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DETERMINANTS OF TECHNICAL EFFICIENCY IN BROILER PRODUCTION

[1]Offiah Ebere O.,[2]Umebali Emmanuel E., [2]Isibor Chinwe A., [1]Ugbajah Maryjane O* and [1]Nwankwo Eucharia C.

[1] Chukwuemeka Odumegwu Ojukwu University Igbariam, Anambra State.

[2] Nnamdi Azikiwe University, Awka Anambra State.

Abstract Abstract

*The declining rate of supply and high cost of matured broiler meat relative to its demand despite the attractions in the industry raises concern on the sector's growth. Operating efficiently is a strategy that can address this challenge. The study technical efficiency of broiler production was carried out in Anambra state Nigeria using Cobb-Douglas stochastic frontier analysis. A cross sectional survey was employed using the questionnaires which was administered to a sample of 370 broiler farmers registered with the ADP as at Dec. 2022. The study focused on levels of Technical efficiency in broiler production using Cobb-Douglas stochastic frontier analysis, determinants of technical efficiencies using 2 stage maximum likelihood. The study revealed coefficient of the Gamma (γ) value of 0.695 significant at 1% level, indicating that variations in broiler production output were attributed to technical inefficiency, meaning that the inefficiency components contributed 69.5% of this deviation in frontier output and the remaining 30.5% arising from random noise which are beyond the farmers control. The coefficient for feed and labour were positive and significant at the 1% level. TE ranged from as low as from 0.006 to a high as 0.964, with an average (mean) value of 0.767 was observed, indicating that about 23% of the output was lost due to the inefficiency in broiler production. The likelihood ratio test yields a value of 17.13***, significant at a 1% probability level. Both production experience and training showcased significance at probability levels of 10% and 5%, respectively. The study recommended adopting modern production methods, credit and training improvement as well as infrastructural development.*

IndexTerms - Technical efficiency, Broiler Production, Determinants

1. Introduction

The practice of farming still remains the pillar of the Nigerian economy for growth, development, poverty alleviation, employment and income generation especially for the rural communities. In a study posited by NBS (2018), the Nigerian livestock sub-sector is the second largest contributor to the agricultural share of the GDP, constituting 17% coming after 80% contribution of the crop sub-sector. Omolayo (2018), observed that Livestock production constitutes a critical and basic part of the agricultural economy of Nigeria, with its contributions going beyond direct food production. It additionally incorporates the source of income to farmers, development of a country's economy, source of vocation to farmers and other multipurpose uses. The higher growth rate in the livestock sub-sector, as suggested by Abigail *et.al.*(2020), was a result of enormous increase in demand–supply gap as animal protein market trends are rising globally, and the sector is expected to be one of the fastest growing agricultural sector in the nearest future. Broilers (*Gallus gallus domesticus*) are birds kept specifically for meat production and are offered at various sizes for sale in the market. Its production deals with the combination of input factors which includes day-old, feed, vaccines, housing etc, to produce matured broiler meat. Broiler farming has been notable for its contributions to employment creation, income generation, poverty reduction and food security; and the sector remains the most commercialized of the country's livestock production in Nigeria (Rabirou, *et.al.* 2022). However, according to Okojie (2023), the

country's livestock subsector, dominated by poultry has contracted by 30.57 percent in the first quarter of 2023 from 5.55 percent in the corresponding quarter in 2022. This was attributed to increased cost of maize and soybean which happens to be the main components in poultry feed production. Consequently, Emmanuel and Cletus (2021) as cited by Akanbi, Olohungbebe and Alao (2022)., noted that the potential of broiler farmers to contribute to employment creation, income generation, poverty reduction and food security, is adversely affected by low revenue and profit in broiler farm enterprise which they opined to be resulting from high prices of broiler feeds, drugs, utilities; high interest rates from the financial institutions and low broiler prices due to market structure in terms of high competition faced by the producers. Thus, inefficiency of production has affected broiler production bringing about high prices of matured broiler in the market. Umar and Dezi (2020), noted that chicken production depends largely on external and internal factors. The external factors include the environment, weather, government policy and markets which are considered in the process of production and these factors are generally not within the control of the producers, but can be managed when efficient chicken production technique is being practiced. The internal factors were regarded as input factors employed in the process of broiler production in order to achieve optimal level of production and sustainability. The efficiency of factor inputs employed in the process of broiler production maximizes output and profitability. Efficiency is a relationship between the quantity of factor input and the level of output that defines a frontier for a firm in an industry.

Technical efficiency is the ability of a firm to produce as much output as possible with available level of inputs, given the existing technology. Increasing technical efficiency within the broiler industry require a good knowledge and competences in the industry as well as being at home with factors responsible for attainment of some levels of competence. The importance of efficiency in increasing agricultural output has been widely recognized by researchers and policy makers, this is because T.E analysis in agricultural production has been an area of focus in most developing countries because of the importance of productivity growth in agriculture for overall economic development and the need to provide healthy protein option for the ever increasing population. Since area expansion is no longer a feasible option in Agriculture, the ability to produce as much output as possible with available levels of inputs and with the existing technology or little modification seems the best alternative. There is no doubt that profit still exists in broiler production but recent studies have shown steady decline in return on investment and the buyers are also lamenting on high cost of matured broiler birds, thus even with increases in supply of the broiler meat it's still not affordable for the average citizen. The concept of technical efficiency in broilers production therefore deals with combination of factors of production as well as managerial attributes to produce matured broiler for consumers at a price that is acceptable for both the buyers and producers.

In Anambra state, high cost of input resources which may likely impede efficient and sustainable production required for increasing productivity within the broiler industry in the nearest future is of great concern to the producers.(Chiekezie *et. al.*,2021)

Hence, assessing the technical efficiency in broiler production becomes necessary because Producers need to be aware early enough of the drivers of technical efficiency for the enterprises they are involved in, if they are to optimize production. Based on the problems in broiler production, the study examined the technical efficiency of broiler production among small-holder broiler farmers. Specifically, the study:

i. described the demographic-characteristics of the farmers;
ii. estimate the technical efficiency levels of broiler farmers;
iii. ascertain the determinants technical efficiency;

2 Methodology:

The study was carried out in Anambra state Nigeria. Anambra sate is one of the five states located in the South-eastern region of Nigeria with its administrative headquarter in Awka. The state is sub-divided into four agricultural zones (Onitsha, Aguata, Awka and Anambra) to aid planning and rural development. The state is bounded by Delta State on the West, Imo State and Rivers State on the South, Enugu State on the East, and Kogi State on the North (NPC, 2006). The state is located between Latitude 6^{o} 45^{1} and $5^{0}44^{1}$N and Longitude $6^{o}36^{1}$ and $7^{0}20^{1}$E with a total land area of four thousand, eight hundred and forty-four square kilometres (4,844 km2), and a population density of about eight hundred and sixty persons per square kilometres (860/Km^{2}). According to the National Population Commission (NPC, 2017), Anambra state has an estimated population of about (5million) people whose major economic activities, apart from farming (crops and livestock) include trading and manufacturing. According to Ofoedu et.al. (2018), the climate of the area is relatively good and favourable for crop production, livestock farming, fishery and agro forestry.

The people are predominantly farmers and traders and the main crops produced are rice, cassava, yam, palm produce and livestock which include poultry, cattle, and goat.

Multi-stage sampling procedure was employed in the selection of the population for the study. Stage 1 involved obtaining the sample population from the list of the registered broiler farmers from the study area. Taro Yamane sample size determination in Otabor and Obahiagbon (2016) was used to derive the sample size for the study; stated as:

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

Where:

N	=	Population of the registered broiler farmers in the state
n	=	Sample Size of broiler farmers
(e)	=	Level of significance (0.05)
1	=	Unit (a constant)

$$n = \frac{4698}{1 + 4698(0.05)^2} = \frac{4698}{1 + 4698\ (0.0025)}$$

n= 368.6 which is approximated to 370

In the second stage, the study adopted Kumaison formula (1997) for sample size distribution which is stated as:

$$\text{ith} = \frac{ni}{N} * n$$

Where:

n = total sample size of broiler farmers for the study

ni = number of items in each stratum in the population

N = the new population size in the strata

ith = sample allocation

Thus,

Table 3.1: Distribution of poultry farmers in the Agricultural zones of Anambra state.

Agricultural Zone	LGAs	Headquarters	No of poultry farmers
Onitsha	Onitsha North, Onitsha South, Ogbaru, Idemili South, Idemili North, Ihiala Ekwusigo	Onitsha	2035
Anambra	Anambra East, Anambra West, Oyi	Ayamelum	107
Aguata	Nnewi North, Nnewi South, Orumba South, Orumba North	Aguata	1263
Awka	Awka North, Awka South, Dunukofia, Njikoka, Anaocha	Amawbia	1293

Therefore;

For Onitsha agricultural zone :

$$\text{ith} = \frac{2035}{4698} * 370 = 160.2 \simeq 160$$

Anambra agricultural zone:

$$\text{ith} = \frac{107}{4698} * 370 = 8.4 \simeq 8$$

Aguata agricultural zone:

$$\text{ith} = \frac{1263}{4698} * 370 = 99.5 \simeq 100$$

Awka agricultural zone:

$$\text{ith} = \frac{1293}{4698} * 370 = 101.8 \simeq 102$$

Table 3.2: Sample representation of poultry farmers for the study

Sn	Agricultural zones	No of Farmers	Sample size
1	Onitsha	2035	160
2	Ayamelum	107	8
3	Aguata	1263	100
4	Amawbia	1293	102
Total	4	4698	370

Finally stage 3 involved purposive selection of minimum of 2 and maximum of 5 poultry farmers from each of the selected local government areas for the study depending on the number of poultry farmers in the area. Primary data used for the study were collected using questionnaire. Data were collected on such variables like demographic characteristics of the farmers, input quantities and output quantities, as well as constraints to broiler enterprise. Descriptive statistics such as mean, frequency and percentages were used in achieving objective i and iv. while Objectives ii and iii were achieved using Cobb-Douglas stochastic frontier production model. The frontier stochastic production method identifies efficient farms as any farm operating on the production frontiers that generates more profits (Mayokun and Ogheneruemu, 2018), thus that was adopted for the study.

Stochastic Frontier Model

Regression model was adopted in the analysis of 2-stage Maximum likelihood and technical efficiency of broiler production and the functional form was the Cobb Douglas production function.The stochastic frontier production model that comes with determinants/effects was adopted for this research coined from Battese and Coelli, (1992). The Cobb-Douglas stochastic frontier production function that assumes the production technology of broiler farmers is specified as follows:

$ln\ Y_i = \beta_{\square\square}\beta_1 \ln X_{i1} + \beta_2 \ln X_{i2} + \beta_3 \ln X_{i3} + \beta_4 \ln X_{i4} + \beta_5 \ln X_{i5} + e_i$

Where *In* = natural logarithm;

Yi is output of the *ith* farm;

β0 represents a constant term,

βs is the vector of the production function (unknown parameters to be estimated)

Xs independent variables / input bundle used by the ith broiler farmer and is defined as follows:

X_1 = Flock size (total number of birds at sales)

X_2 = Quantity of feed used per the production period (kg)

X3 =Labour (total number of man-days)

X4= Vaccines (number of bottles of vaccines and other medications for a production cycle)

X5= depreciation on fixed assets (naira)

Determinants of technical efficiency

Different output levels obtained by farmers may be explained by variations in production efficiencies of the farmers. In order to explain the technical efficiency variations among the sampled broiler producers in the area, the factors were hypothesized as determinants of technical inefficiency and specified as:

$U_i = \delta_o + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_{5i} + \delta_6 Z_{6i} + \delta_7 Z_{7i} + \delta_8 Z_{8i} + \delta_9 Z_{9i} + \delta_{10} Z_{10i}$

Where:

U_i is the technical efficiency of the ith farmer.

δ0 is the constant.

δs are the coefficients:

Z_1= sex (dummy; Yes = 1, No = 0)

Z_2= marital status

Z_3= age of farmer (years)

Z_4= farmer educational level (years)

Z_5= years of farming experience (years spent in broiler farming)

Z_6 = household size (number)

Z_7= number of pens (number)

Z_8= access to credit (amount obtained in naira)
Z_9= training (number of times)
Z_{10}= cooperative membership (Yes = 1, No = 0)

Results and discussion.

Estimation of technical efficiency in broiler production in Anambra state.

This Section presents the results of log-linearized functional form of the parametric estimates of stochastic frontier production function. Technical efficiency measures determined from the SFPF are similarly presented. Subsequently, multiple regression results of factors affecting technical efficiency are given, using two limit censored Tobit regression in STATA software applied to test the significance of factors that were hypothesized to impact on technical efficiency in boiler production.

Parameter estimate of broiler production in the study

The parameter estimates of the stochastic frontier for broiler farmers are displayed in Table 1. A restricted Cobb Douglas function was employed to preserve the degrees of freedom. The Sigma value was found to be 0.159, significant at the 1% level implying a 15.9% deviation from the frontier in broiler production output in the sector. The coefficient of the Gamma (γ) value of 0.695 significant at the 1% level, indicates that variations in broiler production output were attributed to technical efficiency, meaning that the inefficiency components contributed 69.5% of this deviation in frontier output in the stochastic model while the remaining 30.5% arises from random noise which are beyond the farmers control. This means the 69.5% factors are under the control of the producer and reducing the influence of the effect of γ will greatly enhance the technical efficiency of the poultry production in Anambra state and improve their output. A high Gamma points to the need to address inefficiencies, whereas a low Gamma highlights external factors or errors as primary concerns.

Individually, the coefficient for feed was positive and significant at the 1% level, suggesting that a unit(kg) increase in feed quantity boosts the output by 0.729 units(birds). Broilers are efficient feed converters, as evidenced in Table. Similarly, the coefficient for labour was positive and significant at the 1% level, indicating that an additional unit of labour (measured in man-days) raises broiler output by 0.291 units. This reveals that broiler production in the area is labour-intensive, a conclusion supported by Ahiale et al. (2019) who found a significant positive relationship between broiler production and labour supply.

Lastly, the coefficient for depreciated fixed assets was negative and showed marginal significance at the 10% level. This suggests that an increase in asset depreciation decreases broiler output by 0.049 units. It is evident that farmers need to upgrade their fixed assets to achieve optimal production.

Table 1: Parameter estimate of broiler production function in the study area.

Parameter	Coeff.	Std. error.	t-test
Ln-DOC	0.001	0.016	0.02
Ln-Feed	0.729	0.012	62.32***
Ln-Labour	0.291	0.014	21.31***
Ln-Drug	-0.001	0.028	-0.03
Ln-Dep. On fixed assets	-0.049	0.027	-1.86*
_constant	3.015	0.279	10.82
Diagnostic tool			
Sigma	0.159		12.75
Gamma	0.695		16.03
Log-Likelihood	-157.06		
Obs.	359		

Source: Field survey, 2023. *, **,*** Significant @ 10%, 5%, and 1% respectively.

Analysis of the Technical efficiency index of broiler farmers

The Technical Efficiency (TE) index of the farmers is presented in Table 2. Observations reveal that the TE ranged from as low as from 0.006 to a high as 0.964, with an average (mean) value of 0.767. This suggests that, if the average broiler farmer of the sample could achieve the TE level of its most efficient counterpart, then average broiler farmers could increase their output by approximately 20%. Also, the most technically inefficient farmer could increase the production by approximately 99% if he could increase the level of TE

of his most efficient counterpart. However, since the mean TE is 77%, it can be deduced that 23% of the output was lost due to the inefficiency in broiler production/inefficiency of sampled broiler farmers. On average output can be increased by at least 23% while utilizing existing resources and technology given that the inefficiency factors were fully addressed. The result also indicate that broiler farmers in the study area on average can gain higher output growth at least by 23% through the improvements in the technical efficiency. The wide variation in the result shows that broiler farmers were still using their resources inefficiently in the production process and there still exists opportunities for improving on their current level of technical efficiency. If also mean that few farmers were not utilizing their production resources efficiently i.e they do not obtain maximum output from their production given the quantity of inputs used. The average TE result value corroborates the findings of Umar et.al. (2020), who reported average TE of about 81% in their research.

Descriptively analyzing the data, it's evident that the majority of farmers (69.1%) have a TE index ranging from 0.651 to 0.850. An additional 24.2% have TE values between 0.851 and 1.000. The remaining percentages are distributed as follows: 3.3% have a TE index between 0.000 and 0.250, 2.5% between 0.451 and 0.650, and 0.8% between 0.251 and 0.450.

The **null hypothesis 1**, which posited that broiler farmers in the Anambra State are not technically efficient, was subjected to a t-test with a value of 95.01***. The results were significant at the 1% level. Consequently, the null hypothesis 1 was accepted suggesting that the farmers are technically inefficient in the study.

Table 2: Calculation of the technical efficiency of broiler farmers

Level Description	Efficiency index	Frequency	Percentage (%)
Very low	0.000 - 0.250	12	3.3
Moderately low	0.251 - 0.450	3	0.8
Average	0.451 - 0.650	9	2.5
Moderately high	0.651 - 0.850	248	69.1
Very high	0.851 and above	87	24.2
Total		**359**	**100**
Mean		0.767	
Std. Deviation		0.153	
Minimum		0.006	
Maximum		0.964	
t-test		95.01***	

*Source: Field survey, 2023. *, **, *** Significant @ 10%, 5%, and 1% respectively.*

Tobit regression on determinants of technical efficiency in broiler production

Estimation of the ability of the broiler farmers to achieve maximum output in production given available technical know-how and resources within the farmers reach is an important aspect in constructing and addressing the forgoing in broiler production improvement as well as policy formulation. The determinants of technical efficiency (TE) among broiler farmers are detailed in Table 3. A Tobit regression was employed in the two-stage TE estimation. The likelihood ratio test yields a value of 17.13***, which is significant at a 1% probability level. This suggests that at least one component of inefficiency serves as a determinant of TE. The average technical efficiency value, documented as 0.767 in Table 2, was established as the lower boundary for the Tobit analysis.

Contrary to *prior* expectations, the coefficient associated with marital status augments inefficiency by 1.3%. Additionally, the number of pens owned by the farmers increased inefficiency by 0.7% at a 0.05 probability level. This observation contrasts with the findings of Umar and Dezi (2020), who indicated that a larger farm size increases technical efficiency in their research.

The quantity of feed was significantly related to technical efficiency at 10% level showing that birds when fed *adlibitum* as suggested tends to gain more weight than their counterparts, this can be possible by increasing the light hours in the pen so that the birds continues to feed even at night. Although the coefficient of light hours was not significant, it still has a positive t-value.

As anticipated, both production experience and training showcased significance at probability levels of 10% and 5%, respectively. Specifically, production experience heightened technical efficiency by 0.2%, while training did so by 0.9%. Based on these results, it is evident that both experience and training genuinely enhance the farmers' abilities to proficiently undertake broiler production.

Table 4: Determinants of technical efficiency in broiler production

Variables	Coef.	Std. Err.	t-test
Sex	-0.003	0.016	-0.19
Marital status	-0.013	0.007	-1.84*
Age	0.001	0.001	1.21
Education	0.000	0.001	0.43
Experience	0.002	0.001	1.90*
Quantity of water	-0.003	0.004	-1.08
Number of pens	-0.007	0.003	-2.09**
Light management	0.006	0.016	0.38
Training	0.009	0.005	2.00**
Quantity of feed	0.001	0.006	1.24*
_cons	0.744	0.050	15.01
LikelihoodRatio	17.13***		
Log-Likelihood	170.287		
Obs.	359		

Source: Field survey, 2023. **, *** Significant @ 10% and 5% respectively.

Identification of the constraints to broiler production in the study area

The challenges faced by broiler farmers, as detailed in this intensive study, are presented in Table 5. Based on the researcher's observations and data visualizations, several significant impediments are hindering broiler farmers' production capacities. Of the nine challenges identified, the high cost of feed stood out, with a 97.5% response rate. Many studies have consistently highlighted the high feed cost as a primary concern in poultry enterprises (Chiekezie et al 2021, Ezeano et.al 2018). Inadequate capital and poor market infrastructure were other major concerns, cited by 96.9% and 86.9% of the respondents, respectively. Didunyemi and Owoeye (2022) echoed these findings, emphasizing the impact of capital constraints on broiler farming success.

Additionally, the high cost of labour was reported by 83.6% of farmers, and intense competition by 77.7%. It has been noted that broiler production is labour-intensive. To tackle the fierce competition, farmers must sharpen their entrepreneurial skills. Other notable challenges include a high mortality rate, reported by 58.5% of farmers. For a poultry enterprise to be deemed profitable, the mortality rate should not exceed 5% (source).

Moreover, 51.5% of farmers highlighted pest and disease issues. This underscores farmers' priorities; they should be less concerned about the initial costs of day-old chicks and more focused on the resilience and health of the flock.

Security is another pressing issue. Given that 50.4% of farmers reported theft as a significant problem, there is a dire need to bolster security measures around the farms. Nearly half, or 49.9% of farmers, reported issues with predators, emphasizing the necessity for enhanced housing systems. These findings align with Oluwatoye et al. (2016) study that identified theft as prevalent challenge in poultry farming.

Table 5: Identification of the constraints to broiler production in the study area.

Sn.	Constraints	Frequency	Percentage
1	High cost of feed	350	97.5
2	Inadequate capital	348	96.9
3	Poor market infrastructure	312	86.9
4	High cost of labour	300	83.6
5	Intense competition	279	77.7
6	High mortality	210	58.5
7	Pest and diseases	185	51.5
8	Theft	181	50.4
9	High predator incidence	179	49.9

Source: Field survey, 2023.

Conclusion and recommendation

The result from the study suggests that most of the broiler farmers in Anambra state had not yet reached production frontier, indicating that they were not obtaining maximum output possible from the given limited output. This is because the average technical efficiency observed from the study is about 77%, suggesting that broiler farmers studied could increase their output by approximately 23% given the available technology. Doing the right thing at the right time would enable the farmers obtain maximum output possible from their given inputs and in turn increase their profit. The study further recorded that production experience, quantity of feed and training significantly improved level of technical efficiency of the broiler farmers. However the study reported high feed cost, inadequate capital and poor market as the most important problems affecting broiler production in the study area.

Recommendation

1. Production method: To enhance technical efficiency, farmers must adopt modern broiler production techniques/practices/methods as it relates to better breeds, increasing feed time by providing adequate light at night, modern watering and feeding trough to minimize waste and so on.
2. Financial Services: Improving access to credit will enable farmers to upscale operations and adopt advanced farming techniques thus the government at all levels should make fund/capital available to the broiler farmers; this could be given to them by providing production inputs like automated feeders and drinkers which are expensive for some to procure.
3. Farmers should be given more training and Capacity Building encouraged on broiler production so as to maximize their output given their quantities of input since there is a positive relationship between training and education qualification with technical efficiency, thus more structured training programs should be introduced, monitored and followed up.

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