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Evaluation of Technical Efficiency of Broiler Farms in Nigeria

[1]Adeyonu, A. G., [2]Alao, M. E., [3]Okunola, A., [4]Akintayo, O., [5]Okeniyi, F., and [6]Agboola, T.

[1]Department of Agricultural Economics and Extension, Landmark University Landmark University, Omu-Aran, Kwara State, Nigeria
[2]Department of Accounting, Babcock University, Ilishan Remo, Ogun State, Nigeria
[3]Department of Agricultural and Biosystems Engineering, Landmark University, Omu-Aran, Kwara State, Nigeria
[4]Institute of Agricultural Research and Training, Moor Plantation, Ibadan, Nigeria
[5]Department of Animal Science, Landmark University, Omu-Aran, Kwara State, Nigeria
[6]Department of Agricultural Economics and Agribusiness Management, Osun State University, Ejigbo, Osun State, Nigeria

***Corresponding Author:** gbemgail@yahoo.com; **Phone Number:** +2348075598216*

***Target Audience:** Broiler farmers, Entrepreneurs, Government*

Abstract

The poultry industry of which broiler farming is an aspect, is the largest of the livestock sub-sector. Despite this, the industry is characterized by a high level of inefficiency. The focus of this research is on the technical efficiency of broiler farms in Nigeria. Data was collected from 646 respondents with the aid of a questionnaire and analysed with descriptive statistics and Stochastic Frontier Production Function (SFPF) -Cobb-Douglas functional form. Results showed that technical efficiency ranged from 11- 98% with a mean of 67%. The quantity of feed and labour positively influenced broiler output, costs of drugs and vaccines negatively influenced it. Factors that had an indirect influence on the level of technical inefficiency of farms are education, training, access to credit, and other means of livelihood. The sex of the farmer had a direct association with the farm's level of technical inefficiency. Our findings strongly suggest that to increase broiler farm efficiency, feed, and labor should be adequately utilized, while bio-security measures to reduce expenses on drugs and vaccines should be promoted among broiler farmers. Also, policies that will see to adequate training of farmers and improvement in their level of access to credits should be put in place.

***Keywords**: Technical efficiency; Broiler farms; Stochastic frontier analysis; Farmers; Nigeria.*

Description of Problem

Agriculture remains the only sure way through which not less than 1.5 billion people across the globe can navigate their way out of poverty (1). The livestock sub-sector contributes to the livelihood and food security of about a billion people globally (2; 3). Likewise, the role of agriculture in the development of Nigeria's economy like any other agrarian economy across the globe cannot be over-emphasized. About 67% of the workforce is employed in the agricultural sector (4). The sector contributed 25.16% to the nation's real GDP in 2019. The crop sub-sector contributed 22.67% of the agricultural contribution, with livestock following at a far distance by contributing 1.70% (5). The growth in the agricultural sector which was 2.12% in 2018, rose marginally to 2.36% in 2019. The rise was attributable to an increase in non-livestock sub-sectors because the growth in the livestock sub-sector which was

1.61% in 2017, fell to 0.33% and 0.16% in 2018 and 2019 respectively (6; 7). Despite its low contribution to the GDP, the livestock sub-sector is essential to the economic development of the country and crucial for food security. As revealed by (8), the sub-sector supplied 36.5% of the overall protein consumption of Nigerians in 2016. Hence, the sub-sector is crucial to the achievement of SDG-2 (end hunger, achieve food security, and improve nutrition) in the country. The sub-sector consists of cattle, sheep, goats, pigs, rabbits, and poultry. The poultry industry with a population of about 180 million birds is the largest (56%) of the livestock sub-sector in Nigeria (9). In 2013 and 2016, about 300,000 and 450,000 metric tonnes respectively of poultry meat were produced in the country. This made the country to be the second-largest poultry meat producer with South Africa as the leading producer (10; 8). This feat can be attributed to the increase in the number of broilers that possessed the ability to yield more meat per bird.

The consumption of poultry meat in Nigeria was postulated to rise by 200% from 2010 to 2020 (11). The authors envisaged a growth rate of 6 - 10% year-on-year for five years (2020 -2025). With the surge in consumption, the nation was unable to meet its local demand which led to the illegal importation of about 70% of its poultry needs as succor. It is anticipated that in the future, the demand-local supply deficit will widen. The reduction in local supply due to low productivity is due to the high cost of feed, non-availability of highly prolific and early maturing local breeds, and poor infrastructure among other challenges (8). Hence, the enhancement in livestock productivity will require addressing the challenges facing the industry. The livestock industry comprises many sub-sectors such as ruminants, piggery, and poultry. The poultry sub-sector is made up of turkey, guinea fowl, duck, and broilers. Broiler is a type of poultry that has been genetically developed to grow fast and produce meat within a short period of time. In Nigeria, it takes an average of about 56 days to raise a broiler from a day old to market weight. This makes it possible to produce a number of batches in a year unlike other types of poultry. The rearing time can be reduced under sound management. Broiler farming is done in all parts of the country and there are no known cultural or religious constraints linked with the eating of poultry meat. This makes broiler farming an important aspect of the poultry industry in Nigeria. The main constraint associated with broiler farming has been identified to be low productivity due to technical inefficiency, high cost of inputs due to non-availability of high-quality locally made ones, diseases, poor infrastructure, and inadequate extension and training services among others (12; 13). For Nigeria to be able to minimize the illegal importation of poultry meat and narrow the gap that exists between the demand and local supply, broiler production in the country must be increased. Given the poor production resources in the country, improving the efficiency level of broiler farms (BFs) will be the only option (14). This makes it imperative to examine the technical efficiency (TE) of BFs. Hence, this study focused on the evaluation of TE of BFs in Nigeria. The study findings will be used to improve the productivity of the BFs, increase household food security, and reduce the level of poverty among smallholder farm households.

Researchers have previously studied the TE of BFs in Nigeria (12; 13; 15; 16). All the researchers used primary data which were analyzed with SFPF (Cobb-Douglas (CD) functional form) to measure the efficiency levels of the farms. The studies reported varying levels of efficiency and the factors influencing inefficiency also varied. Likewise, studies on TE of BFs have been conducted in other parts of the world (17; 18; 19; 20; 21; 22; 24; 25; 26; 27; 28; 29; 30). Researchers, (18; 22; 24; 31) employed SFPF-C-D to analyze farms' efficiency levels. Authors that utilized Data Envelopment Analysis to measure the technical efficiency of broiler farms include (23; 25; 27; 29; 30). In 2018, (19) employed SFPF (trans-log functional form) to measure BFs' TEs with panel data. In addition, TE of non-poultry farms with SFPF have been conducted across the globe (32; 33; 34; 35; 36; 37). The researchers adopted SFPF to measure TE due to its popularity in agrarian economies. Its adoption was also based on its ability to readily incorporate the technical efficiency and inefficiency components. Most of the studies on TE of BFs in Nigeria used just one state or local government as the study area, but this study focused on two geopolitical zones of the country that are prominent in poultry enterprise. Thus, this study has a larger sample size from four states and is expected to produce robust estimates for policy intervention. Hence, the objective of this study is to measure the technical efficiency of broiler farms in Nigeria using SFPF-CD.

Materials and Method

Sampling Technique

The study was carried out in Nigeria and made use of cross-sectional primary data gathered from a representative sample selected using a multi-stage sampling procedure. The north-central (NC) and southwest (SW) geo-political zones were purposively selected in the first stage. This was followed by a purposive selection of Kwara and Benue States as well as Ogun and Oyo States from the NC and SW zones respectively. The purposive selection of the zones and the states was a result of the high concentration of poultry farms in the areas. The same consideration led to the selection of one senatorial district purposively from each of the states selected at the third stage. The stage that followed witnessed a selection of two Local Government Areas (LGAs) with the highest number of poultry farms in commercial quantity from each of the chosen districts. At the fifth stage, we employed the Snowballing technique to identify poultry farmers who do not belong to the Poultry Association of Nigeria (PAN) from where a list of some members was obtained. The final stage was a random selection of commercial BFs using probability proportionate to size in each selected LGA. The data which was collected in 2017-2018 was obtained with the aid of a structured questionnaire from 1000 respondents. The consent to participate in the survey was part of the introductory section of the questionnaire and it was clearly stated that participants were at liberty to discontinue the survey any time they felt like it. However, only 646 respondents supplied full information that was relevant to this study. Information was gathered on farmers' and farm-specific characteristics (inputs and outputs). Data were subjected to descriptive statistics and SFPF-C-D using STATA 14 and FRONTIER 4.1.

Analytical Technique

Stochastic frontier production function

In this study, we adopted an SFPF suggested by (38; 39) and earlier adopted by (40; 41; 42). The model allows for a calculation of technical inefficiency in the

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SFPF approach is hinged on a parametric specification of a production frontier. By applying a general production function to the data, the approach is as presented:

$$Y_i = f(X_i, \beta).\exp(\varepsilon_i) \quad (1)$$

Where: Y_i is the output of i[th] broiler farm; X_i refers to the vector of input used in the production process; f ( ) represent Cobb-Douglas functional form; β refers to unknown parameters of the function; i = 1, 2, ……………, n farms, ε_i implies error term which is defined as:

$$\varepsilon_i = V_i - U_i \quad (2)$$

V_i and U_i are presumed to be independent of each other, where V_i is a two-sided normally distributed random variable which repre-

$$[V_i \sim N(0, \sigma_V^2)]$$

sents statistical noise (disease outbreak, weather, measurement error, etc.) in the model, and $U_i \geq 0$, is a one-sided inefficiency component which is assumed to follow a half-normal distribution $[U_i \sim N(0, \sigma_U^2)]$ and within farmer's control. This study used a single-stage analysis of the CD functional form frontier to model both the stochastic and technical inefficiency effects using the procedure of maximum likelihood to estimate all the parameters.

Technical efficiency

The estimation of TE and its determinants are fundamental in the theory of production. Researcher (43) defines TE as a measure of how well a farm is able to transform inputs to output(s) given the existing technology and environment. It refers to the proportion of actual output (Y_i) to the expected frontline output (Y_i^*) with certain levels of input and technology and it is as depicted in equation 3:

$$TE_i = \frac{E(Y_i/X_i, U_i)}{E(Y_i/X_i, U_i = 0)} = \frac{f(X_i, \beta).\exp(V_i - U_i)}{f(X_i, \beta).expV_i} = \exp(-U_i) = \frac{Y_i}{Y_i^*} \quad (3)$$

Since $Y \leq Y^*$, then, $0 > TE \leq 1$; TE is at its upper bound when a farm is producing at its highest possible level ($Y = Y^*$) given the input quantities. For the estimation of the TE, we adopted the SFPF-CD functional form following (44; 20; 24; 29). The model is specified as:

$$\ln Y_i = \ln\beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 X_5 + V_i - U_i \quad (4)$$

Where:

ln = natural logarithms

Y_i = output of the broiler by ith broiler farm in one year (Kg)

X_1 = number of Day Old Chicks (DOC)

X_2 = feed used (Kg)

X_3 = amount of labor (man-days)

X_4 = cost of drugs and vaccines (₦)

X_5 = cost of other intermediate materials (depreciation of fixed capital, wood shavings, transport, energy, etc.) (₦)

β_i = unknown parameters

V_i = random effect

U_i = technical inefficiency effect

i = individual BF

Note: 1 USD = ₦500 at the black market as of when the data was collected.

The technical inefficiency effect model which is in tandem with equation 4 is as specified:

$$U_i = \alpha_0 + \alpha_1 G_1 + \alpha_2 G_2 + \alpha_3 G_3 + \alpha_4 G_4 + \alpha_5 G_5 + \alpha_6 G_6 + \alpha_7 G_7 + \epsilon_i \quad (5)$$

Where:

U_i= extent of technical inefficiency of each BF

G_1= age of the broiler farmer (years)

G_2 = sex of the farmer (Male = 1, 0 otherwise)

G_3= education level of farmers (years)

G_4 = years of experience in broiler farming

G_5 = training in broiler farming (Yes = 1, 0 otherwise)

G_7 = other means of likelihood

α_i = unknown parameters

ϵ_i = error term

Results and Discussion

The results in Table 1 indicated that the average broiler output in one production year was 11,813.07 Kg. The highest number of DOC stocked on the farm was 230,000 with a mean of about 5,364 birds. Within the years of investigation, the average feed consumed by the birds was about 27,265 Kg. The mean man-day for the production period stood at 1,974.72. The average cost of drugs and vaccines was found to be ₦32,112.23, while the mean cost of other intermediate materials stood at ₦123,007.90. We found the mean age of the farmers to be about 44 years, with males dominating broiler farming (75.9%). The result on age is in consonance with the submission of (45) who reported that the average age of poultry farmers in the country stood at about 44 years. Our results on the sex of the farmers aligned with the results of (46; 47; 48; 49; 50; 51) who submitted that farming is a male-dominated enterprise in Nigeria. While some of the farmers had no formal education, the mean years of schooling were about 13 years. We found that about 34%, 61%, and 37% of the respondents had been trained in broiler farming, had access to credit, and had other means of livelihood respectively. The result on other means of livelihood aligned with those of (52; 53). The high proportion of farmers with access to credit may be attributed to the policy of the government targeted at improving livestock production through the provision of loans. This however contradicts the findings of (54) who indicated that far below half of the poultry farmers in Nigeria had access to credit.

Table 1. Descriptive statistics of the variables used in the production models.

Variable (n = 646)	Unit	Mean	Minimum	Maximum
Output	Kg	11,813.07 (24,055.07)	2,553	434,000
DOC	Number	5,363.7 (11,582.76)	1,500	230,000
Feed	Kg	27,264.69 (58,904.38)	7,320	1,157,000
Labor	Man-day	1,974.72 (4,456.15)	374	69,087
Cost of drugs and vaccines	₦	32,112.23 (69,499.29)	4,100	1,380,000
Other intermediate costs	₦	123,007.9 (157,135)	28,800	3,010,000
Age	Years	43.759(8.701)	22	66
Sex	Dummy	0.759 (0.428)	0	1
Education	Years	13.444 (2.887)	0	15
Experience	Years	6.902 (4.614)	2	35
Training	Dummy	0.337 (0.473)	0	1
Access to credit	Dummy	0.608 (0.488)	0	1
Other means of livelihood	Dummy	0.367 (0.382)	0	1
Flock size	Number	5,157.84 (11,338.82)	1,340	217,000

Note: Figures in parenthesis are the standard deviati
Source: Data analysis, 2020.

The results presented in Table 2 revealed that the TE levels of BFs in Nigeria ranged between 0.11 and 0.99 with an average value of 0.68. This indicates that a wide variation exists between TE levels of BFs and that ample opportunities exist for about 29% of the farms with TE of less than 75% to improve on their TEs. The mean value indicates that the farmers need to increase output by 32% to reach the frontier output. Nonetheless, the mean value is higher than 62% reported by (55) and lower than 81%, 85%, and 89% respectively for broiler farms reported by (56; 55; 24).

Table 2. Distribution of farms based on their levels of efficiency.

Efficiency level	Frequency	Percentage
<0.5	172	26.63
0.5-0.75	14	2.17
>0.75	460	71.21
Total	646	100
Mean	0.68	
Minimum	0.11	
Maximum	0.99	

Source: Data analysis, 2020.

The results in Table 3 depict that the estimated coefficients of feed, drugs, and vaccines as well as labor *with* values of 0.945, -0.400, and -0.101 respectively were *statistically* significant with the feed having the highest absolute value. As shown in the table, a 1% increase in feed consumption will lead to a 0.945% increase in broiler output. Our finding agrees with the reports of (57; 12; 16; 55). All the researchers indicated that a direct relationship exists between feed and broiler output. In the same vein, ceteris paribus, a 1% change in the costs of drugs and vaccines will result in a decrease in broiler output by about 0.400%. The result concurs with the findings of (58; 24) who reported an indirect relationship between drugs and vaccines and broiler output. Furthermore, all things being equal, a 1% change in labor will result in an increase in broiler output by almost 0.1%. The result concurs with the submission of (59; 24) who reported a direct correlation between labor and broiler output, but deviates from the submission of (12).

Table 3. Maximum Likelihood estimates of technical efficiency model.

Variable	Parameter	Coefficient	Standard error	t-value
Constant	β_0	-0.579	0.344	1.681
DOC	β_1	0.409	0.484	0.845
Feed	β_2	0.945*	0.453	2.085
Costs of drugs and Vaccines	β_3	-0.400**	0.046	8.700
Labor	β_4	0.101*	0.052	1.933
Other costs	β_5	0.667	0.449	1.485

Source: Data analysis, 2020.
*, ** implies significant at 10%, and 5% level respectively.

As depicted in Table 4, all the identified factors with the exception of age and experience significantly determined the technical inefficiency of BFs. While the estimate of sex is positive, those of other significant variables are negative. This implies that while sex has an increasing effect on technical inefficiency, inefficiency decreases with an increase in the level of education of farmers and access to training, credit, and involvement in other means of livelihood. Our result on education compared well with the opinion of (16; 59) but not in line with that of (12). Likewise, our submission on the negative link between access to credit and inefficiency is in line with that of (24; 59). Furthermore, our results on other means of likelihood concur with that of (24) who found a negative relationship between other means of livelihood and inefficiency.

Similarly, the estimate of sigma-square (σ^2) obtained shows the total variation from the frontier model and it is significant at the 1% level. This indicates that the deviation from the frontier is very vital and one not to be disregarded. The estimate of gamma (γ) obtained means that nearly 80% of the disparity in the entire output amongst the broiler farms was a result of differences in their TE. In other words, it means that the inefficiency contributes about 80% in the composite error term, while the remaining 20% was contributed by random factors which were outside the farmers' control.

Table 4. Estimates of technical inefficiency effect model.

Variable	Parameter	Coefficients	Standard error	t-value
Constant	α_0	21.819***	2.772	7.872
Age	α_1	0.140	0.1463	0.972
Sex	α_2	6.028***	0.431	19.983
Education	α_3	-0.804***	0.084	9.626
Experience	α_4	-0.101	0.144	0.702
Training	α_5	-0.385***	0.075	5.155
Access to credit	α_6	-2.261**	0.728	3.107
Other means of livelihood	α_7	-2.290**	0.905	2.530
Sigma-squared	σ^2	15.094	0.740	20.411
Gamma	γ	0.800	0.100	7.991
log-likelihood	430.6755			

** implies significant at 5%, and *** implies significant at 1%.
Source: Data analysis, 2020.

Generally, it was discovered that the average broiler output per annum was low despite that the farmers were still economically active while male gender dominated broiler farming in the study area. Feed, costs of drugs and vaccines as well as labour were the important inputs in the production of broilers, therefore these variables should be well managed for improved broiler production. The findings have also shown that broiler farms were not technically efficient, implying that farmers could increase their broiler output for a given level of inputs if they become more technically efficient. The level of inefficiencies of farms was influenced by the farmer's sex, level of education, training, access to credit, and other means of livelihood, indicating that the variables play key roles in the level of technical inefficiencies of broiler farms. While being male compared to female increases inefficiency, other variables had a decreasing effect on inefficiency.

Conclusion and Application

Our findings strongly suggest that to increase farm efficiency the following should be considered

1. Feed and labour should be adequately

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   to reduce expenses on drugs and vaccines should be promoted among broiler farmers.
2. The policies that will see to adequate training of farmers on good management practices by extension

agents and other development partners will be a good option.

3. Policies that will lead to improvement in credit facilities advanced to farmers by agricultural and cooperative banks and microfinance banks on good terms need to be pursued.
4. More females should be encouraged to go into broiler farming to boost broiler production in the country.
5. The paucity of nationally representative panel data on broiler farms in the country hindered us from analyzing the technical efficiency of broiler farms over time. It then becomes important for the National Bureau of Statistics or another stakeholder in the development of the livestock industry to embark on data collection on the subject matter consistently. Future research can then build on this study by making use of such data. Also, future research can also employ various functional forms and compare their results.

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