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Comparative Productivity Analysis of Median Scale Battery Cage and Deep Litter Housing Chicken Egg Production in Rivers State, Nigeria

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Abstract**—**This paper analyses the productivity of median scale battery cage and deep litter chicken egg producers in Rivers State, Nigeria. 90 battery cage and 90 deep litter farmers giving a total of 180 farmers were sampled through a multistage sampling procedure. Mean productivity was higher for the battery cage than the deep litter farmers at 2.65 and 2.33 respectively. Productivity of battery cage farmers were positively influenced by age, extension contacts, experience and feed quantity while the productivity of deep litter farmers was positively influenced by age, extension contacts, household size, experience and labour. The major constraints identified by both categories are high cost of feed, high price of day-old chick, inadequate finance, lack of credit and high cost of drug/vaccination. Furthermore, the work recommends that government should assist chicken egg farmers through subsidies of input resources and put policies to make financial institutions give out loans at low interest rate to the farmers. The farmers should abide by the recommended number of birds per unit area while stocking.

Keywords**—**Productivity, battery cage, deep litter, median scale, egg production.

I. Introduction

PRODUCTIVITY as an issue of study in agriculture has long become a matter of interest to agricultural economists. Agriculture productivity growth is a core element in the economic growth of some countries like the countries of the European Union [1]. Improving agricultural productivity has become a common strategy to reducing poverty and over the years, economists have examined productivity using production functions with the assumption that all decision-making units use common underlying technology [2]. However, in reality, the underlying production technology and production possibilities could differ because of resource endowments [3]. In Nigeria, food production is not in commensuration with the exponentially growing population [4]. Livestock production is a significant section of farming in agriculture upon which humans depend on for nutrition, wears, fuel, manure alongside others in sustaining the economy. Livestock production as well acts as a supplementary occupation to the income of the poor and minor farm families [5].

The poultry industry has occupied a cardinal stance due to its huge ability to swiftly cause rise in the economic growth, specifically advancing the low-income population [6]. More to it, production of eggs and poultry meat may require little capital investment but starts to yield returns within a few months. Chicken egg is one of the mostly consumed animal proteins without religion or culture restrictions in Nigeria. It records one of the cheapest and main contributors of animal protein intake for developing countries like Nigeria [7]. Housing condition for poultry holds a pivotal role in maintaining the bird's welfare, health and production strength [8]. The attainment of success by any poultry farm has an anchor on the system of housing and management system on board. To maintain birds in safe health is of necessity for their welfare and to upsurge productivity through good production practices [9]. Matters on housing system make a strong stake in determining the pool of returns to be accrued to the farmer which is dependent on the input/output relationship. There are three common poultry housing systems practiced in Nigeria namely; free range, battery cage and deep litter system but for commercial purposes are the deep litter and the battery cage systems.

A number of studies, such as [8], [10], [12] and [14], have shown that housing in poultry production plays a pivot role in the optimal health, growth and productive response of birds. A few accessed works have been done comparing production of laying birds housed under battery cage and deep litter system. This paper compared productivity level focusing on medium scale operators who are capable of reducing the animal protein demand supply gap as well as providing continuous flow of income for poultry farmers according to [10].

Medium scale poultry egg production refers to those whose operations are characterized by moderately low production level opportunity to obtain sufficient input to expand production. Medium scale poultry egg farms are farms having flock size between 1000 laying birds to 3000 laying birds [4]. The result of comparing the productivity level of the battery cage and deep litter layer poultry farmers and identifying their major constraints could help in best housing decision for commercial production aiding to bridge the supply demand gap of the poultry layer enterprise.

Hence in this paper, we estimate and compare the productivity level of poultry egg production, analyse the factors influencing the productivity level of poultry egg production and identify the constraints to egg production under battery cage and deep litter systems in the study area.

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II. Materials and Methods

A. The Study Area

This study took place in Rivers State, Nigeria. Rivers State is to the southern part of Nigeria and has Port Harcourt as the capital and largest city. Rivers state lies between latitude 4° 44' 59 North of the equator and longitude 6°49' 39 East of the Greenwich meridian line with an area of 11,077 km^2. The borders of the state are Atlantic Ocean to the South, Imo, Abia and Anambra States to the North, Akwa Ibom State to the East and Bayelsa and Delta States to the West.

B. Sampling and Data Collection

Multistage sampling procedure was used. Stage one is a purposive selection of zone 1 and zone 3 of the agricultural zones in Rivers State due to dominancy of livestock and crop farming unlike the zone 2 which is riverine. Stage two was a selection of five Local Government Areas from the two zones purposively on the basis of large number of poultry egg farmers in the area. In stage three, simple random sampling technique was used to select three communities from each of the Local Government Areas giving a total of 15 communities. Finally, stage four was a snowball sampling using enumerators from the five Local Government Areas.

These enumerators from the five Local Government Areas were identified with some poultry egg farmers from each of the fifteen communities who then mentioned other poultry egg farmers within the communities. This process continued until a total of 180 medium scale poultry egg farmers comprising of 90 battery cage and 90 deep litter housing system users were obtained. Data for the study were collected with the use of a structured questionnaire through scheduled interview and analysed using Total Factor Productivity model for the productivity level following [11] and then Z-test was used to compare the means.

Factors influencing the productivity under battery cage and deep litter systems were analysed using the multiple regression analysis model following [12]. Constraints to egg production under battery cage and deep litter systems was achieved using a Five-Point Likert Scale rating to measure the responses of the farmers.

C. Hypothesis

The hypothesis is:

- H0$_1$: There is no significant difference between the productivity of farmers under battery cage and deep litter systems in the study area.

D. Model Specification

The Total Factor Productivity Model (TFP_i) is given as:

$$TFP_i = \frac{Y_i}{\sum P_i X_i} \quad (1)$$

where; Y_i = Quantity of egg produced (₦); P_i = Unit price of variable input (₦); X_i = Quantity of variable input used.

Z-test for comparison of means is stated as:

$$Z_{cal} = \frac{\bar{Y}_1 - \bar{Y}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}} \quad (2)$$

where; $\bar{Y}_1$ is the mean productivity of farmers under battery cage system; $\bar{Y}_2$ is the mean productivity of farmers under deep litter system; S_1^2 is the variance of productivity of farmers under battery cage system; S_2^2 is the variance of productivity of farmers under deep litter system; n_1 is the number of selected farmers under battery cage system; n_2 is the number of selected farmers under deep litter system; $n_1 + n_2$ is 2 degree of freedom.

The regression model was used in examining the factors affecting TFP. The implicit form of the model is given as:

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, e) \quad (3)$$

where; Y is the total Factor Productivity; X_1 is the age of the farmers (years); X_2 is the farmers' education (years); X_3 is the Extension agent visits (Dummy; Yes = 1, No = 0); X_4 is the Household size of the farmer (number of persons); X_5 is the Stock size (number of birds); X_6 is the Farmers' experience (number of the years of farming); X_7 is the Labour (Man-days); X_8 is the Capital (depreciation on assets); X_9 is the Feed quantity (Kg); e is the error term.

The four functional forms of the model that was tried are explicitly stated as;

Linear Function:

$$Y = \begin{pmatrix} b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 \\ + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + e \end{pmatrix} \quad (4)$$

Semi – Log Function:

$$lnY = \begin{pmatrix} b_0 + b_1X_1 + b_2X_2 + b_3X_3 \\ + b_4X_4 + b_5X_5 \\ + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + e \end{pmatrix} \quad (5)$$

Cobb Douglas:

$$lnY = \begin{pmatrix} b_0 + b_1lnX_1 + b_2lnX_2 + b_3lnX_3 \\ + b_4lnX_4 + b_5lnX_5 + b_6lnX_6 \\ + b_7lnX_7 + b_8lnX_8 + b_9lnX_9 + e \end{pmatrix} \quad (6)$$

Exponential Function:

$$Y = \begin{pmatrix} b_0 + b_1lnX_1 + b_2lnX_2 + b_3lnX_3 \\ + b_4lnX_4 + b_5lnX_5 + b_6lnX_6 \\ + b_7lnX_7 + b_8lnX_8 + b_9lnX_9 + e \end{pmatrix} \quad (7)$$

where; $X_1 - X_9$ are the independent variables; $b_1 - b_9$ are the regression coefficients; b_0 is a constant; e represents the error term.

The lead equation was chosen based on the magnitude of R^2, F-ratio and number of significant variables.

The *a priori* expectation of the direction of change for the factors affecting productivity as a result of a unit change in any of the independent variables in the model is as follows:

Variables such as education level, extension contacts, household size, farming experience, labour and feed quantity may positively influence productivity while variables like age, stock size and capital may have negative effect on productivity of the farmers.

The Five-Point Likert Scale is read from very serious '1', serious '2', moderately serious '3', not serious '4' and not aware '5'. The mean value was computed as: $\frac{1+2+3+4+5}{5} = 3$. Any constraint with a mean value of 3 and above is considered a major constraint otherwise, minor constraint.

III. Results and Discussion

TABLE I
DISTRIBUTION OF FARMERS ACCORDING TO THEIR PRODUCTIVITY LEVEL

Productivity	Battery cage		Deep litter	
	Frequency (f)	Percentage (%)	Frequency (f)	Percentage (%)
0.1-1.0	12	13.33	15	16.67
1.1-2.0	17	18.89	26	28.89
2.1-3.0	25	27.78	22	24.44
3.1-4.0	22	24.44	18	20.00
4.1-5.0	14	15.56	9	10.00
Total	90	100.00	90	100.00
Mean	2.65		2.33	
Std deviation	1.36		2.12	

Table I shows that the mean productivity of the farmers was 2.65 and 2.33 for battery cage and deep litter farmers respectively. Using the mid productivity level of 2.1 – 3.0 as our bench mark to ascertain the percentage of farmers with high productivity since we had five levels, the result shows that 67.78% of the battery cage farmers have productivity level above 2.0 while 54.4% of the deep litter farmers have productivity level above 2.0. This shows that these farmers have high productivity which could be as a result of appropriate conversion of resources to output but the battery cage farmers are more productive than the deep litter farmers. According to [13], the higher the total factor productivity, the more productive the enterprise is.

TABLE II
RESULT OF TEST OF SIGNIFICANT DIFFERENCE IN PRODUCTIVITY BETWEEN BATTERY CAGE AND DEEP LITTER SYSTEMS OF POULTRY EGG FARMERS

Variables	Mean	Std. Deviation	Std. Error Mean	Z-value
Productivity (₦) for battery cage	2.6511	2.3604	0.46882	
Productivity (₦) for deep litter	2.3278	2.1201	0.49222	1.746
Differences	0.3233	4.46177	1.70719	

Table II shows that the battery cage and deep litter farmers has a slim mean productivity difference of 0.3233 in favour of the battery cage farmers. This is similar with the findings of [14], who found that both the battery cage and deep litter farmers were profitable but with a slim profit difference in favour of the battery cage producers. The calculated z-statistic of 1.746 is less than the critical value of 1.96. This implies that there was no statistical significant difference between the productivity in battery cage and deep litter enterprises. We therefore accept the null hypothesis.

From (4)-(7), we obtain Tables III and IV.

TABLE III
RESULT OF REGRESSION ANALYSIS OF THE FACTORS AFFECTING PRODUCTIVITY OF BATTERY CAGE

Variables	Linear	Exponential	Cobb Douglas+	Semi log
Intercept	-85197.226 (-0.921)	11.592 (44.906)***	3.967 (6.545)***	-2640658.701 (-7.122)***
Age (X_1)	0.775 (2.222)**	0.021 (2.121)**	0.072 (1.723)*	4.460 (1.736)*
Farmers' education (X_2)	0.358 (1.396)	0.006 (0.800)	0.023 (0.726)	2.668 (1.360)
Extension contacts (X_3)	3.421 (3.588)***	0.079 (2.968)***	0.219 (2.978)***	14.870 (3.306)***
Household size (X_4)	0.242 (2.421)**	0.004 (1.280)	0.059 (0.968)	7.225 (1.946)*
Stock size (X_5)	-0.247 (-1.153)	0.000 (-0.070)	-0.028 (-0.613)	-2.742 (-1.515)
Experience (X_6)	3.864 (2.166)**	0.116 (2.337)**	0.074 (2.551)**	2.046 (1.154)
Labour(X_7)	-0.001 (-7.942)***	1.573E-5 (6.840)***	-0.783 (-13.777)***	24.828 (7.141)***
Capital inputs (X_8)	-0.841 (-.1.223)	-0.027 (-1.414)	-0.027 (-1.016)	-1.368 (-.852)
Feed quantity (X_9)	0.429 (1.304)	0.022 (2.433)**	0.070 (2.574)**	-0.214 (-0.129)
R^2	0.811	0.733	0.910	0.813
R^{-2}	0.777	0.685	0.894	0.778
F-ratio	28.820***	15.288***	55.132***	23.614***

+ indicates lead equation, *** Significant at 1%, ** Significant at 5%, *significant at 10%. Figures in parenthesis are t-ratios.

Table III shows that the double log functional form was chosen as the lead equation. The choice of the lead equation was based on the number of significant variables, the magnitude of the coefficient of multiple determinations (R^2), the conformity of signs borne by the variables to *a priori* expectation as well as the significant F-ratio. The table shows that the coefficient of multiple determination (R^2) was 0.91 which implies that 91% of the productivity of the battery cage farmers was explained by the explanatory variables included in the model.

Productivity of the farmers was positively influenced by age (X_1) at 10% significant level. With advancement in age, farmers are expected to gain practical knowledge on how to handle challenges in production activities [15]. Extension contact (X_3) was positively related to productivity and significant at 1%. This result conforms with the findings of [16] who noted that access to extension services improves the productivity of poultry egg producers because they get to be trained regularly and are opportune to participate in some demonstration trials.

Farming experience (X_6) was significant at 5% and positively related to productivity. It is generally expected that

productivity increases with years of experience as farmers master the techniques of production and avoid previous mistakes. This corroborates with the findings of [16].

Labour input (X_7) was significant at 1% level and negatively signed to productivity of the farmers which implies that increase in this variable will decrease productivity. This negates *a priori* expectation and may be probably because the battery cage system has been structured to reduce labour and so increasing labour may be a necessary condition but not a sufficient condition to cause increase in productivity for the battery cage system producers.

Feed quantity (X_9) was statistically significant at 5% and positively signed to the farmer's productivity. This result is consistent with [12] who noted that the more the level of feed intake by the birds, the more the quantity of eggs produced.

TABLE IV
RESULT OF REGRESSION ANALYSIS OF THE FACTORS AFFECTING PRODUCTIVITY OF DEEP LITTER SYSTEM FARMERS

Variables	Linear+	Exponential	Double log	Semi log
Intercept	-13.675 (-0.848)	2.416 (5.569)***	-5.727 (-9.358)***	-295.230 (-7.904)***
Age (X_1)	1.336 (2.743)***	0.036 (2.752)***	0.121 (1.659)	7.356 (1.648)
Farmers' education (X_2)	0.412 (1.119)	0.008 (0.785)	0.054 (0.930)	4.987 (1.408)
Extension contacts (X_3)	7.231 (6.200)***	0.173 (5.498)***	0.261 (2.898)***	18.298 (3.335)***
Household size (X_4)	0.331 (2.322)**	0.006 (1.590)	0.065 (1.056)	7.509 (2.006)*
Stock size (X_5)	-0.536 (-1.767)*	-0.009 (-1.094)	-0.018 (-0.607)	-2.775 (-1.538)
Experience (X_6)	2.609 (1.021) **	0.074 (1.075)	0.073 (2.530)**	1.973 (1.115)**
Labour(X_7)	0.000 (2.257)**	3.807E-6 (0.820)	0.791 (14.173)***	25.190 (7.397)***
Capital inputs (X_8)	-2.049 (-2.145)	-0.060 (-2.320)	-0.027 (-1.039)	-1.435 (-0.893)
Feed quantity (X_9)	-0.290 (-0.641)	0.001 (0.83)	0.072 (2.619)**	-0.139 (-0.083)
R^2	0.612	0.491	0.893	0.813
R^{-2}	0.542	0.399	0.797	0.779
F-ratio	8.758***	5.357***	54.950***	23.655***

+ indicates lead equation, *** Significant at 1%, ** Significant at 5%, *significant at 10%. Figures in parenthesis are t-ratios.

Table IV shows the linear functional form chosen as the lead equation. The choice of the lead equation was based on the number of significant variables, the magnitude of the coefficient of multiple determinations (R^2), the conformity of signs borne by the variables to *a priori* expectation as well as the significant F-ratio. The coefficient of multiple determinations (R^2) was 0.612 fordeep litter a farmer which implies that 61.2% of the productivity of the deep litter farmers was explained by the explanatory variables included in the model.

Age (X_1) of farmers was significant and positively related to the productivity at 1% level of significance. Farmers are expected to gain mastery of production activities [15] as increase in age in business goes with experience.

Extension contact (X_3) was positively related to productivity and significant at 1%. This is similar with the findings of [16]. Contacts with extension agents introduce the farmers to novel packages and information on use of improved farm technologies, tools among others, which also have strong positive influence on increase in productivity.

The coefficient of household size (X_4) was positive and significant at 5% level. Large household size enhances family labour availability. In poultry egg production, labour supply is a major challenge [17].

Stock size (X_5) was negatively signed and statistically significant at 10%. This may be due to failure of use of recommended floor space as this may lead to cannibalism, pecking of eggs and high rate of spread of diseases among others.

Farming experience (X_6) was significant at 5% and positively related to productivity. This means that as farmers gained more experience, productivity also increased. Experienced poultry egg farm owners are likely to make better decisions to enhance productivity with respect to inputs combinations and resource allocation. This is similar with the findings of [16].

Labour input (X_7) was positively signed at 5% level of significance. Employing enough labour will bring about specialization due to division of labour and ensure that every production activity is carried out timely. This collaborates with the study by [12].

TABLE V
CONSTRAINTS TO EGG PRODUCTION BY THE FARMERS

Constraints	Battery cage		Deep litter	
	Mean	Std. Deviation	Mean	Std. Deviation
High price of day old chick	3.34	1.007	3.52	0.864
Shortage of day old chick	2.67	1.006	2.76	0.975
High cost of feed	3.80	0.479	4.21	4.158
Low quality of feed	2.96	0.860	3.03	0.827
Inadequate finance	3.38	0.773	3.48	0.838
Lack of credit	3.33	0.902	3.50	0.851
High cost of labour	3.20	0.889	2.80	1.030
High cost of drug/vaccination	3.16	1.038	3.08	0.927
Lack of disease control facility	2.69	1.128	3.12	1.004
High cost of electricity tariff	2.51	0.915	2.68	0.922
Inadequate extension services	2.39	0.920	2.42	0.960
Low egg price	2.66	0.901	2.46	0.850
Disease outbreak	2.44	0.901	2.81	0.935
Environment pollution	2.36	0.975	2.37	0.930
Predator animals	2.17	0.903	2.16	0.923
High mortality rate	2.69	0.956	2.76	0.852
Theft of birds	2.07	1.079	1.93	0.981

The result on constraints to egg production by the farmers shows the battery cage farmers' responses from the highest ranked constraint as high cost of feed, inadequate finance, high price of day-old chick, lack of credit, high cost of labour and high cost of drug/vaccination with mean values of 3.80, 3.38, 3.34, 3.33, 3.20 and 3.16. This implies that they are the major constraints to poultry egg production under battery cage system while the deep litter farmers' responses from the highest ranked constraint show high cost of feed, high price of day-old chick, lack of credit, inadequate finance, lack of disease control facility, high cost of drug/vaccination and low quality of feed with mean values of 4.21, 3.52, 3.50, 3.48, 3.12, 3.08, 3.03. This implies that these are the major constraint to poultry egg production under deep litter system in the area.

IV. Conclusion

The result of this study has shown that the mean productivity was 2.65 and 2.33 for battery cage and deep litter production housing system farmers respectively with a z-score of 1.746, showing there was no statistically significant difference between the productivity in battery cage and deep litter enterprises and so there may be no need for preferences in housing system decisions.

Multiple regression on factors influencing the productivity levels of poultry egg production under battery cage and deep litter in the study area shows that productivity of the battery cage farmers was positively influenced by age, extension contact, farming experience and feed quantity but negatively influenced by labour. Also, productivity of the deep litter farmers was positively influenced by age, extension contacts, household size, farming experience and labour but negatively influenced by stock size.

The major constraints identified by both categories are high cost of feed, high price of day-old chick, inadequate finance, lack of credit and high cost of drug/vaccination. The many constraints to egg production have not denied that poultry egg production under medium scale operation is a dimension in the poultry industry with the potential to ensure regular and sustainable production to solve national protein deficiency problem and make good business option for individuals. Hence, it is advised that government should assist poultry egg farmers through subsidies of input resources and put policies to make financial institutions let out loans at low interest rate to them. Farmers should abide by the recommended number of birds per unit area while stocking.

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