Technical Efficiency of Honey Production by Members of Apicultural Society of Nigeria, Anambra State Chapter

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Abstract

The study examined the technical efficiency of honey production among members of the Apicultural Society of Nigeria, Anambra State chapter. Using a random sample from 80-chapter members. A one stage stochastic frontier analysis, and principal factor analysis technique were the methods used to operationalize the study objectives. The mean technical efficiency (TE) was 0.8874, implying that a typical member of the association is about 88.7% technically efficient in honey production. The sigma squared (0.0299) revealed that TE accounted for 97.1% of the variation in output. The study further established that production factors such as the number of beehives (1.78)*, depreciation on equipment (5.18)***, and total logistics expenditure (9.71)*** significantly contributed to the TE of output. The determinants of TE were found to be level of education (2.07)**, farming experience (1.70)*, and household size (2.05)**. Furthermore, the problems affecting the TE of honey production were rotated into three (institutional, management, and economic) factors. These three factors jointly explained 97.08% of the total variance in the problems affecting honey production in the study area. Among the three factors, the institutional factor accounted for the majority 82.71%) of the explained variance. The problems grouped under institutional factors included high labour costs reducing profits, inadequate markets, poor information on quality standards, inadequate access to finance hindering progress, and poor pricing of products. The study clearly revealed that production under association yields better output due to the training available to members. To further improve TE frontier, these challenges need to be strategically addressed.

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1. Introduction

The agricultural sector remains the largest employer of labour in Nigeria and continues to play a central role in national economic development and rural livelihoods. Recent estimates indicate that agriculture engages more than 60–70% of the working population and contributes substantially to food security, income generation, and poverty reduction, particularly in rural areas (National Bureau of Statistics [NBS], 2023; World Bank, 2022) [16, 26]. Contemporary literature like Obianefo et al. (2019) emphasized that Nigerian agriculture is composed of crop production, livestock, fisheries, and forestry, all of which contribute to national output and export earnings, although, with varying levels of productivity and efficiency (Obianefo et al., 2019) [18].

Beyond staple crop production, the Food and Agricultural Organization (FAO) observed a growing attention which is being directed toward high-value agribusinesses such as apiculture that offer opportunities for income diversification and inclusive rural development (FAO, 2021) [13]. The study by Uchechukwu et al. (2024) [25] noted that apiculture, or beekeeping has been increasingly recognised as a profitable agricultural enterprise with strong economic and ecological benefits. Ojo et al. (2017) noted that bee-keeping is a profitable agricultural venture that requires little investment. Corroboratively, FAO (2021) [12, 13] described honey production as a low-capital, land-efficient activity capable of generating income while supporting biodiversity through pollination services. Despite this potential, Alabi and Anekwe (2023) [4] opined that honey production in Nigeria remains largely underdeveloped and dominated by small-scale producers who relied mainly on traditional methods. Again, Akinmulewo et al. (2017) [3] submitted that this underdeveloped nature of apicultural sector in Nigeria limits honey output and profitability. Current global market trends further reinforce the relevance of honey production, as demand for natural sweeteners and health-oriented food products continues to rise. Market projections suggest a sustained growth in the global honey market driven by consumer preference for natural and functional foods (Zion Market Research - ZMR, 2019; IMARC Group, 2023). However, Zion Market Research estimated that between 2018 to 2025, honey will inject USD10,336 million to the world's market economy (ZMR, 2019).

This empirical evidence by Alabi and Anekwe (2023) [4] and Uchechukwu et al. (2024) [25] uncovered that technical inefficiency is a major constraint to honey production in Nigeria. Studies from different agro-ecological zones in Nigeria showed that most honey producers operate below their optimal production frontier, this report implied a significant scope for improving output without increasing input use (Alabi & Anekwe, 2023; Uchechukwu et al., 2024) [4, 25]. Example, Alabi and Anekwe (2023) [4] found an average technical efficiency scores below 60% among honey and beeswax producers in Northern Nigeria, suggesting that output could be substantially increased through better management practices and technology adoption. Equally, Uchechukwu et al. (2024) [25] revealed that inefficiencies in hive management, harvesting techniques, and pest control significantly reduced honey yield among smallholder producers in Southeastern Nigeria. These findings is an indication that productivity challenges in apiculture are less about resource scarcity and more about inefficient resource utilization.

Conceptually, technical efficiency has therefore become central to contemporary agricultural efficiency studies. Put differently, Ajayi et al. (2018); Amos. (2018) assert that "efficiency refers to the success of producing a large amount of output as possible given a set of input.

Obianefo et al. (2021) [19] and Obianefo et al. (2023) [22] referred to technical efficiency as the ability of producers to obtain maximum output from a given set of inputs. This is widely used to assess performance gaps and guide policy and farm-level decision-making (Coelli et al., 2005; Abbas et al., 2024) [9]. Scholars like Adebayo et al. (2020) [1] and Erena et al. (2021) [11] uncovered that improving technical efficiency can lead to substantial productivity gains and income growth without additional capital investment, this observation is very relevant for smallholder farmers. In apiculture, efficiency analysis is particularly important because honey production depends heavily on management skills, timing, hive placement, and environmental interactions rather than on large quantities of purchased inputs.

Several literatures identified socio-economic and institutional factors as key determinants of technical inefficiency in agricultural production. Variables such as age, education level, farming experience, household size, access to extension services, cooperative membership, and access to credit have been uncovered to significantly influence efficiency levels among farmers (Ndubueze-Ogarak., 2021; Obianefo et al., 2023; Abbas et al., 2024; Uchechukwu et al., 2024) [17, 22, 25]. Specifically, for apiculture, Alabi and Anekwe (2023) [4] and FAO (2021) [12, 13] found education and training to have enhanced beekeepers' ability to adopt improved hive technologies, disease management practices, and hygienic harvesting methods, thereby improving efficiency and output quality. Conversely, limited extension contacts, poor access to credit, and reliance on traditional practices have been associated with higher inefficiency levels (Alabi & Anekwe, 2023; FAO, 2021) [4, 12, 13]. Also, age, extension contact, level of education and farm size, access to credit and access to labour (Bethel et al., 2016); household size, age and farming experience (Sudrajat, 2017) [7, 23] were similarly found as the inefficiency variables affecting farmer's production capacity.

In Anambra State, honey production is being actively promoted through the Apicultural Society of Nigeria (ASN), particularly in response to rising domestic demand and emerging export opportunities supported by structured trade and quality control initiatives. However, producing honey alone is not enough for achieving sustainable income growth if production processes remain inefficient. Given the predominance of small-scale producers and the technical nature of apiculture, understanding the efficiency with which members of the ASN utilize available resources is critical. However, Abbas et al. (2024) and Erena et al. (2021) [11] stressed that identifying inefficiency sources is a prerequisite for designing effective extension programmes, training interventions, and policy support mechanisms aimed at improving productivity and competitiveness. It is against this backdrop, that we identified a clear need to empirically examine the level of technical efficiency exhibited by honey producers who are members of the Apicultural Society of Nigeria, Anambra State Chapter. By identifying efficiency levels and the socio-economic factors contributing to inefficiency, the study will provide evidence that can support targeted interventions to improve honey production, enhance incomes, and strengthen the contribution of apiculture to rural development and agricultural diversification in the State.

1.1. The Objective of the Study

The specific objectives of the study are to:

1. determine the level of technical efficiency of honey production among members of the Anambra State chapter of Apicultural Society of Nigeria (ASN),
2. ii ascertain the determinants of technical efficiency among members of ASN, and
3. find out the problems affecting technical efficiency of honey production by members of ASN in the study area.

2. Empirical Review

2.1. Level of technical efficiency of honey production among ASN members

There are several empirical studied that have existed in the area of apiculture, not in this very study location. This study is novel as it remains one of the first to investigate this topic in the study area. The study by Alabi and Anekwe (2023) [4] on technical efficiency of honey and beeswax production in Kaduna State found a mean technical efficiency of 0.563, this report implied that honey producers still have the opportunity to raise output by about 43.7% using existing technology and input levels if they operated on the best practice frontier. Again, Dagnachew (2020) [10] on technical efficiency and its determinants of honey production in Ethiopia uncovered an overall mean technical efficiency of 0.605, the result showed a clear efficiency gains associated with improved beehive technology and better production practices. Moreso, Aşkan (2023) [6] on honey production effectiveness in Erzincan and Van Provinces used the data envelopment analysis (DEA) approach and found the average technical efficiency 65.7% for constant return to scale (CRS), with a bootstrap average of 60.5%, and 71.6% for variable return to scale (VRS) with a bootstrap average of 70.0%. the results revealed inefficiency of roughly 30% to 39% depending on specification.

2.2. Determinants of Technical Efficiency Among ASN Members

Based on the determinants, Alabi and Anekwe (2023) [4] found that efficiency differences were closely related to operational and support conditions, with producers' performance constrained by issues such as limited finance and weak support services, which typically shape how well inputs are converted into output in practice. Dagnachew (2020) [10] on determinants of honey production efficiency found that efficiency improved notably among adopters of improved beehives (mean TE 0.89), reinforcing the point that technology choice and the capacity to implement improved husbandry practices are not optional extras, they sit at the centre of efficiency differences across producers. Also, Aşkan (2023) [6] found that factors such as income, cooperative membership, and benefiting from veterinary services were observed as relevant in the context of enterprise continuity and technical support; these are practical "efficiency variables" because they affect input quality, disease control, and the producer's ability to sustain better management routines.

2.3. Problems Affecting Technical Efficiency of Honey Production by ASN Members

The study by Alabi and Anekwe (2023) [4] equally observed that producers reported concrete bottlenecks including unfavourable weather, pests and diseases, finance problems, labour shortages, lack of equipment, inadequate storage, weak extension service, and theft. These constraints directly reduce technical efficiency by disrupting production timing, lowering hive productivity, and increasing avoidable losses. Again, Dagnachew (2020) [10] found that high cost, inadequate skills, and limited access to equipment, and support translates into measurable technical inefficiency.

3. Research Methodology

3.1. The Study Area

Anambra state is in Southeastern Nigeria comprising of 21 (Aguata, Awka North, Awka South, Anambra East, Anambra West, Anaocha, Ayamelum, Dunukofia, Ekwusigo, Idemili North, Idemili South, Ihiala, Njikoka, Nnewi North, Nnewi South, Ogbaru, Onitsha North, Onitsha South, Orumba North, Orumba South and Oyi) local government area, the State is sub-divided into four (Aguata, Awka, Anambra, and Onitsha) agricultural zones to aid planning and rural development. The state administrative headquarter is located in Awka. According to NPC (2006), Anambra State has a population of 4,055,048 people. The State equally has an estimated land area of 4,865sqkm. Anambra State is located on a 5° 32' and 6°45' N and Longitude 6°43' and 7° 22 'E

3.2. Sampling Procedure and Method of Data Collection

The sample representative was made up the members of Anambra State chapter of Apicultural Society of Nigeria (ASN) from the four agricultural zones which are; Anambra zone (Anambra East, Anambra West, Ayamelum, and Oyi local government areas), Onitsha (Idemili North, Idemili South, Ihiala, Ogbaru, Onitsha North, and Onitsha South local government areas), Awka zone (Awka North, Awka South, Dunukofia, Ekwusigo, and Njikoka local government area), and Aguata zone (Aguata, Anaocha, Nnewi North, Nnewi South, Orumba North, and Orumba South local government areas). Anambra State is situated between Latitudes 5° 32' and 6°45' N and Longitude 6°43' and 7° 22 'E respectively. The state has an estimated land area of 4,865sqkm. Furthermore, the data was collected from four days (15th – 18th July 2024) training session organized by the Anambra State Chapter of Apicultural Society of Nigeria. The researcher(s) used SurveyCTO collect (Android data collection Application) to randomly select the study representative for the study. 20 members were interviewed in each day of the training to bring the sample size to 80 honey producers for the study.

3.3. Method of Data Analysis

A Stochastic production function (SPF) model and principal factor analysis (PFA) were used to achieve the stated objectives of the study.

A. The SPF for Objective One is Defined by:

$$Y_i = f(X_i.\beta_i) + e_i \quad \text{….. eqn. 1}$$

$$e_i = V_i - U_i \quad \text{…. eqn. 2}$$

Where:

Y_i = Quantity of honey produced by ith number of farmers
X_i = Vector of the input used
β_i = the parameter to be estimated
e_i = the error term
U_i = technical inefficiency effect
$f(X_i.\beta_i)$ = suitable function of the vector.

Thus, the technical efficiency was better estimated with Cobb Douglas double log function defined by:

$$LnY = \beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \ldots \beta_5 LnX_5 + (V_i - U_i) \quad \ldots\text{. eqn. 3}$$

Where:

Ln = natural logarithm
Y = total honey output (kg)
X_1 = number of bee hive (No)
X_2 = labour employed (manday)
X_3 = depreciation on equipments (N)
X_4 = Logistic expenditure in Naira made up of wages/salary, transportation cost, and miscellaneous (N)
β_0 = constant term
$\beta_1 - \beta_n$ = regression coefficient
V_i = random variability in the production that cannot be influenced by the farmers
U_i = deviation from maximum production capacity associated with technical inefficiency effect.

A linear stochastic model was used to model the factors assumed to affect the technical efficiency of honey production in the study area. Such factors relates to the socioeconomic and management variable. This model is defined by:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \ldots \delta_6 Z_6 \quad \ldots\text{. eqn. 4}$$

Where:

U_i = inefficiency effect
Z_1 = sex (dummy; 1= male, and 0 = female)
Z_2 = age (years)
Z_3 = Marital status (dummy; 1 = married, 0 = otherwise)
Z_4 = level of education (years of formal learning)
Z_5 = farming experience (years)
Z_6 = household size (No)
δ_0 = constant
$\delta_1 - \delta_6$ = parameter to be estimated.

B. The PFA for Objective Two is equally defined by:

$$X_{ij} = \delta_{i1}F_{i1} + \delta_{i2}F_{i2} + \delta_{jm}F_{ik} + e_{ij} \quad \ldots\text{. eqn. 5}$$

Where:

X_{ij} = observation on variables
X_j = the ith sample number
F_iK = score on kth number of factors (K = 1, 2, 3 …m)
F_1-F_m = common factors
e_{ij} = the value on the residual variable
E_j = the ith sample number
j_i…. j_m = factor loading (regression weight).

The associated assumption will be applied accordingly while the suitable number of factors will subjectively be selected based on varimax rotated factor matrix obtained using SPSS version 23.0 software. The explanatory techniques using Principal component factor model with interactions and varimax rotation will be adopted. According to Obianefo et al. (2019b); Obianefo et al. (2020) [18, 21], the factor loading under constraint (beta weight) represented a correlation of the variables (constraints areas).

Note: Factor loading of 0.30 and above will be used in naming and interpretation.

4. Results and Discussions

4.1. Technical efficiency of honey production among members of the Anambra State chapter of Apicultural Society of Nigeria.

The results of the parameter estimate of the stochastic frontier production function are presented in Table 1. Honey output, measured in kilograms, was specified as the dependent variable in the stochastic frontier model. The estimated log-likelihood value of 203.3569 indicates a good model fit, suggesting that the specified stochastic frontier adequately explained variations in honey production among the sampled farmers. In line with frontier theory, a higher log-likelihood value reflects a better-fitting efficiency model (Coelli et al., 2005) [9].

The estimated mean technical efficiency of 0.8874 implied that, on average, honey producers in the study area operated at 88.74% of their potential production frontier. This suggests that farmers were only 11.26% below their maximum attainable output, given the existing technology and input levels. This relatively high efficiency level indicates that honey production among members of the Apicultural Society of Nigeria (ASN) in Anambra State is fairly efficient compared to results reported in other apiculture studies. For instance, Alabi and Anekwe (2023) [4] reported a mean technical efficiency of 0.563 among honey producers in Northern Nigeria, while Dagnachew (2020) [10] found a mean technical efficiency of 0.605 among Ethiopian honey producers. The higher efficiency observed in the present study may reflect the role of collective learning, shared experience, and institutional support associated with membership of the ASN.

The estimated sigma-squared value of 0.0299 further confirmed the presence of inefficiency effects in honey production. The inefficiency parameter indicates that approximately 97.0% of the variation in honey output is attributable to technical inefficiency rather than random noise. This finding reinforces the relevance of efficiency analysis in apiculture and aligned with recent efficiency studies which argue that productivity gaps in smallholder agriculture are largely driven by management and operational inefficiencies rather than pure stochastic factors (Abbas et al., 2024; Erena et al., 2021) [11]. The implication is that substantial output gains can still be achieved through improved efficiency, even without expanding input use.

Furthermore, the coefficient of the number of beehives was negative and statistically significant at the 10% level of probability, with an absolute magnitude of 0.1820. This implied that a unit increase in the number of beehives owned by farmers reduced honey output by about 18.20%. Although this result appears counterintuitive, it suggests that many farmers may lack the managerial capacity, labour, or technical skills required to efficiently manage a larger number of hives. Similar findings were reported by Uchechukwu et al. (2024) [25], who observed that hive expansion without corresponding improvements in management practices often leads to lower productivity per hive.

This result contrasts with the argument that increasing hive numbers automatically increases output, and instead highlights the importance of capacity building and management efficiency in apiculture.

In contrast, the coefficient of depreciation on equipment was positive and statistically significant at the 1% level of probability, with a magnitude of 0.3829. This implied that a unit increase in investment in honey production equipment increased output by 38.29%. This finding aligned with Alabi and Anekwe (2023) [4] and FAO (2021) [12, 13], who reported that access to improved beekeeping equipment enhances harvesting efficiency, reduces post-harvest losses, and improves honey quality. The result confirmed the a-priori expectation that investment in modern equipment strengthens technical efficiency by enabling farmers to operate closer to the production frontier.

Similarly, the coefficient of logistics was positive and statistically significant at the 1% level, with a magnitude of 0.1078. This indicates that an increase in expenditure on logistics-related activities such as wages, training, transportation, advertisement, and other operational costs led to a 10.78% increase in honey output. This finding supports recent empirical evidence by Abbas et al. (2024), which showed that improved logistical support and operational spending enhance production efficiency by facilitating timely input use, access to markets, and knowledge dissemination. In the context of apiculture, logistics play a critical role in hive monitoring, honey evacuation, and market access, all of which contribute to improved technical efficiency.

However, the coefficient of labour was not statistically significant at the 10%, 5%, or 1% levels of probability. This suggests that variations in labour use did not significantly influence honey output among ASN members. This finding contrasts with earlier agricultural studies that identified labour as a significant determinant of output, but it is consistent with recent apiculture studies which argue that honey production is less labour-intensive and more dependent on management quality, timing, and technology than on sheer labour input (Dagnachew, 2020; Uchechukwu et al., 2024) [10, 25]. The result implied that increasing labour alone, without corresponding improvements in skills and management practices, may not lead to higher honey output.

4.2. Determinants of technical inefficiency of honey production among members of Anambra State chapter of Apicultural Society of Nigeria.

The inefficiency variables estimated in the model included sex, age, marital status, level of education, farming experience, and household size. The results showed that sex, age, and marital status were not statistically significant at the 10%, 5%, or 1% levels of probability. This implied that differences in gender, age, or marital status did not systematically explain variations in technical efficiency among honey producers in the study area. The result did not agree with Bethel, et al., (2016); Sudrajat, (2017) [7, 23] whose findings identified age, gender, among other socioeconomic and management variables as the inefficiency variables affecting technical efficiency.

This finding equally contrasts with many recent agricultural efficiency studies which identified demographic characteristics as significant sources of inefficiency. For example, Ndubueze-Ogarak (2021) [17] and Abbas et al. (2024) found age and gender to be significant determinants of efficiency among smallholder farmers in Nigeria, arguing that younger and male farmers often have greater physical capacity and better access to productive resources. Similarly, Obianefo et al. (2023) [22] reported that marital status influenced labour availability and management efficiency in farm enterprises. However, the absence of significance in the present study suggests that apiculture may differ from conventional crop and livestock farming, as honey production relies less on physical strength and more on management skills, experience, and timing. This supports the argument by Uchechukwu et al. (2024) [25] that demographic factors tend to matter less in apiculture than in more labour-intensive agricultural enterprises.

The coefficient of level of education was positive and statistically significant at the 5% level of probability, with a magnitude of 0.0081. This implied that a one-year increase in formal education reduced technical efficiency by 0.81%. Although counterintuitive, this result suggests that as members of the association become more educated, they may allocate less time and attention to beekeeping in favour of non-farm or white-collar employment opportunities. Similar findings were reported by Alabi and Anekwe (2023) [4], who observed that more educated honey producers were often engaged in multiple livelihood activities, reducing their managerial focus on apiculture. Erena et al. (2021) [11] also noted that education does not automatically translate into higher technical efficiency unless it is complemented by enterprise-specific training and sustained farm engagement. In this context, formal education alone may not enhance efficiency if it leads to divided attention rather than improved beekeeping practices.

In contrast, the coefficient of farming experience was negative and statistically significant at the 10% level of probability, with a magnitude of 0.0112. This implied that a one-year increase in beekeeping experience increased technical efficiency by 1.12%. This finding underscores the importance of learning-by-doing in apiculture, where practical knowledge accumulated over time improves hive management, harvesting techniques, and disease control. This result aligned with the study by Uchechukwu et al. (2024) [25], who found that experienced beekeepers consistently operated closer to the production frontier due to better understanding of seasonal patterns and hive behaviour. The finding reinforces the view that experience is a critical driver of efficiency in technically sensitive enterprises such as honey production.

Furthermore, the coefficient of household size was negative and statistically significant at the 5% level of probability, with a magnitude of 0.0152. This implied that a one-person increase in household size increased technical efficiency by 1.52%. This result suggests that larger households provide readily available family labour, which supports routine hive management, harvesting, and processing activities at minimal or no monetary cost. Similar findings were reported by Dagnachew (2020; Ndubueze-Ogarak (2021) [10, 17] and Abbas et al. (2024), who showed that household labour availability improves efficiency by reducing reliance on hired labour and ensuring timely farm operations. The result also corroborates the report of Ohajianya et al. (2015) who noted that large household size supplies cheap labour or in most cases free labour to the farm. In apiculture, where frequent monitoring of hives is essential, household labour appears to play a supportive role in improving technical efficiency.

Similarly, the results indicate that the key determinants of technical efficiency among members of the Apicultural Society of Nigeria, Anambra State Chapter, are level of education, farming experience, and household size. While education was associated with reduced efficiency, farming experience and household size enhanced efficiency.

Table 1: Maximum likelihood parameter estimate of stochastic production frontier (n = 80)

Variable	Parameter	Coefficient	Standard error	t-ratio
Production function				
Constant	β_0	0.3656	0.2278	1.60
No of bee hive	β_1	-0.1820	0.1022	-1.78*
Total labour	β_2	0.0166	0.0926	0.18
Dep. On equipments	β_3	0.3839	0.0742	5.18***
Total logistics	β_4	0.1078	0.0111	9.71***
Inefficiency parameter				
Constant	δ_0	0.2568	0.0449	5.71
Sex	δ_1	-0.0242	0.0188	-1.29
Age	δ_2	-0.0015	0.0013	-1.18
Marital status	δ_3	0.0167	0.0198	0.85
Level of education	δ_4	0.0081	0.0039	2.07**
Farming experience	δ_5	-0.0112	0.0066	-1.70*
Household size	δ_6	-0.0152	0.0074	-2.05**
Sigma squared	δ^2	0.0299	0.0001	17.65***
Gamma	γ	0.9770	0.80647	5.52***
Log likelihood function	= 203.3569			
Mean efficiency	= 0.8874			

Source: Field Survey Data, July 2024. (*) significant at 10%, (**) significant at 5%, (***) significant at 1%.

4.3. Level of Technical Efficiency

The distribution of technical efficiency among members of the Apicultural Society of Nigeria, Anambra State Chapter, is presented in Table 2. The results showed that the mean technical efficiency was 88.74%, indicating that, on average, honey producers operated close to the production frontier. This implied that members could still increase honey output by about 11.26% using existing technology and input combinations if inefficiencies were eliminated. The minimum and maximum technical efficiency scores were 63.40% and 99.28%, respectively, revealed some degree of variation in efficiency levels across producers, although most farmers clustered around relatively high efficiency values.

A closer examination of the efficiency distribution showed that the largest proportion of members, 27.73%, recorded technical efficiency indices between 0.6340 and 0.8601. This group represents farmers who are moderately efficient but still operate noticeably below the best practice frontier, suggesting room for improvement through better management practices and technical support. Meanwhile, 15.00% and 14.54% of the members recorded efficiency levels between 0.8602–0.9072 and 0.9073–0.9324, respectively, indicating relatively strong performance. Furthermore, 19.01% of the members achieved efficiency scores between 0.9325–0.9598, while as much as 23.64% fell within the highest efficiency range of 0.9599–0.9928. This concentration of farmers in the upper efficiency brackets suggests that a sizeable proportion of ASN members have adopted effective production practices and are managing their beekeeping operations efficiently.

The relatively high mean technical efficiency obtained in this study compares favourably with recent empirical findings in apiculture and related agricultural enterprises. For instance, Dagnachew (2020) [10] reported an average technical efficiency of 60.5% among honey producers in Ethiopia, while Alabi and Anekwe (2023) [4] found a lower mean efficiency of about 56% among honey and beeswax producers in Northern Nigeria, indicating substantial inefficiencies. Similarly, Aşkan (2023) [6], using Data Envelopment Analysis, reported average technical efficiency values ranging between 60% and 72% for honey producers in Turkey, depending on the scale assumption. Compared with these studies, the higher efficiency levels observed among ASN members in Anambra State suggest better managerial performance, possibly driven by cooperative membership, peer learning, and exposure to improved production practices.

However, the presence of farmers with efficiency levels as low as 63.40% indicates that efficiency gains are not evenly distributed. This supports the argument by Uchechukwu et al. (2024) [25] that even within organized producer groups, differences in experience, management skills, and access to technical support can lead to wide disparities in efficiency outcomes. The findings therefore suggest that while many members of the Apicultural Society of Nigeria in Anambra State are performing close to optimal levels, a non-negligible proportion still operate below potential and could benefit from targeted training, extension services, and practical capacity-building interventions.

Table 2: Level of technical efficiency among members. (n = 80)

Technical efficiency interval	Frequency	Percentage	Mean technical efficiency
0.6340 - 0.8601	22	27.73	
0.8602 - 0.9072	12	15.00	0.8874
0.9073 - 0.9324	12	14.54	
0.9325 - 0.9598	15	19.09	
0.9599 - 0.9928	19	23.64	
Min. = 0.6340			
Max. = 0.9928			

Source: Field Survey Data, July 2024.

4.4. Problems facing honey production among members of Apicultural Society of Nigeria, Anambra State chapter.

Principal factor analysis was employed to identify and operationalize the key problems affecting the technical efficiency of honey production among members of the Apicultural Society of Nigeria in the study area. Prior to factor extraction, the dataset was subjected to a series of diagnostic tests to confirm its suitability for factor analysis. The Kaiser–Meyer–Olkin (KMO) Measure of Sampling Adequacy yielded a value of 0.708 (Appendix, Table a), which exceeds the recommended minimum threshold of 0.60 and falls within the acceptable range of 0.7–1.0. This indicates that the sample was adequate and that the variables shared sufficient common variance for factor analysis (Obianefo et al., 2020; Obianefo et al., 2022) [21]. The normality and relevance of the variables were further assessed using the communality values (Appendix, Table b). All variables recorded communality values above 0.50, implying that each variable contributed meaningfully to the extracted factors and none required deletion. This conforms with the recommendation that variables with communalities below 0.50 should be excluded to improve factor solution quality (Obianefo et al., 2020; Hair et al., 2022) [21, 14]. In addition, all retained variables exhibited positive eigenvalues, ensuring convergence and interpretability of the factor structure.

To assess internal consistency, a Cronbach's alpha reliability test was conducted. The result produced a very high alpha coefficient of 0.970 (Appendix, Table c), confirming that the measurement items were highly reliable and internally consistent. Such a value indicates that the responses were stable and that the instrument effectively captured the underlying constraints affecting honey production efficiency (Taber, 2018; Boateng et al., 2020) [24, 8]. The Promax rotation method was adopted to allow for correlation among factors, while variables with factor loadings below 0.50 were suppressed to ensure clarity and robustness of the factor solution.

The Promax rotation extracted three distinct factors, namely institutional, management, and economic factors. Factor 1, labelled institutional factors, accounted for the largest share of the explained variance at 82.71%. Factor 2, management factors, explained 11.91% of the variance, while Factor 3, economic factors, accounted for 2.46%. Collectively, the three factors explained 97.08% of the total variance in the problems affecting technical efficiency of honey production among ASN members, indicating that the identified constraints comprehensively captured the major sources of inefficiency in the study area.

Factor 1, the institutional factor, emerged as the most dominant constraint. Variables loading strongly on this factor included high cost of labour affecting profits, inadequate market access, poor information on quality standards, inadequate finance, and poor pricing of honey products. These constraints point to systemic and market-related bottlenecks that limit producers' ability to convert inputs into optimal output. Similar institutional challenges have been reported in recent apiculture studies. For instance, Alabi and Anekwe (2023) [4] found that limited access to finance, weak market structures, labour constraints, and poor extension support significantly reduced honey productivity in Nigeria. Likewise, Uchechukwu et al. (2024) [25] observed that poor market coordination and lack of price information constrained efficiency among smallholder beekeepers in Southeastern Nigeria. These findings suggest that even when producers possess technical skills, institutional failures can substantially undermine production efficiency.

Table 3: Problems facing association memebers on honey production:

Sn.	Probles facing the members	Pattern Matrix^a		
		Institutional	Management	Economic
1	High cost of labour affect profits	0.984		
2	Inadequate market	0.951		
3	Poor information on quality standards	0.901		
4	high level of inadequate finance hinders progress	0.853		
5	Poor pricing of products	0.851		
6	High cost of equipment/tools		0.739	
7	High honey fermentation and crystallization		0.655	
8	High rate of poor cooperation among members of the association that affect production		0.593	
9	Inefficiency in management of resources hinder productivity progress		0.532	
10	Poor storage hinders profitability			0.996

Source: Field Survey Data, July 2024

Factor 2, the management factor, comprised constraints such as high cost of equipment and tools, high incidence of honey fermentation and crystallisation, poor cooperation among association members, and inefficient resource management. These issues reflect operational and organisational weaknesses at the farm and group levels. Poor handling and processing practices can compromise honey quality, leading to losses and reduced market value, while weak cooperative coordination limits collective action benefits such as bulk purchasing, shared equipment use, and knowledge exchange. This aligned with the findings of Aşkan (2023) [6], who reported that inefficiencies in hive management, processing techniques, and cooperative functioning significantly reduced technical efficiency among honey producers. Similarly, FAO (2021) [12, 13] emphasised that management skills and adherence to best practices are critical determinants of productivity in apiculture, given the sensitivity of honey to handling and environmental conditions.

Factor 3, the economic factor, was represented primarily by poor storage facilities, which hinder profitability. Although this factor accounted for a smaller proportion of the explained variance, its importance should not be underestimated. Inadequate storage leads to post-harvest losses, quality deterioration, and forced sales at unfavourable prices, thereby reducing the returns from honey production and weakening incentives for efficiency improvement. Recent studies have similarly highlighted storage and post-harvest handling as persistent constraints in apicultural value chains in developing countries (Alabi & Anekwe, 2023; FAO, 2021) [4, 12, 13]. Poor storage conditions also limit producers' ability to meet quality standards required for premium and export markets, which is particularly relevant given the growing demand for high-quality honey.

5. Conclusion

The study clearly established the level of technical efficiency among members of the Apicultural Society of Nigeria, Anambra State Chapter, and provided empirical insight into how efficiently honey producers utilize available production resources. The estimated mean technical efficiency of 0.8874 indicates that, on average, honey producers are operating at about 88.74% of their production frontier, leaving a relatively small efficiency gap of 11.26%. This finding suggests that members of the association are already performing at a high level and that only modest improvements in management practices and resource utilisation would be required for them to attain optimal production levels.

The relatively high efficiency observed among the respondents can reasonably be linked to their membership of a structured and organised association. Belonging to a cooperative platform such as the Apicultural Society of Nigeria likely enhances access to shared knowledge, training opportunities, peer learning, and information on improved production practices. These collective advantages can strengthen farmers' managerial capacity, improve decision-making, and promote more efficient allocation of inputs, all of which contribute to higher technical efficiency in honey production.

Based on these findings, the study concludes that honey producers who are members of the Apicultural Society of Nigeria possess the capacity to operate close to their maximum production potential and to achieve higher income levels if existing efficiency gaps are further reduced. This outcome underscores the importance of farmer organization and collective action in agricultural production. It therefore justified sustained efforts to encourage beekeepers to join cooperative groups and strengthen existing associations, as such structures facilitate economies of scale, collective input procurement, stronger bargaining power, coordinated marketing of products, and access to institutional support, all of which are critical for improving productivity, income, and long-term sustainability in apiculture.

6. Recommendations

1. State and Federal Government through agricultural credit schemes needs to strengthen access to affordable finance and credit facilities to enable timely purchase of equipment, inputs, and packaging materials.
2. Apicultural Society of Nigeria (ASN) and State Ministry of Commerce and Industry Should establishing structured market linkages, price information systems, and quality certification mechanisms to enhance profitability and efficiency.
3. Agricultural extension services and Apicultural Society of Nigeria (ASN) need to organize a regular training on modern beekeeping techniques, post-harvest handling, and equipment use.
4. Apicultural Society of Nigeria (ASN) and Cooperative development agencies improve farmer's ability to adopt improved technologies to improve beekeeping.

7. Appendix

Table 1: Data adequacy test: KMO

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.708
Bartlett's Test of Sphericity	Approx. Chi-Square	2041.657
	df	45
	Sig.	0.000

Table 2: Normality test: Communalities

Sn.	Variable	Initial	Extraction
1	There is a high cost of equipment/tools	1.000	0.990
2	High honey fermentation and crystallization	1.000	0.995
3	There's a high rate of poor cooperation among members of the association that affect production	1.000	0.971
4	There is poor pricing of products	1.000	0.990
5	There is poor information on quality standards	1.000	0.987
6	The level of inadequate finance hinders progress	1.000	0.991
7	Inadequate market	1.000	0.970
8	Poor storage hinders profitability	1.000	0.998
9	Inefficiency in management of resources hinder productivity progress	1.000	0.983
10	The high cost of labour affect profits	1.000	0.956
	Extraction Method: Principal Component Analysis.		

Table 3: Reliability Test

Cronbach's Alpha	N of Items
.970	11

Table 4: Total variance explained for non positive defite

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	8.271	82.707	82.707	8.271	82.707	82.707	7.965
2	1.191	11.914	94.621	1.191	11.914	94.621	6.826
3	.246	2.459	97.079	.246	2.459	97.079	1.222
4	.122	1.216	98.295	.122	1.216	98.295	.948
5	.075	.748	99.043				
6	.050	.505	99.548				
7	.029	.292	99.840				
8	.010	.103	99.943				
9	.005	.048	99.991				
10	.001	.009	100.000				
Extraction Method: Principal Component Analysis.							
a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.							

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