Normalized price of family labour, (₦/manday)

q_2 = Normalized price of hired labour, (₦/manday)

q_3 = Normalized price of fertilizer in (₦)

q_4 = Normalized price of agrochemicals (₦)

q_5 = Normalized price of capital inputs (₦)

q_6 = Normalized price of cassava cuttings (₦)

q_7 = Farm size (ha)

q_8 = Annual depreciation on durable capital items (₦)

V_i = Normal random errors which are assumed to be independent and identically distributed having N (0, σ^2).

U_i = Non-negative random variables associated with the technical inefficiency of the cassava farmer

It is assumed that the technical efficiency effects are independently distributed and arise by truncation at (zero) of the normal distribution with mean U_i and variance δ^2, where U_i is specified as:

$$U_i=\delta_o+\delta_1 Z_{1i}+\delta_2 Z_{2i}+\delta_3 Z_{3i}+\delta_4 Z_{4i}+\delta_5 Z_{5i}+\delta_6 Z_{6i}+\delta_7 Z_{7i}+\delta_8 Z_{8i} \text{ ………………..……………… (2)}$$

Where;

U_i =Technical inefficiency of the i^{th} farmer

Z_1 = Age of farmer (years)

Z_2 = Level of education (No. of years spent in school)

Z_3 = Farming experience (years)

Z_4 = Household size (No.)

Z_5 = Extension contact (No.)

Z_6 = Credit status (Dummy variable, 1 for access, zero otherwise)

Z_7 = Membership of cooperative (1 for membership, zero otherwise)

Z_8 = Sex (binary variable, Male = 1, female = 0)

The above model was incorporated in the frontier model to determine the economic inefficiency of cassava enterprise. This was done with the belief that the variables have direct influence on the level of efficiency (Battese *et al.* 1995).

Results and Discussion: Summary Statistics of Production Factors: Profit efficiency of factor inputs such as farm size, cost of labour, cost of fertilizer, cost of agrochemicals, cost of cassava cuttings and annual depreciation are discussed in this section. Results show that an average cassava farmer cultivated a mean farm size of 1.58 hectares and produced an average of 15,240 kg (15.24 metric tons) of cassava roots per production season. This yield level aligns with smallholder productivity estimates in southeastern Nigeria, which range between 12–18 tons per hectare under semi-improved management (FAOSTAT, 2024). The average hired labour used was 54.62 mandays, while family labour averaged 79.18 mandays, confirming the labour-intensive nature of cassava production. Expenditure on fertilizer averaged ₦41,350, agrochemicals ₦23,480, cassava stem cuttings ₦29,720, and annual depreciation on durable capital items was estimated at ₦19,870. The wide variation between minimum and maximum values suggests heterogeneity in scale and management practices among farmers, a characteristic feature of smallholder cassava systems in Nigeria (Oyinbo et al., 2022).

Empirical results of the economic efficiency for the production factors: Table 2 presents the Maximum Likelihood Estimates (MLE) of the stochastic frontier normalized profit function for the economic efficiency of smallholder cassava production. The estimate of sigma-squared (σ^2 = 3.9184) is statistically significant at 1%, confirming the adequacy of the model and correctness of the specified distributional assumptions.

The gamma estimate (γ = 0.9146) is positive and statistically significant at 1%, indicating that approximately 91% of the variation in normalized profit is attributable to inefficiency effects rather than random shocks. This confirms the dominance of managerial and institutional factors in explaining profit variations and justifies the use of the stochastic frontier model. (Coelli et al., 2005). It also indicates that about 91% of the variation in output of cassava is caused by inefficiency of the producers. This confirms the presence of inefficiency and justifies the use of the stochastic frontier model over Ordinary Least Squares (Coelli et al., 2005). The result indicates that the normalized price of family labour (β_1 = 0.0924) is positive and significant at 5%, implying that a 1% increase in family labour utilization increases normalized profit by 0.0924%. This reflects the importance of household labour in smallholder cassava systems, consistent with findings by Ogundari (2021).

The coefficient of fertilizer (-0.1532) is negative and significant at 1%. This indirect relationship implies that as the price of fertilizer increased, the profit made by the farmers decreased and vice versa. An increase in the price of fertilizer will probably dispose farmers to use less fertilizer. The use of less fertilizer will adversely affect output and consequently profit will decrease. Also, an increase in the price of fertilizer will lead to an increase in the total cost of production which will affect profit negatively. This result is at variance with the findings of (Liverpool-Tasie et al., 2020 and Okorie et al, 2021) who found that improved soil fertility management as a result of increase in fertilizer application significantly enhanced cassava productivity and increased profitability in southeastern Nigeria. The elasticity of Cassava cuttings (0.1845) is positive and significant at 1%, suggesting that use of improved cassava varieties significantly raised farm profit. Improved cassava varieties have been shown to increase yield by 30–40% under smallholder conditions (International Institute of Tropical Agriculture [IITA], 2023). An increase in the quantity of cassava cuttings used will lead to an increase in output and as a result, profit will increase The coefficient of farm size (0.3718) is positively signed and significant at 1%, indicating economies of scale in cassava production. This implies that farmers with large farm sizes reap the benefits of the economies of scale as their levels of use of other inputs are commensurate with their large farm size. This finding is analogous with those of Amusa and Onu (2024) who found that large farm size could predispose the farmers to embark on commercial production The depreciated value of farm tools ($\beta_8 = 0.1015$) was positively related to normalized profit. This direct relationship implies that as depreciated value of farm tools increased, profit increased and vice versa. A higher depreciated value of farm tools and equipment implies that farm tools and equipment were intensively used. An intensive use of farm tools and equipment suggests the use of more of other inputs. The use of more of other inputs will lead to an increase in output. Consequently, profit will increase given that the price of output remains unchanged.

Determinants of economic inefficiency : The result of the determinants of economic efficiency is presented in Table 3. The inefficiency model showed that the signs and significance of the estimated coefficients in the model have an important implication on the economic (profit) efficiency of farmers. Based on this, all variables in the inefficiency model have negative coefficients except for age. The result shows that the coefficient of age (0.0317) is positive and significant at 5%, implying that older farmers tend to be more economically inefficient, possibly due to lower adaptability to improved technologies (Oyinbo et al., 2022). The relationship with age and inefficiency observed in this study also agrees with the work of Simonyan and Onu (2023). The results indicated that level of education ($\delta_2 = -0.0614$) is negative and highly significant at 1%, indicating that additional years of schooling reduce inefficiency. Education enhances managerial capability and technology adoption (Ogundari, 2021). Another implication of this findings is that many years of educational attainments enhance the acquisition of information on improved technologies and innovations (Okorie et al., 2021) . Farming experience ($\delta_3 = -0.0283$) is negative and statistically significant at the 5% level, suggesting that increased years of farming enhance farmers' ability to make efficient production decisions. This finding implies that experienced farmers are better able to allocate resources optimally, adopt appropriate technologies, and respond effectively to production risks. The result corroborates the findings of Akinsulu (2024), who reported that farming experience significantly improves technical efficiency among cassava farmers in Nigeria. Similarly, Dogba et al. (2021) emphasized that experience enhances learning-by-doing, thereby reducing inefficiency in smallholder agricultural systems. Household size ($\delta_4 = -0.0215$) is negatively signed and significant at the 10% level, indicating that larger household sizes contribute to improved efficiency. This can be attributed to the availability of family labour, which reduces dependence on hired labour and ensures timely execution of farm operations. In labour-intensive farming systems such as cassava production, household labour plays a crucial role in enhancing productivity. This finding is consistent with Olawuyi and Afolami (2023), who observed that household size positively influences efficiency by providing a reliable and cost-effective labour source. Access to credit ($\delta_6 = -0.2478$) is negative and highly significant at the 1% level, indicating that credit availability substantially reduces inefficiency. Access to financial resources enables farmers to procure inputs such as fertilizers, improved planting materials, and agrochemicals at the appropriate time, thereby preventing sub-optimal production decisions. This result aligns with the findings of Akinsulu (2024), who noted that credit access enhances farmers' capacity to operate closer to the production frontier. Furthermore, Dogba et al. (2021) highlighted that liquidity constraints are a major source of inefficiency among smallholder farmers in sub-Saharan Africa.

Cooperative membership ($\delta_7 = -0.2063$) is negative and statistically significant at the 5% level, implying that participation in farmer-based organizations reduces inefficiency. Cooperative societies facilitate access to productive inputs, credit, extension services, and market information, thereby improving farmers' overall productivity. In addition, collective action enhances bargaining power and reduces transaction costs. This finding is supported by Kehinde et al. (2025), who found that cooperative membership significantly improves technical efficiency through better access to resources and institutional support.

Distribution of Economic Efficiency

The distribution of cassava farmers according to their economic efficiency in production is shown in Table 4. The results indicated that the economic efficiency ranged from 0.36 to 0.95, with a mean of 0.73 (73%) indicating notable inefficiency in cassava production. This result implies that the smallholder cassava Farmers lose about 27% potential profit due to inefficiency in resource use. This result is similar to that of Okorie et al, (2021) who found mean profit efficiency of 73% among smallholder cassava farmers in Enugu State, Nigeria. The minimum economic efficiency of

0.36 (36%) and the maximum of 0.95 (95%) were obtained. The means for the best 10 and worst 10 are 0.44 and 0.92 respectively. This means that if an average farmer in the sample is to achieve economic efficiency he/she would require a 23% cost saving i.e., [1 - (0.73/0.95) x 100]. The worst economically inefficient farmer needs a cost saving of 45% i.e., [1 - (0.44/0.95) x 100].

This also implies that a smallholder cassava farmer can increase economic efficiency by 23% if productive inputs are optimally utilized. If this increase is achieved by these farmers, they will be operating on the production frontiers. Thus, there is still need for improvement on the productivity of farmers and income through increased efficiency in the use of existing resources. The best economically efficient farmers operated almost on the frontier, as depicted by the maximum economic efficiency of 0.95. However, there exists a gap between economic efficiency levels of best ten and worst ten farmers. To bridge this gap, the average best farmer needs to save 25% costs to attain to the frontier. This is in contrast with the findings of Ume *et al*. (2016) who found the mean economic efficiency of cassava farmers to be 84.34% and affirmed that about 15.66% of the profit is lost due to economic inefficiency.

Conclusion and Recommendation: Based on the findings of this research, it is concluded that smallholder cassava farming in Aninri Local Government Area of Enugu State is of the small scale type considering the average farm size cultivated. Smallholder cassava farmers in Aninri Local Government Area of Enugu State operate below optimal economic efficiency levels, primarily due to managerial and institutional constraints rather than random shocks. Addressing credit access, human capital development, and improved input dissemination can substantially close the observed efficiency gap. Enhancing economic efficiency in cassava production has significant implications for food security, rural employment, and agro-industrial development in southeastern Nigeria. This study also recommends that to expand cassava farmers' scale of operation, farmers in the study area should form cooperative societies so as to enable them have access to productive inputs that will enable them expand their resource base and consequently their scale of operation

References

Aigner, D., Lovell, C. A. K., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, *6*(1), 21–37. https://doi.org/10.1016/0304-4076(77)90052-5

Akinola, A. O., Obayelu, A. E., Shittu, A. M., & Akinbode, S. O. (2020). Production efficiency and its determinants in cassava production in Ogun State, Nigeria. *Ife Journal of Agriculture, 32*(1), 1–15.

Akinsulu, A. A. (2024). A stochastic frontier approach to determine technical efficiency of cassava farmers in Ondo State, Nigeria. *Journal of Agriculture and Environment, 20*(2), 43–52. https://doi.org/10.4314/jagrenv.v20i2.5

Amusa, T.A., & Onu, D.O., (2024). Factors influencing contribution of women to farm decision in rice producing households in Ebonyi State, Nigeria. *Faman Journal*, 24(2), 264-273

Awerije, B. O., & Rahman, S. (2014). Profitability and efficiency of cassava production at the farm level in Delta State, Nigeria. *African Journal of Agricultural Economics and Rural Development, 2*(3), 78–86.

Battese, G. E., & Coelli, T. J. (1995). A model for technical inefficiency effects in a stochastic frontier production function. *Empirical Economics, 20*(2), 325–332. https://doi.org/10.1007/BF01205442

Coelli, T. J. (1994). A guide to FRONTIER version 4.1: A computer program for stochastic frontier production and cost function estimation (CEPA Working Paper No. 7/96). University of New England, Centre for Efficiency and Productivity Analysis.

Coelli, T. J., Rao, D. S. P., O'Donnell, C. J., & Battese, G. E. (2005). *An introduction to efficiency and productivity analysis* (2nd ed.). Springer.

Dogba, K. B., Sarr, M., Diagne, A., & Arouna, A. (2021). Stochastic meta-frontier analysis of cassava production efficiency in Liberia. *African Journal of Agricultural and Resource Economics, 16*(1), 45–60..

Eze, C.C., Okoye, B.C., & Nwibo, S.U. (2023). Technical efficiency of smallholder cassava farmers in Southeat Nigeria: A stochastic frontier approach. *Journal of Agricultural Economics and Development*, 12(2), 45-56

Eze, E. U., Osuji, E. E., Enyia, C. O., Nwose, R. N., Ugochukwu, G. U., & Nwaizuzu-Daniel, J. C. (2023). Efficiency of marketing systems of cassava in Southeast Nigeria. *Emerging Issues in Agricultural Sciences, 6*, 44–52.

Food and Agriculture Organization. (2024). *FAOSTAT statistical database*. https://www.fao.org/faostat

Food and Agriculture Organization. (2024). *FAOSTAT statistical database*. Retrieved January, 2025, from https://www.fao.org/faostat

International Institute of Tropical Agriculture. (2023). *Cassava productivity and varietal performance report*. IITA.

Kehinde, A. D., Oyenpemi, L. O., & Oladimeji, O. O. (2025). Leveraging agricultural cooperative membership to improve the technical efficiency of smallholder cocoa farmers in Nigeria. *Scientific African, 27*, e02345. https://doi.org/10.1016/j.sciaf.2025.e02345

Liverpool-Tasie, L. S. O., Omonona, B. T., Sanou, A., & Ogunleye, W. O. (2020). Is increasing inorganic fertilizer use for maize production in Nigeria a profitable proposition? Evidence from household panel data. *Food Policy, 91*, 101887.

National Bureau of Statistics. (2023). *Agricultural performance survey report*. Abuja, Nigeria.

Nwadiolu, R., Kperegbeyi, J. I., Ewododhe, A. C. A., Adaigho, D. O., Samuel, A. P., & Nwankwo, W. (2024). Unleashing economic potential: Enhancing cassava production efficiency in Nigeria. *African Journal of Applied Research, 10*(1), 93–103.

Nwakpu, C. N. (2024). Technical efficiency of cassava farmers in Yewa Division of Ogun State, Nigeria. *Journal of Agricultural Economics and Development, 9*(1), 23–34.

Ogundari, K. (2021). Resource-use efficiency and productivity of cassava production in Nigeria: A stochastic frontier analysis. *Journal of Agricultural Economics*, 72(3), 1–15.

Ogundari, K., & Ojo, S. O. (2006). An examination of technical, economic and allocative efficiency of small farms: The case study of cassava farmers in Osun State of Nigeria. *Journal of Central European Agriculture, 7*(3), 423–432.

Okorie, O. J., Nwalieji, H. U., & Obi, A. (2021). Profit efficiency analysis of cassava production in Enugu State, Nigeria. *Journal of Agricultural Economics and Development*, 10(3), 55–67.

Okorie, O.J; Okon, U.E. and Enete, A.A (2021). Profit Efficiency Analysis of Cassava production in Enugu State, Nigeria. *Journal for the Advancement of Developing Economies.*10(1): 37-51

25

Olawuyi, T. O., & Afolami, C. A. (2023). Determinants of profit inefficiency of soybean producers in Niger State, Nigeria. *Badeggi Journal of Agricultural Research and Environment, 5*(3), 67–75.

Oluwasola, B. T., Omowunmi, B. O., & Nobert, A. N. (2025).Economic analysis and technical efficiency of cassava production in rural households of Yewa South Local Government, Ogun State. *Journal of Bioresource Management, 12*(4), 103–112.

Onu, D. O., Somonyan, J. B. and Igwe, K.C. (2023). Farm Plans Optimization for Cassava Based Farmers in Enugu State, Nigeria: An Application of Linear Programming (LP) and Target Minimization of Total Absolute Deviation (T-MOTAD). *Journal of Agriculture, Environmental Resources and Management.* 5(6*):* 1022-1037

Onu, D.O, Simonyan J.B. and K.C Igwe. 2023. Efficient resource allocation patterns for cassava-based food crop farmers in Abia State, Nigeria. *Journal of Agripreneurship and Sustainable Development* 6(4):204-217.

Onu, D.O. and Onu, C.I. (2024). Optimum Production Plan for Cassava-Based-Crop Farmers in Nigeria: Evidence from Ebonyi State, Nigeria. *UNIZIK Journal of Agricultural Economics and Extension (UJAEE).* 1(1): 03-113

Onu, D.O.and Okoronkwo, F.C. (2019). Comparative Analysis of Technical Efficiency and Profitability of Broiler and Layer Production Enterprises in Aba Agricultural Zone, Abia State Nigeria. *FUTO Journal Series.*5 (1): 42 – 56

Simonyan, J.B. and Onu, D.O (2023). Economic Efficiency in Egg Enterprise in Abia State, Nigeria. *Agricultural Economics and E*

Tanko, Y., Yong, K. C., & Islam, R. (2020).Economic efficiency of farm size, fertilizer, and improved seeds on rice production in Kano State, Nigeria. *Academic Journal of Economic Studies, 6*(2), 21–32.

Udealor, A., Unamma, R. P. A , Ezulike, T. O., Okwor, G. C., Ene ,L. S. O., Ikeorgu, J. E. G. and Ezumah, H. C. (2019) Evaluation of cassava-yam-maize intercrop in the rainforest zone of Nigeria. In: cassava-based cropping systems research. Contributions from the second annual meeting of the collaborative group in cassava-based cropping systems research, organized by the Resource and Crop Management Programme, Nigeria, IITA, Ibadan. *xtension Research Studies.* 11(2): 1-14

Ume, S. I., Onuh, N. C., Jiwuba, F. O., & Onunka, B. N. (2016). Technical efficiency among women cassava smallholder farmers in Ebonyi State, Nigeria. *Asian Journal of Agricultural Extension, Economics & Sociology, 12*(2), 1–6.

Table 1: Summary Statistics of Output and Inputs in Cassava Production Enterprise (n = 120)

Variable	Mean	Min	Max
Output (kg)	15,240	4,800	34,600
Farm size (ha)	1.58	0.42	3.90
Hired labour (mandays)	54.62	0.00	160.00
Family labour (mandays)	79.18	12.00	210.00
Fertilizer (₦)	41,350	0.00	118,000
Agrochemicals (₦)	23,480	0.00	82,500
Cassava cuttings (₦)	29,720	7,500	90,000
Annual depreciation (₦)	19,870	0.00	55,000

Source: Field Survey, 2025.

Table 2: Maximum Likelihood Estimates of the Stochastic Frontier Normalized Profit Function for Cassava Farmers

Variables	Parameters	Coeff	Std error	
Constant	β_0	-0.8934	0.3547	-2.5186**
Normalized price of family labour	β_1	0.0924	0.0404	2.2874**
Normalized price of hired labour	β_2	0.1186	0.0821	1.4442
Normalized price of fertilizer	β_3	-0.1532	0.0332	-4.6127***
Normalized price of agrochemicals	β_4	0.0827	0.0518	1.5965
Normalized price of cassava cuttings	β_6	0.1845	0.0535	3.4472***
Farm size	β_7	0.3718	0.0637	5.8324***
Annual depreciation	β_8	0.1015	0.0583	1.7421*
Log-likelihood function		-128.7745		
Sigma squared (σ^2)		3.9184	0.2026	19.336***
Gamma (γ)		0.9146	0.0142	64.1827***
L-R test		59.2148		

Source: Field Survey, 2026. Note: *, **, * significant at 1%, 5%, 10%.**

Table 3: Determinants of economic inefficiency among smallholder cassava farmers

Variables	Parameters	Coefficient	Standard Error	t-ratio
Constant	δ_0	0.6845	0.2730	2.5074**
Age	δ_1	0.0317	0.0148	2.1456**
Education	δ_2	-0.0614	0.0159	-3.8521***
Experience	δ_3	-0.0283	0.0128	-2.2164**
Household size	δ_4	-0.0215	0.0120	-1.7853*
Extension contact	δ_5	0.0247	0.0238	1.0388
Credit access	δ_6	-0.2478	0.0528	-4.6893***
Cooperative membership	δ_7	-0.2063	0.0752	-2.7416**
Sex	δ_8	0.0184	0.0191	0.9635

Source: Survey analysis, 2026/ computed from Frontier 4.1 version

Note: ***, **, and * implies statistical significance at the 0.01, 0.05 and 0.10 probability levels respectively.

Table 4: Frequency distribution of economic efficiency

Efficiency index	Number	Percentage
0.31–0.40	6	5.00
0.41–0.50	14	11.67
0.51–0.60	18	15.00
0.61–0.70	22	18.33

26

0.71–0.80	30	25.00
0.81–0.90	20	16.67
0.91–1.00	10	8.33
Total	120	100
Mean	0.73	
Minimum	0.36	
Maximum	0.95	
Mean of worst 10	0.44	
Mean of best 10	0.92	

Source: Survey analysis, 2026

27