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Assessment of Effect of Biosecurity Level on Profit Efficiency in Poultry Egg Production in Southwestern, Nigeria

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Target Audience: *Poultry producers and Policy makers.*

Abstract

The problem of diseases outbreak led to the decline in poultry production over the years. This study was conducted among 343 poultry egg farmers in Southwestern, Nigeria. Primary data was utilized with the use of questionnaire to assess the level of biosecurity practices among poultry egg farmers in the study area. Descriptive statistics, farm budgeting techniques and stochastic frontier production function model were used to analyze the data. The findings of the study revealed that majority (74.3%) of the poultry egg farmers were male with an average age 42 ± 8.9 years. More than half (57.8%) of the farmers were educated above secondary education. More than half (63.6%) of the farmers had between 5-10 years of layers rearing experience with the mean years of experience being 9.0 ± 5.4 years. Majority (70.9%) of the farmers had access to livestock extension services. Majority (68.5%) of the poultry egg farmers operated at low level of biosecurity. Stock size, access to extension services, livestock insurance and biosecurity practices significantly increase the profit efficiency of the poultry farmers. This study recommends regular training for poultry farmers on improved biosecurity practices in order to increase profit efficiency.

Key words: *Poultry; egg; profit; efficiency; Nigeria*

Description of Problem

The livestock industry is very important in the Nigerian economy because it provides a good source of animal protein such as meat, milk and egg that are rich in the essential amino acids required for body functions. Excess released from such products could as well be exported for foreign exchange (1). Evidence from the Central Bank of Nigeria (CBN) in 2012 shows that livestock subsector is the second largest agricultural sub-sector of the Nigerian economy contributing about 0.5% to Nigeria's gross domestic product (GDP). According to the Federal Department of Livestock (2), livestock estimates in Nigeria as at 2009 stood at 7.18 million pigs, 16.43 million cattle, 34.69 million sheep, 55.15 million goats and 183.16 million poultry. These estimates revealed that poultry is the most commonly kept livestock in Nigeria. Poultry meat and eggs offer considerable potential for meeting human needs for dietary animal supply (3). Poultry products (meat and eggs) have assumed the role of providing much needed animal protein to human populace (4). Poultry contributes about 15 percent of the total annual protein intake with approximately 1.3kg of poultry products consumed per head per annum (5). In the past decades, there has been a recorded improvement in poultry production in Nigeria with its share of the Gross Domestic Product (GDP) increasing in absolute terms.

The problems associated with poultry production in Nigeria are low egg production, diseases and pests, low and poor performing breeds, poor weight gain or feed conversion, feeding and management problems and lack of capital (6). According to (7), poultry industry in Nigeria is plagued by host of risks and uncertainties and these include natural risks, poultry diseases, pests, all these result in high mortality rates in poultry production; social risks; economic risks (price fluctuation;), loss or unexpected depreciation of investment: uncertain or unstable supply of feed as well as variation in the quality of feed. In addition to the problems aforementioned; poultry production in Nigeria is confronting with low productivity and inefficiency in resource allocation and utilization (8).

Biosecurity will not only maintain the good environment but also minimize infectious and zoonotic diseases and subsequently increase public health (9). The failures in biosecurity measures will greatly enhance introduction and spread of poultry diseases (10). The implementation of sound biosecurity measures would go a long way in minimizing the problems of disease outbreak and spread in the Nigerian poultry industry and also maintain consumers' confidence in Nigerian poultry products (11).

There have been several economic studies which focused on profitability, technical and profit efficiency of poultry production (12; 1; 13; 14; 15; 16; 17). However, none of these studies has taken into account the assessment of the level of biosecurity practices and its effect on poultry farm profit in Nigeria. Therefore, this study contributes to the literature on poultry disease management through the assessment of level of biosecurity practices and its effect on poultry egg farm profit. The specific objectives are

assessing the level of biosecurity practices;

evaluating the profit of poultry egg production and

examining the effect of biosecurity practices on farm profit.

Materials and Methods

Study Area: The study was carried out in Southwest, Nigeria where the bulk of commercial poultry production system with moderate to high bio-security systems is based. It is estimated that over 65% of Nigeria's commercial poultry is located in the Southwest states; while another 25 % is based in the South-south and South-east geo-political zones. The balance of 10% or less of Nigeria's commercial poultry is based in the North-central, North-west and North-east states (18). However, Oyo, Osun and Ogun States were selected as the available records (19) show that the three states have the highest chicken population in Southwest, Nigeria.

Osun State has 30 Local Government Areas with an estimated population of 3.4 million (20) and land area of 14,875 km^2 on latitude 5^0N and 8^0N; between longitude 4^0E and 5^0E. The climate is humid tropical type with a mean annual temperature of about 28^0C and a mean annual rainfall of over 1600 mm. Oyo State has 33 Local Government Areas with an estimated population of 5.6 million (20). The land area is 35,743 km^2 located within latitude 3^0N and 5^0N; between longitude 7^0E and 9.3^0E. The average temperatures are between 24^0C and 25^0C. Rainfall figures over the state vary from an average of 1200 mm at the onset of heavy rains to 1800 mm at its peak in the southern part of the state to an average 800 mm and 1500 mm at the northern part of the state. Ogun State has twenty Local Government Areas bordered to the east by Ondo State and to the north by Oyo and Osun states. Its border with the Republic of Benin to the west makes it an access route to the expansive market of the Economic Community of West Africa States (ECOWAS); and it is bordered to the south by Lagos State and by the Atlantic Ocean. The state covers about 16,762 square kilometer which is approximately 1.81 percent of Nigeria's land mass of about 923,768 and population of 3.8 million (23). The mean annual rainfall and temperature are about 1,270 mm and 28ºC respectively while the estimated mean annual potential evaporation is 1,100 mm.

Source and type of data: Primary were obtained with the aid of well-structured questionnaire that captured socio-economic characteristics of poultry egg farmers and farm characteristics. These include age of the poultry egg farmer, gender, level of education, layer rearing experience, household size, access to livestock insurance and sources of credit. Also, information was sought on various practices of biosecurity measures and the level of occurrence of poultry disease outbreak.

Data collection and sampling techniques: A multistage sampling technique was employed in selecting the poultry egg farmers in the study area. The first stage was the purposive selection of Ogun, Osun and Oyo States from the six states in Southwest, Nigeria; based on the highest exotic-chicken layers population distribution in Southwest, Nigeria (21). The second stage involved the purposive selection of five (5) local government areas (LGAs) from Ogun State and four (4) local governments from Osun State and six (6) local governments from Oyo State. The size of the local governments chosen from each state was based on available records of number of registered members of the Poultry Association of Nigeria (PAN) in which Oyo State has the highest number of poultry farmers. The purposive selection of the local governments in each state was based on those with the highest number of registered members of the Poultry Association of Nigeria (PAN). Local governments selected in Ogun State include Abeokuta North, Egbado North, Odeda, Remo North and Sagamu. In Osun State, Iwo, Ejigbo, Irepodun and Ilesa West were selected. Egbeda, Lagelu, Atiba, Oyo East, Ona Ara and Oyo West local governments were selected in Oyo State.

The third stage was the random selection of one hundred and twenty (120), one hundred (100) and one hundred and forty (140) poultry egg farmers selected from Ogun, Osun and Oyo States respectively proportionate to the size of registered members of the Poultry Association of Nigeria (PAN) in each state. Also, the number of farmers selected in each selected Local Governments Area is proportionate to the size of registered members of the Poultry Association of Nigeria (PAN) in each LGAs. In all, three hundred and sixty (360) poultry egg farmers were sampled. However, due to incomplete responses, only three hundred and forty three (343) questionnaires were used for the analysis.

Fuzzy Logic Model: Fuzzy logic model was adopted to estimate the biosecurity level index based on farmers' decisions in the application of various biosecurity options in farm. The term fuzzy was proposed by Zadeh in 1965, when he published the famous paper on Fuzzy Sets. Mathematical expression of the fuzzy set theory, following (21), and (22) proceed as follows: let X be a set and x an element of X. A fuzzy subset P of X can therefore be defined as follows:

$$P = \{x, F_p(X)\}, \text{ for all } x \in X \qquad (1)$$

where, F_p, is a membership function which takes its values in the closed interval [0, 1]. In other words, the fuzzy sub-set P of X is characterized by a membership function $F_p(x)$ associating a real number in the interval [0, 1] to each point of X. The value F_p represents the degree of belonging to P. That is, each value $F_p(x)$ is the degree of membership of x to P.

In a simple application to determination of biosecurity level, let X be a set of poultry layer farms (i=1, 2, 3… n) and P, a fuzzy subset of X. In the fuzzy approach $F_p(x)$, the membership function of the level of biosecurity of poultry farm i is defined as:

$x_{ij} = 1$; farm i is of high level biosecurity (2)

$0 \leq x_{ij} \leq 1$; if farm i reveals a partial degree of level of biosecurity

Estimation of Membership Function: The determination of the individual membership function $F_P(x_i)$ depends on the type of variable. The variables that define indicators of biosecurity index are either dichotomous or categorical in nature.

Dichotomous Variables: Following Costa (23), the degree of membership to the fuzzy set P of the a_i^{th} chicken egg farm (i=1, 2… n) with respect to the j^{th} attribute (j=1,……,m), is stated as follows:

$$F_p = (a_i)j = X_j(a_i) = x_{ij} \qquad (3)$$

$X_j(a_i)$ is the m order of attributes that will result in a state of disease management if totally or partially owned by the a_i^{th} farm.

Categorical Variable: Ordinal or categorical discrete variables are those that present several modalities (more than two values). The lowest modality is denoted as $C_{inf,j}$ and the highest modality as $C_{sup,j}$, then, following (24); (23); (21), the membership function of the a_i^{th} farm is expressed as:

$$F_p(a_i) = 1 \text{ if } 0 < C_{ij} \leq C_{inf,j}$$

$$F_p(a_i) = \frac{C_{sup,j} - C_{ij}}{C_{sup,j} - C_{inf,j}} \text{ if } C_{inf,j} < C_{ij} < C_{sup,j} \qquad (4)$$

$$F_p(a_i) = 0 \text{ if } C_{ij} \geq C_{sup,j}$$

The Biosecurity index (BI) of the a_i^{th} poultry farm, $F_P(a_i)$ (i.e. the degree of membership of the a_i^{th} farm to the fuzzy set P) is defined as the weighted average of x_{ij} as equation 5 following (25):

$$F_p = \sum_{i=1}^{n} (a_i) n_i \Big/ \sum_{i=1}^{n} n_i \qquad (5)$$

F_p is the Biosecurity index (BI) for the population of poultry egg farms studied is expressed as equation 6:

$$F_p = \sum_{i=1}^{n} F_{P(a_i)n_i} / n \qquad (6)$$

Estimation of Weight: The degree of attainment of the selected biosecurity index is express by equation 5 and 6. It is conceptualized as equation 7:

$$F_p = \sum_{j=1}^{m} x_{ij} w_j \Big/ \sum_{j=1}^{m} w_j \qquad (7)$$

Where w_j is the weight given to the j^{th} attribute in equation 8 as:

$$w_j = log n \sum_{i=1}^{n} x_{ij} n_i \geq 0 \qquad (8)$$

Biosecurity Index (BI): Equation (8) expresses the biosecurity index of the j^{th} attribute for the entire population of *n* poultry egg farms. Equation 8 is expressed as:

$$F_p = \sum_{i=1}^{n} (a_i) n_i \Big/ \sum_{i=1}^{n} n_i = \sum_{i=1}^{n} F_{P(a_i)n_i} / n \qquad (9)$$

Biosecurity Index (BI) of the population F_P is defined as a weighted average of F_P (X_j) is expressed in equation 9 as:

$$F_p x_j = \sum_{i=1}^{n} x_{ij} n_i / \sum_{i=1}^{n} n_i \quad (10)$$

Estimation of Biosecurity Level: The level of biosecurity was estimated from index generated in equation (10). The level of biosecurity was categorized following (26); (25) as (1) Low level (0 up to 0.33); (2) Moderate level (0.34-0.66) and (3) High level (0.67-1.0). Biosecurity practices attributes were selected following (27) as shown in Table 1.

Table 1: Biosecurity Index.

Dimensions	Attributes	Categories
Biosecurity Practices	Location of farm	Poultry farm's distance from public roads, poultry farm's distance from the next poultry farm and poultry farm's distance from a pond or lake.
	Traffic on and off the farm	Poultry farm has a gate; poultry farm is surrounded by a fence and disinfection of vehicles that come to the poultry farm.
	Pest management of other livestock and animals	Rodent control plan, keeping grass and weeds trimmed around the poultry house, regular checking and repairing of wire screening on the sides of the house and control of other livestock within 50 metres of the poultry houses.
	Poultry house cleaning and disinfection	Total cleanout of facility, the time interval of litter removal, litter that is removed is stored in a covered shed, litter is composting in an approved composting facility, spreading of litter on fields adjacent to the poultry houses and regular cleaning and disinfection of feed bin and boot.
	Poultry farmer's personal hygiene	Wearing the street clothes or shoes in the poultry houses, separate cap and pair of coveralls for each house, separate pair of boots for each house, disinfectant dip pans at every poultry house entrance, the time interval of changing the disinfectant and visitors who wish to enter the poultry houses must wear clean, sanitized caps, overalls, gloves, and boots.
	Flock Health Care and Monitoring	The time taken to learn more about the types of diseases that affect poultry, stocking multiple age groups of layer chickens on the farm and specific employees caring for different age group.

Source: Adapted from (27).

Gross Margin Analysis

The gross margin of an enterprise is expressed as the difference between the gross revenue and total variable cost.

Gross margin = Gross Revenue-Total variable cost (20)

It is given by a formula in equation 21:

$$GM = \sum_{i=1}^{n} P_i Q_i - \sum_{j}^{m} Y_j X_j$$

Where

GM = Gross margin in Naira

P_i = Price of output (eggs and culled layers) in Naira

Q_i = Quantity produced per flock (eggs and culled layers)

Y_j = Unit price of input j in Naira

X_j = Quantity of input j used for producing output i.

Net Revenue Analysis

π = TR - TC; Where

TC = TVC + TFC and TR = PQ

Therefore,

$$\pi = PQ - TVC - TFC \quad (22)$$

Where TR is Total Revenue from sales of eggs and culled layers per annum, π is profit, P is price of unit of output sold, Q is quantity of eggs sold per crate per day and culled layers sold per annum and TVC is total variable costs including the cost of purchase of the birds, feed, transportation, fuel, power, medication, veterinary services and cost of labour for feeding, watering and general management of birds. TFC is total fixed costs which include cost of depreciation on housing and equipment, annual cost of repairs and maintenance of assets, cost of insurance and interest on capital. TC is total cost of production. The straight line depreciation method was used to estimate the depreciation value of fixed items used in a year.

Measurement of Efficiency: The Stochastic Frontier Models

Production efficiency is usually analyzed by its two components – technical and allocative efficiency. In a production context, technical efficiency relates to the degree to which a farmer produces the minimum feasible output from a given bundle of inputs (an output oriented measure), or uses the minimum feasible level of inputs to produce a given level of output (an input oriented measure). Allocative efficiency, on the other hand, relates to the degree to which a farmer utilizes inputs in optimal proportions, given the observed input prices (28).

Recent developments combine both measures into one system, which enables more efficient estimates to be obtained by simultaneous estimation of the system (29). The popular approach to measure efficiency – the technical efficiency component– is the use of frontier production function (30; 31). However, it has been argued that a production function approach to measure efficiency may not be appropriate when farmers face different prices and have different factor endowments (32). This led to the application of stochastic profit function models to estimate farm specific efficiency directly (32; 29). The profit function approach combines the concepts of technical and allocative efficiency in the profit relationship and any errors in the production decision are assumed to be translated into lower profits or revenue for the producer (28). Profit efficiency, therefore, is defined as the ability of a farm to achieve highest possible profit given the prices and levels of fixed factors of that farm and profit inefficiency in this context is defined as loss of profit for not operating on the frontier (28). (33) extended the stochastic production frontier model by suggesting that the inefficiency effects can be expressed as a linear function of explanatory variables, reflecting farm-specific characteristics. The advantage of this model is that - the estimation of farm specific efficiency scores and the factors explaining the efficiency differentials among farmers is a single stage estimation procedure (34).

Stochastic Profit Frontier

Production efficiency is usually analysed by its two components – technical and allocative efficiency. However, it has been argued that a production function approach to measure efficiency may not be appropriate when farmers face different prices and have different factor endowments (32). This led to the application of stochastic normalized profit function models to estimate farm specific efficiency directly (32; 29). Profit efficiency is defined as the ability of a firm to attain the highest possible profit given the prices and levels of fixed factors of that firm while profit inefficiency in this framework is defined as loss of profit from not operating on the frontier (32). The profit function approach combines the concepts of technical and allocative efficiency in the profit relationship and any errors in the production decision are assumed to be translated into lower profits or revenue for the producer (28). The stochastic profit function is defined as:

$$\pi_i = f(P_i Z_j).exp(\varepsilon_i);\ \varepsilon_i = v_i - u_i \quad (23)$$

π_j = profit of the jth farm and it is computed as gross revenue less variable cost.

P_{ij} is the price of *j*th variable input faced by the *i*th farm;

Z_{ik} is level of the *k*th fixed factor on the *i*th farm;

e_i is an error term; and i = 1, ….., n, is the number of farms in the sample.

The error term *ei* is assumed to behave in a manner consistent with the frontier concept (32), i.e.

$e_i = v_i\text{-}u$

For this study, the production technology of chicken egg farmers in Southwest, Nigeria is assumed to be specified by the Cobb Douglas frontier production function defined as follows:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + v_i - u_i \quad 25$$

Where

$$u_i = \delta_0 + \sum_{d=1d}^{D} \delta_d Z_{di} + e_i$$

In these equations,

Y_i = Profit in naira (₦) per enterprise.

X_1 = Quantity of Feed consumed (Kg)

X_2 = Expenses on drugs and medication (₦)

X_3 = Expenses on stocking (₦).

X_4 = Labour cost (₦)

u_i= Profit inefficiency.

v_i= Statistical disturbance term.

The model specified in equation below is formulated and estimated jointly with the stochastic frontier profit model (33) to determine factors influencing observed profit efficiency. In addition to the general model, this inefficiency model was defined to estimate the influence of some farmer's socio-economic variables on the profit inefficiencies of the farmers. The model is defined by

$$u_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7$$

Where:

u_i, = Profit inefficiency

Z_1= Age (years)

Z_2= Sex (dummy = 1 if female, 0 otherwise)

Z_3 = Years of formal education

Z_4 = Household size

Z_5 = Poultry rearing experience measured in years.

Z_6 = Stock size (number of layers stocked)

Z_7 = Access to Extension services (dummy = 1 if yes, 0 otherwise)

Z_8 = Access to Credit (dummy = 1 if yes, 0 otherwise).

Z_9 = Access to Livestock insurance (dummy = 1 if yes, 0 otherwise).

Z_{10} = Biosecurity practices Index
δ_0, δ_i are the parameters to be estimated.

Statistical Analysis: Data was subjected to descriptive, fuzzy sets, budgetary techniques and stochastic frontier analyses

Results

Socio-Economic Characteristics of Poultry Egg Farmers: Table 2 presents socio-economic characteristics of poultry egg farmers. Majority (74.3%) of the poultry egg farmers were male. The average of age chicken egg farmers in the study area was 42 ± 8.9 years with majority (75.9%) below 50 years. Majority (84.0%) of the poultry egg farmers were married. Average household size of the poultry egg farmers was 5.0 ± 2.0 persons. More than half (57.8%) of the farmers were educated above secondary education. More than half (63.6%) of the farmers had between 5-10 years of layers rearing experience with the mean years of experience being 9.0 ± 5.4 years. Majority (98.0%) of the poultry egg farmers had access to credit while the remaining (2.0%) were discovered not to have access to any source of credit. Only 2% of the farmers insured their poultry farms as shown on Table 2. Majority (70.9%) of the farmers had access to disease control and medication advisory services.

Table 2: Socio-Economic Characteristics of Poultry Egg Farmers

Characteristics	Frequency	Percentage (%)
Age (Years)		
<30	23	6.7
30-39	101	29.5
40-49	136	39.7
≥ 50	83	24.2
Mean = 42	S.D = 8.86	
Sex		
Male	255	74.3
Female	88	25.7
Marital Status		
Married	288	84.0
Single	36	10.5
Divorced	7	2.0
Widowed	12	3.5
Household Size		
1-3	53	15.5
4-6	244	71.1
>6	46	13.4
Mean = 5	S.D = 2.0	

Level of Education		
Adult Literacy Training	4	1.7
Some Primary Education	2	0.9
Completed Primary Education	30	8.8
Some Secondary Education	4	1.2
Completed Secondary Education	105	30.6
Post-Secondary Education	193	56.3
Koranic	5	1.5
Poultry Farming Experience (Years)		
<5	50	14.6
5-10	218	63.6
11-16	46	13.4
>16	29	8.5
Mean = 9	S.D = 5.4	
Access to Credit		
No	7	2.0
Yes	336	98.0
Use of Livestock Insurance		
No	336	98.0
Yes	7	2.0
Access to Livestock Extension		
No	100	29.2
Yes	243	70.9

Source: Field Survey Data, 2018

Level of Biosecurity: The membership function for each attribute and the weights for the attributes from Fuzzy Logic analysis were presented on Table 3. Both values were further utilized to calculate absolute and relative contributions as presented on Table 4. Table 5 revealed that majority (68.5%) of the poultry egg farmers operated at low level of biosecurity. Also, 23.9 % was at moderate level while 7.6% was at high level.

Table 3: Average Membership Functions and Weights for Attributes of Biosecurity Index.

	Membership Functions $\frac{n}{\sum_{i=1}^{n} x_{ij} n_i}$	***Weights*** $\log \frac{n}{\sum_{i=1}^{n} x_{ij} n_i}$
Biosecurity Attributes		
Poultry farm's distance from public roads	2.919	0.4652
Poultry farm's distance from the next poultry farm	1.1122	0.0462
Poultry farm's distance from a pond or lake	1.0502	0.0213
Poultry farm has a gate that restricts vehicle access	3.03	0.4814
Poultry farm is surrounded by a fence	2.1113	0.3246
Disinfection of vehicles that come to the poultry farm	1.4423	0.1591
Rodent control plan	2.1483	0.3321
Keeping grass and weeds trimmed around the poultry house	2.3771	0.3760
Regular checking and repair of wire screening on the sides of the house	2.3788	0.3764
Control of other livestock within 50 metres of the poultry houses	1.0201	0.0086
Recent total cleanout of facility	1.003	0.0013
Time interval of litter removal	2.1583	0.3341
Litter that is removed is stored in a covered shed	5.3038	0.7246
Composting litter in an approved and properly managed composting facility	4.3746	0.6409
Litter is not spread on fields adjacent to the poultry houses	1.1714	0.0687
The feed bin, boot, and auger are regularly cleaned and disinfected	3.2605	0.5133
Wearing of street clothes or shoes in the poultry houses	1.8319	0.2629
Separate cap and pair of coveralls for each house	5.6166	0.7495
Separate pair of boots for each poultry house	6.0654	0.7829
Disinfectant dip pans at every poultry house entrance	3.0965	0.4909
The time interval of changing the disinfectant	3.3124	0.5201
All visitors who enter poultry houses must wear clean, sanitized caps, coveralls and gloves.	6.9623	0.8428
The time taken to learn more about poultry diseases	1.9652	0.2934
Multiple age groups of birds on the farm	2.9623	0.4716
Specific employees caring for different age group	3.8452	0.5849

Source: Field Survey Data, 2018.

Table 4: Absolute and Relative contributions to Biosecurity Index by Attributes

Attributes	Absolute Contributions	Relative Contributions
Poultry farm's distance from public roads	0.0234	2.5321
Poultry farm's distance from the next poultry farm	0.0231	3.3186
Poultry farm's distance from a pond or lake	0.012	3.64321
Poultry farm has a gate that restricts vehicle access	0.02341	2.3215
Poultry farm is surrounded by a fence	0.0115	2.9863
Disinfection of vehicles that come to the poultry farm	0.0214	7.7532
Rodent control plan	0.0134	3.4321
Keeping grass and weeds trimmed around the poultry house	0.0197	2.6753
Regular checking and repair of wire screening on the sides of the house	0.0012	3.9612
Control of other livestock within 50 metres of the poultry houses	0.0086	1.8613
Recent total cleanout of facility	0.0023	1.6517
Time interval of litter removal	0.0123	3.0765
Litter that is removed is stored in a covered shed	0.0231	3.1231
Composting litter in an approved and properly managed composting facility	0.0034	2.1234
Litter is not spread on fields adjacent to the poultry houses	0.0034	1.8713
The feed bin, boot, and auger are regularly cleaned and disinfected	0.0231	3.0743
Wearing of street clothes or shoes in the poultry houses	0.0315	2.6754
Separate cap and pair of coveralls for each house	0.0018	2.1342
Separate pair of boots for each poultry house	0.0196	2.6753
Disinfectant dip pans at every poultry house entrance	0.0046	1.6753
The time interval of changing the disinfectant	0.0126	3.7123
All visitors who enter poultry houses must wear clean, sanitized caps, coveralls and gloves.	0.0143	2.1321
The time taken to learn more about poultry diseases	0.0106	3.9432
Multiple age groups of birds on the farm	0.0396	2.5432
Specific employees caring for different age group	0.0143	6.7862

Source: Field Survey Data, 2013.

Table 5: Distribution of Biosecurity Level of the Poultry Farmers

Poultry Disease Management Level	Frequency	Percentage (%)
Low (0 up to 0.33)	235	68.5
Moderate (0.34-0.66)	82	23.9
High (0.67-1.0)	26	7.6
Total	343	100

Source: Field Survey Data, 2018.

Costs and Returns of Poultry egg production: Three profitability indicators were estimated as shown on Table 6. These were net profit, gross margin and return on investment per naira invested. The gross margin and net profit respectively, were ₦1,867,428.00; ₦1,576,645.00. The gross return per naira invested showed that every naira invested earned ₦1.05.

Table 6: Costs and Returns of Poultry egg production per annum

Variables	Mean Value (Naira)
Sales of Eggs	29,085,596.30
Culled layers sales	1,585,906.56
Total Revenue (TR)	30,671,502.60
Total Variable Cost (TVC)	28,804,075.07
Fixed Cost (FC)	290,782.53
Total Cost (TVC+FC)	29,094,857.6
Gross Margin (TR-TVC)	1,867,428.00
Net Profit (TR-TC)	**1,576,645.00**
Return on Investment (TR/TC)	**1.05**

Source: Field Survey Data, 2018.

Maximum Likelihood Estimates (MLE) of Stochastic Frontier Profit Function

Table 7 shows the result of the maximum likelihood estimate of stochastic frontier profit function of poultry egg production in Southwest, Nigeria. The result showed that the gamma (λ) is estimated as 2.2057 and is statistically significant at 5%. The result shows the relative importance of the variable inputs in poultry egg production. All the coefficient of significant variables was positive except feed. Only the estimate of labour was statistically significant at 1%.

The parameter estimates of the relationship between profit inefficiency and poultry farm's characteristics and farmers' socio-economic as shown in Table 7 revealed that the only coefficients of age was positive and statistically significant at 5% level. Also, the coefficients of stock size, access to extension services, livestock insurance and biosecurity practices were all negative and significant at 1% level.

Table 7: Maximum Likelihood Estimates (MLE) of Stochastic Frontier Profit Function

Variables	Parameters	Coefficients	Std. Error	t-ratio
General Model				
Constant	β_0	1.8213***	0.6771	2.69
Feed (kg) (X_1)	β_1	-0.0498	0.0571	-0.87
Vaccines and drugs (₦) (X_2)	β_2	0.0277	0.0516	0.54
Stock of birds (₦) (X_3)	β_3	0.0235	0 .0358	0.66
Labour (₦) (X_4)	β_4	0.6446 ***	0 .0418	15.43
Inefficiency Function				
Constant	δ_0	-0.0679	0.2034	-0.33
Age (years)	δ_1	0.0067**	0.0030	2.18
Female Gender	δ_2	0 .0054	0.0536	0.10
Education (years)	δ_3	-0.0306	0.0218	-1.40
Experience (years)	δ_4	-0.0031	0.0047	-0.67
Household size	δ_5	-0.0234	0 .0148	-1.58
Stock size	δ_6	-0.0004***	0.00002	-18.79
Access to Extension services	δ_7	-0.1405***	0.0492	-2.85
Access to Credit	δ_8	0.0262	0.0459	0.57
Livestock Insurance	δ_9	-0.5603***	0.1538	-3.64
Biosecurity Practices Index	δ_{10}	-0.3907***	0.1379	-2.83
Diagnostic Statistics				
Sigma-square	δ^2	0.4163	0.0529	0.31
Gamma γ		2.2057**	0.8011	2.05
Log likelihood function	-199.63			
LR Test	21.9			
Mean Profit Efficiency-	0.86			

Source: Field Survey Data, 2018.
*Significant at 10% level; ** Significant at 5% level; *** Significant at 1%

Discussion

Majority (75.9%) of the poultry egg farmers were below 50 years which implied that most of these poultry farmers were in their active and productive years who can easily understand and adopt new innovations that could enhance productivity. Majority (74.3%) of the poultry egg farmers were male which indicates that poultry egg farming is still predominantly a male occupation. Consistent with this finding are those of (34); (35); (36). More than half (57.8%) of the farmers were educated above secondary education. This level of education is expected to affect their attitude towards adoption of scientific techniques positively in order to improve their level of disease management on the farm as also reported by (37).

The gross margin and net profit respectively, were ₦1,867,428.00; ₦1,576,645.00. The gross return per naira invested showed that every naira invested earned ₦1.05. The values obtained for these profitability indicators showed that poultry egg production is a profitable business in Southwestern zone of Nigeria.

The result revealed that the gamma (λ) is estimated as 2.2057 and is statistically significant at 5% which suggests the existence of profit inefficiency amongst the poultry egg farmers in south west, Nigeria. It means that variations in farm profits mainly arose from differences in farm practices. Therefore, profit can be optimized if the inefficiency effects among the poultry farmers are minimized. The estimate of labour X_4 with a coefficient of 0.6446 appears to be the most important variable determining profit efficiency. This means that for a 10% increase in the cost of labour, the profit obtainable from egg production will decrease by 6.4%.

The negative and significant coefficients of stock size, access to extension services, livestock insurance and biosecurity practices indicates that increase in stock size; access to extension services, livestock insurance and higher levels of biosecurity practices reduce profit inefficiency. Also, positive and statistically significant relationship found between age of the poultry farmer signifies a positive effect on profit inefficiency. This result agrees with the findings of (5) that increase age would lead to decrease in profit efficiency since aging poultry farmers would find it difficult to understand new innovations in modern poultry farming.

Conclusion and Applications.

1. The profitability indicators revealed that poultry egg production is a profitable business.
2. The most important input that influenced the level of profit efficiency negatively was labour. 3. Stock size, access to extension services, livestock insurance and biosecurity practices are found to significantly decrease the profit inefficiency of the poultry farmers, while the profit inefficiency of the farmers increased as they grew older.
4. Mitigation option through the use of livestock insurance policy was very low amongst the poultry farmers.
5. This study recommends that poultry farmers should be encouraged by extension agents to participate in livestock insurance policy.
6. Biosecurity practices had positive influence on the level of profit efficiency. The policy implication of this finding is that profit inefficiency can be reduced significantly by improving the level of biosecurity practices of farmers.
7. It is recommended that Poultry Association of Nigeria (PAN) should organize regular training for poultry farmers which should be handled by the professionals.

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