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COMPARATIVE PRODUCTION EFFICIENCY OF BATTERY CAGE AND DEEP LITTER SYSTEM IN THE DRIVE TOWARDS SUSTAINABLE POULTRY EGG FARMING IN OGUN STATE, NIGERIA

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ABSTRACT

This study investigated the production efficiency of battery cage and deep litter systems in the drive towards sustainability in poultry egg farming to meet the gap in per caput protein sufficiency in the study area. The multistage sampling procedure was adopted in selecting 75 battery cage and deep litter poultry egg farmers each from the three out of the six Poultry Association of Nigeria Ogun State Chapter (PANOG). Primary data were collected with the aid of a well structured questionnaire. The data collected were analyzed using budgetary technique, Stochastic Frontier Analysis and the statistical difference of means analysis. The Net Farm Income (NFI) per production period of an average battery cage and deep litter farmer each on a small scale (<1000 birds) were ₦324,995.07 and ₦205,978.87. These for the medium (1001-3000 birds) and large scales (>3000 birds) were ₦1,467,611.32 and ₦1,213,428.86 and ₦2,727,405.30 and ₦2,396,751.10 in that order. The Maximum Likelihood Estimates (MLEs) for the production function showed that stocks of birds ($p<0.01$), quantity of feed ($p<0.10$) and size of land ($p<0.05$) significantly determined the output in poultry egg farming among battery cage and deep litter farmers. The inefficiency model result revealed that farmers' sex ($p<0.01$), location of farm ($p<0.01$), scale of operation ($p<0.05$) and membership of poultry association ($p<0.01$) significantly increase farm efficiency. The MLEs for cost function reveal that wage rate of labour ($p<0.05$), price of medication/drugs ($p<0.01$) and price of feed ($p<0.01$) significantly increase the production cost among battery cage and deep litter farmers. The mean technical efficiency for battery cage and deep litter farmers were 0.91 and 0.90 respectively while the mean allocative efficiencies were 1.00 and 0.98 respectively. The overall mean economic efficiencies were 0.92 and 0.89 for the battery cage and deep litter farmers in that order. The economic efficiency of the battery cage farmers differed significantly ($p<0.01$) from that of the deep litter farmers. The battery cage farmers were economically more efficient than their deep litter counterparts. It is therefore imperative to emphasize and adopt the battery cage production system over that of the deep litter in bridging the gap in protein deficiency and meeting the drive towards sustainable egg farming in the study area.

Keywords: Stochastic Frontier Analysis**,** battery cage, deep litter, production efficiency, sustainability, poultry egg farming, Ogun State, Nigeria

INTRODUCTION

The importance of food and especially meeting the gap in the Food and Agricultural Organization per caput protein requirement to the development of Nigerian economy cannot be over-emphasized. In recent times, rural households have experienced setback in food consumption, in terms of availability, accessibility and affordability. Awosanmi (1999) claims there is an increasing evidence of high infant mortality, low resistance to diseases, mental retardation, poor growth and development that come as a result of inadequate protein in the diet of most Nigerians. Food production in Nigeria has not increased at the rate that can meet the increasing population. While food production increases at the rate of 2.5%, food demand increases at the rate of about 3.5% due to the high rate of population growth of 2.83% (FOS, 2006). The apparent disparity between the rate of food production and demand for food in Nigeria has led to: a food demand supply gap thus leading to a large deficit between domestic food production and total food requirement, with an increasing resort to food importation and high rates of increase in food prices.

Apart from Nigeria's agriculture not meeting up in food production to meet the food requirement of the increasing population (FMARRD, 2008), its greatest problem is that of inadequate animal protein in the diets of a large proportion of the population especially in the rural areas which constitute over 70% of the population. In realization of the importance of animal protein, the various governments in Nigeria have been pursuing programmes at national, state and community levels to boost the mass production of livestock products, to ensure the attainment of the Food and Agriculture Organization (FAO) recommendation of thirty-five grams per caput of animal protein per day. Some of these programmes include the farm settlement and micro credit schemes for livestock production. Of recent too is the United Nations Development Programme (UNDP) intervention which involves sponsoring the establishment of livestock parent/foundation stock at community level in Nigeria with the objectives of training farmers on modern rearing and production methods to upgrade the local breeds and increase farmers' income. Poultry is by far the largest livestock category and is estimated to be about 140,000 million, consisting mainly of chickens, ducks and turkeys (FAO, 2010). In total, poultry products (egg and meat) constitute 30% of all animal proteins consumed worldwide. IFPRI (2000) traces this growth pattern from the last 10 years. The source claims the proportion increased from 20% to 30% of all animal proteins and it has been projected to increase to 40% before the year 2015.

Egg, which is one of the major products of poultry production, is one of the most nutritious and complete food known to man. Chicken egg protein has biological value of 1.0 and so shares with human protein the distinction of being a perfect protein (Orji *et al.,* 1981). Egg is more easily affordable by the common man than other sources of animal protein. An average boiled egg costs about ₦30 (0.19 US dollars), hence boiled eggs are sold freely at motor parks, railway stations, market places, roadsides and schools in Nigeria. This therefore, justifies that more eggs will be consumed if the prices are right. Chicken meat and eggs provide a readily available, high-quality source of proteins, vitamins and micronutrients. Eggs are an excellent source of iron, zinc and vitamin A, all of which are essential for health, growth and wellbeing. Chickens and eggs contribute to a nutritious, balanced diet, which is especially important for children, nursing mothers and people who are ill (ACIAR, 2009).

Poultry egg production can serve as a means of improving the living condition of most rural households as a result of its immense contribution in alleviating poverty and increasing their standard of living. The great advantage of egg production is that it provides frequent if not daily provision of nutrients of high biological value though the outputs may not be large. It provides ideal nutrients to pregnant and lactating women and young children. In economic terms, eggs are highly divisible and less lumpy than meat, and when marketed they can provide important some earnings that can be used to cover daily needs such as food to improve and diversify and other essential domestic needs.

Poultry production is predominant among livestock production in Nigeria. In view of this, it is a common practice among poultry egg farmers in Ogun State adopting either battery cage or deep litter housing system for egg production depending on availability of capital. Ekunwe *et al.*(2006) assert that people especially the small and marginal rural farm families depend on poultry farming for food and it serves as additional occupation that supplements their incomes. Optimum production efficiency can be achieved by effective utilization of the available inputs thus improving upon the outputs. The efficiency with which farmers use available resources and improved technology is important in agricultural production (Rahji, 2005). Increased efficiency associated with the quality of resources used and the right choice of better technology, reduce wastage and increase production. Wrong choice on the type of inputs and technology to adopt in poultry production in a particular location and at a particular time result in poor efficiency and eventually poor output. In other to achieve optimum production level, resources must be available and in whatever quantity resources must be efficiently utilized to maximize output.

Egg production has been troubled by unstable trends in the economy. The several problems plaguing the industry make it difficult for existing firms to expand while new ones are reluctant to go into the business. Such problems include high cost of feed, non-remunerative price for egg and birds, supply of poor quality feeds and feed ingredients, lack of disease control facilities, marketing problem, production cost among others. This situation has forced many poultry farms to close down and those still managing to survive are producing at very high cost and also contending with serious inputs limitations (Adepoju, 2008). In most situations, measures adopted by both the government and farmers to address problems facing the poultry sector and to improve the efficiency of poultry production are geared towards reimbursing the input supplies which are mainly targeted to production increase while neglecting the productivity aspect of the enterprise. In line with Onyenweaku and Effiong (2006) and Ashagidigbi *et al*. (2011), the major problems of poultry production in Nigeria are that of sustainability, low productivity and inefficiency in resource allocation and utilization. Improvement of efficiency and fulfilment can be the most effective methods to realize production development and sustainability of the poultry sub-sector. Available literature and studies on technical efficiency of farmers in Nigeria setting include Binuomote *et al.,* (2008), Ojo (2003), Adepoju (2008), Ajibefun and Abdulkadiri (1999), Adesina and Djato (1997), Ajibefun *et al.,* (2002), Ashagidigbi *et al.,* (2011) and Yusuf and Malomo (2007). They all focus on technical efficiency of poultry production generally. This paper moves further and focuses on the sustainability and comparison of the production efficiency of battery cage and deep litter users which encompasses technical and allocative efficiency which could help to bridge this gap by helping the poultry farmers in these categories to raise productivity without increasing resource base and in the process sustaining productivity.

In line with the foregoing, this paper seeks to compare the relative performance of the processes used in egg production under battery cage and deep litter systems to ensure sustainability in egg production and bridge the gap in protein deficiency. The specific objectives however are to:

(i) Estimate and compare the profitability in battery cage and deep litter systems of poultry egg production in the study area.

(ii) Analyze and compare the production efficiency (technical, allocative and economic efficiency) in battery cage and deep litter systems of poultry egg production in the study area.

(iii) Determine and compare the factors affecting the production efficiency in battery cage and deep litter systems of poultry egg production in the study

METHODOLOGY

Study area

The study area is Ogun State, one of the six states that constitute the southwest geo-political zone in Nigeria. It lies within latitude 6°N and 8°N and longitude 2°E and 15°E. It shares an international boundary with the Republic of Benin to the west, interstate boundaries with Ondo State to the east, Oyo State to the North and Lagos State and the Atlantic Ocean to the south.

The state is approximately 1.9% (i.e. 16,762 km^2) of Nigeria's 923,218km^2 land area and has a total population of 3,728,098 (NPC, 2006). It is located within the tropical rain forest belt and has two distinct seasons - the rainy season which lasts from March/April to October/November and the dry season that lasts from October/November to March/April. The mean temperature which is relatively high during the dry season is around 30°C. The distribution of rainfall varies from about 100mm in the western part to about 2000mm in the eastern part especially in the Ogun waterside.

Ogun State is agrarian and well situated for production of perennial and arable crops because of the favourable climatic conditions. The occupation of the rural inhabitants is predominantly peasant farming cultivating food and cash crops. They also embark on small, medium and large-scale livestock production such as rearing of goat, sheep, pigs, rabbits and poultry as well as marketing of the products

Sampling procedure and sample size

The multistage sampling procedure was carried out within the Poultry Association of Nigeria, Ogun State Chapter (PANOG) six (6) zones - Remo, Ota, Egba, Mowe, Ijebu and Yewa. At the first stage, a purposive sampling technique was used to select three (3) out of the six (6) PANOG zones in the state based on higher population of poultry egg farmers in these zones and availability of market for poultry products. The zones included Egba, Ota and Ijebu. The second stage employed random selection of two (2) LGAs from each of the zones giving a total of six - Odeda, Abeokuta South, Ado Odo/Ota, Ifo, Ijebu-Ode and Ijebu North East. The third stage employed random selection of five (5) villages from each LGA giving a total of thirty (30) villages. In the fourth stage, 5 farmers each using battery cage and deep litter system were selected in each village to make 75 randomly selected for the battery cage and the same number through snowball sampling for the deep litter making the total of 150 respondents interviewed for the paper. Based on Omotosho and Oladele (1988), Subhash *et al*. (1999) and Ojo (2003), the number of birds owned by the proprietors of the poultry farms in each of the villages were grouped under different scales of operation - small scale (≤ 1000 birds), medium scale (1001- 3000) and large scale (> 3000 birds).

Analytical Procedure

The analytical tools adopted for this paper are budgetary techniques, stochastic production frontier function and the z-test. The budgetary technique was applied for the estimation and comparison of profitability of battery cage and deep litter systems while the stochastic production frontier was used for the comparison of production efficiency (technical, allocative and economic efficiency) of the two egg production system. It was equally adopted for the determination of factors affecting production efficiency in the two egg production systems while the z-test determined significant difference in the efficiency of the two systems.

Model specification

The model for the budgetary analysis involved the gross margin concept as shown:

$$GM = TR - TVC \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (1)$$

Where:

TR	=	Total revenue from sales of eggs and birds (₦)
TVC	=	Total variable cost for eggs and birds
GM	=	Gross Margin (₦) per farmer

The net farm income was derived as follows:

$$\pi = GM - TFC \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (2)$$

Where:

π	=	Net Farm Income (₦) per farmer
GM	=	Gross margin (₦) per farmer
TFC	=	Total Fixed Cost

Profitability was then determined by financial ratios as follows:

The Rate of Return On Investment (RROI) and Rate of Return on Fixed Cost (RRFC) was used to determine and compare the measure of financial outcomes of the poultry egg farmers that used battery cage or deep litter system in the study area. They were calculated as follows:

$$RROI = \frac{\text{Net Farm Income}}{\text{Total Cost}} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (3)$$

$$RRFC = \frac{\text{Gross Margin}}{\text{Total Fixed Cost}} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

The straight line depreciation method as shown was used to calculate the depreciation cost of the equipments (fixed assets):

$$\text{Annual Depreciation} = \frac{Pp - S}{n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (5)$$

Where; Pp = Purchase price (₦), S = Salvage value (₦), n = Useful life span of the asset (Years).

The test for the significant difference in economic efficiency of the two egg production systems was carried out with the model as follows:

$$Z = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} \quad \text{...} (6)$$

Where

$\overline{X_1}$ = Mean economic efficiency of farmers that use battery cage system

$\overline{X_2}$ = Mean economic efficiency of farmers that use deep litter system

σ_1 = Variance of economic efficiency of farmers that use battery cage system

σ_2 = Variance of economic efficiency of farmers (NFI) that use deep litter system

n_1 = Number of farmers that use battery cage system

n_2 = Number of farmers that use deep litter system

Z = Test statistics of large sample i.e $n \geq 30$

The rule of thumb is to reject the null hypothesis ($H_{o)}$ if Z calculated is greater than Z tabulated.

Stochastic Production Frontier Analysis (SFA)

The Stochastic Frontier Production function analysis based on Battse and Coelli (1995) was used to estimate the coefficients of the parameters of the production function and to analyse and compare the production efficiency based on the type of system adopted by the poultry egg farmer.

Technical Efficiency (TE)

The technical efficiency of the poultry egg farmers that use battery cage and deep litter system in the study area was analysed and compared using the Stochastic Production Frontier Analysis. The estimation of the Stochastic Production Frontier was accomplished by Maximum Likelihood Estimation (MLE) (Olowofeso and Ajibefun, 1999). The production technology of the poultry egg farmers in the study area was assumed to be specified explicitly by the Cobb Douglas production frontier which was presented as:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \ldots + \beta_7 \ln X_{7i} + (vi - \mu_i) \ldots\ldots (7)$$

Where:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 \ln X_{6i} + \beta_7 \ln X_{7i}$$

Y_i = Total output per poultry egg farmer (measured in physical terms of number of eggs)

X_1 = Stock of Birds (heads of adult layers/number)

X_2 = Quantity of Labour (manday)

X_3 = Quantity of Medication/drugs (litres)

X_4 = Quantity of Water (litres)

X_5 = Quantity of Feed (Kg)

X_6 = Size of Land (Ha)

β_0 = Constant

β's = Parameters to be estimated

v_i = Random error which covers random effects on production outside the control of the farmers' decision unit

μ_i = Technical inefficiency

Allocative efficiency (AE)

The allocative or Price efficiency of the poultry egg farmers that use either battery cage or deep litter systems was analysed and compared using the Stochastic Cost Production Frontier. Cobb-Douglas Cost frontier for poultry egg farmers in the study area is presented explicitly as:

$$\ln C_i = \alpha_0 + \alpha_1 \ln P_{1i} + \alpha_2 \ln P_{2i} + ... + \alpha_6 \ln P_{6i} + (vi + \mu_i) \quad .... (8)$$

Where:

C_i = Total production cost per poultry egg farmer (₦)

P_1 = Price of Day Old Chick per one (₦)

P_2 = Wage rate on labour per manday (₦)

P_3 = Price of medication/drug per litre (₦)

P_4 = Price of water used per litre (₦)

P_5 = Price of feed per Kg (₦)

P_6 = Rent on land per hectare (₦)

α_0 = Constant

α_s = Parameters to be estimated

v_i = Random errors which cover random effects on production outside the control of the farmers decision unit

μ_i = Cost inefficiency

Technical inefficiency

Technical inefficiency effect is the result of behavioral factors which could be controlled by efficient management (Xu and Jeffrey, 1998). They are assumed to be independent of the error term (μ's). The inefficiency model was used to determine and compare the factors affecting the production efficiency of battery cage and deep litter poultry egg production in the study area.

The estimated technical inefficiency model is presented explicitly by

$$\mu_i = \delta_0 + \delta_1 D_1 + \delta_2 D_2 + \delta_3 D_3 + \delta_4 D_4 + \delta_5 D_5 + \delta_6 D_6 + \delta_7 D_7 ..... (9)$$

Where:

μ_i = Inefficiency effect

D_1 = Age of poultry farmer (years)

D_2 = Experience of farmer (years)

D_3 = Level of Education (years)

D_4 = Sex (dummy variables: 1 if male and 0 otherwise)

D_5 = Membership of Livestock Association (dummy variables: 1 if member of livestock association, 0 otherwise)

D_6 = Location of farm (dummy variables: 1 if Urban and 0 if rural)

D_7 = Acess to loan (dummy variables: 1 if had access to loan and 0 otherwise)

D_8 = Scale of operation (dummy variables: 0 if small scale, 1 if medium and 2 if large scale)

δ_0 = Constant

δ's = Parameters to be estimated

Economic Efficiency (EE)

The Economic efficiency (EE) or overall efficiency is an overall performance measure of the poultry egg farmers in the study area that use either battery cage or deep litter system of poultry egg production. Therefore, technical and allocative efficiency are components of economic efficiency (Abdullai and Huffman, 2000). The Economic efficiency of the poultry egg farmers was therefore analysed and compared using the relationship below

$$EE_i = \frac{1}{CE} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

Where:

EE_i = Economic Efficiency per poultry egg farmer

CE = Cost Efficiency

RESULTS AND DISCUSSION

Comparative Profitability Analysis of Battery Cage and Deep Litter Egg Production Systems

The analyses here were based on the different scales of operation - small, medium and large in the two systems of egg production. The total variable cost for battery cage and deep litter systems on small scale were ₦1,699,213.37 and ₦1,501,569.23 in that order. That for the medium scale were ₦5,227,628.40 and ₦4,962,310.00 while for the large scale, they were ₦19,883,941.53 and ₦20,051,840.83. The cost of feeding accounted for the highest proportion of the total variable cost in all instances in both systems of egg production. This supports the findings of Ashagidigbi *et al.* (2011) who asserted that the cost of feeding laying birds accounted for over 70 percent of the total cost of production. The cost of day old chicks was next in the order of magnitude to cost of feeding for all scales of operation in both the battery cage and deep litter systems of egg production. It accounted for between 5.67 to 8.43 % of total cost of production (Table 1). The revenue from poultry eggs accounted for the highest proportion of the total revenue from the business for both battery cage and deep litter system. In the case of small scale, they were ₦1,797,958.19 and ₦1,469,227.61 respectively; medium scale ₦6,015,617.00 and 5,363,884.62; while for large they were ₦21,033,367.45 and ₦20,332,330.81 respectively. The gross margin from battery cage and deep litter under small scale were estimated as ₦479,154.72 and ₦296,064.34, medium scale were estimated as ₦1,925,752.30 and ₦1,541,966.41 while large scale were estimated as ₦2,727,405.30 and ₦3,877,226.41 respectively. The Net Farm Income on the other hand for battery cage and deep litter under small scale were estimated as ₦324,995.07 and ₦205,978.89, medium scale were estimated as ₦1,467,611.32 and ₦1,213,428.86 while large scale were estimated as ₦2,727,405.30 and ₦2,396,751.10 respectively. The gross margin and net farm income are positive for both categories under the different scales of operation though they were higher in the battery cage. On sustainability criterion, this may engender the adoption of the battery cage system of egg production. Two profitability indicators estimated for the different scales of operation under the two egg production systems - Rate of Return on Investment (RROI) and Rate of Return on Fixed Cost (RRFC) tend to support this as the RROI and RRFC in small scale was 17.54% and 12.94% and 310.82% and 328.65% respectively in that order. The medium were 25.81% and 22.93% and 420.34% and 469.34% while for large, they were 29.50% and 23.77% and 403.99% and 402.33% respectively. These show that every naira invested on battery cage and deep litter system respectively under small scale, earns ₦17.54 and ₦12.94 respectively. For the medium, the earnings would be ₦25.81 and ₦22.77 while in large scale, it would be ₦29.50 and ₦23.7 respectively. This agrees with the findings of Utomakili and Aganmonyi (1995) and Ogbonna and Ezedinma (2005) who stated that returns on investment account for the profit that accrue to the farmer on each one naira invested on production.

Table 1: Costs and Returns Structure per Production Period of an Average Poultry Egg Farmer by Scale of Operation

	Battery cage						Deep litter					
Description	**Small Scale Amount (₦)**	**% of Total Cost**	**Medium Scale Amount (₦)**	**% of Total Cost**	**Large Scale Amount (₦)**	**% of Total Cost**	**Small Scale Amount (₦)**	**% of Total Cost**	**Medium Scale Amount (₦)**	**% of Total Cost**	**Large Scale Amount (₦)**	**% of Total Cost**
Revenue from Eggs (₦)	**1,797,958.19**		**6,015,617.00**		**21,033,367.45**		**1,469,227.61**		**5,363,884.62**		**20,332,330.81**	
Revenue from Spent Layers (₦)	**380,409.90**		**1,137,763.70**		**3,409,430.15**		**328,405.96**		**1,140,391.79**		**3,596,736.42**	
Total Revenue (₦)	**2,178,368.09**		**7,153,380.70**		**24,442,797.60**		**1,797,633.57**		**6,504,276.41**		**23,929,067.23**	
Variable Cost Items												
Cost of initial stock (DOC)	192,198.04	10.409	584,954.00	10.288	2,095,538.04	9.650	176,514.76	11.090	555,265.77	10.288	1854801.74	8.614
Cost of brooding (DOC)	39,884.68	2.152	112,123.75	1.972	245167.09	1.129	33,552.13	2.108	106,433.14	1.972	313,081.23	1.454
Cost of transportation	6,175.12	0.333	1,9820.00	0.349	59,519.23	0.274	5,698.01	0.358	25,692.31	0.349	75,755.64	0.352
Cost of medication	113,126.00	6.104	281,090.00	4.944	1,231,775.91	5.672	10,0973.49	6.344	383,588.46	4.944	999,366.24	4.641
Cost of fuel	1,354.42	0.073	5,400.00	0.095	2,9001.94	0.134	1,647.60	0.104	7,961.54	0.095	25,425.42	0.118
Cost of electricity	576.11	0.031	6,120.00	0.108	27,189.32	0.125	266.93	0.017	1,000.00	0.108	8,071.56	0.037
Cost of repairs and maintenance	420.81	0.023	2,640.00	0.046	13,775.92	0.063	312.95	0.020	1,923.08	0.046	3,632.20	0.017
Cost of water	0.00	0.000	400.00	0.007	5,437.86	0.025	46.02	0.003	384.62	0.007	6053.67	0.028
Cost of feed	1,334,174.32	71.986	4,175,956.40	73.446	16,032,971.26	73.832	1,171,821.71	73.623	3,725,740.77	73.446	16,567,769.54	76.944
Cost of	10,589.16	0.571	39,132.00	0.688	143,559.61	0.661	1,0730.09	0.674	64,423.08	0.688	197,753.25	0.918

Labour												
Total Variable cost (₦)	**1,699,213.37**	**91.682**	**5,227,628.40**	**91.942**	**19,883,941.53**	**91.566**	**1,501,569.23**	**94.340**	**4,962,310.00**	**91.942**	**20,051,840.83**	**93.124**
Fixed Cost Items												
Land cost	4,314.50	0.233	49,268.31	0.867	195,763.11	0.901	6,716.85	0.422	50,193.49	0.867	45,931.03	0.213
Fence cost	891.30	0.048	4,736.25	0.083	30,814.56	0.142	0.00	0.000	0.00	0.083	6,461.64	0.030
Building cost	104.37	0.006	2,133.33	0.038	0.00	0.000	0.00	0.000	0.00	0.038	0.00	0.000
Farm stead cost	8,0768.04	4.358	1,98575.71	3.493	1,008,678.90	4.645	65,032.59	4.086	195,321.09	3.493	106,9607.79	4.967
Feed store cost	1,170.95	0.063	265.00	0.005	4,531.55	0.021	80.54	0.005	0.00	0.005	4,689.90	0.022
Farm vehicle cost	2,398.20	0.129	3,2371.72	0.569	115,835.14	0.533	2,071.00	0.130	11,474.36	0.569	93,798.00	0.436
Borehole/Deep well cost	559.53	0.030	6,231.62	0.110	3,7617.07	0.173	1,102.81	0.069	8,840.36	0.110	36,676.79	0.170
Pump cost	295.26	0.016	1,101.43	0.019	3,933.39	0.018	28.99	0.002	0.00	0.019	0.00	0.000
Generator set cost	279.64	0.015	3,199.37	0.056	21,099.34	0.097	135.99	0.009	3,165.40	0.056	11,455.37	0.053
Battery cage cost	6,2067.78	3.349	1,56474.92	2.752	70,9196.74	3.266	0.00	0.000	0.00	2.752	0.00	0.000
Feeder cost	0.00	0.000	0.00	0.000	0.00	0.000	8,226.52	0.517	30,660.02	0.000	97,575.46	0.453
Drinker cost	0.00	0.000	0.00	0.000	0.00	0.000	6,635.22	0.417	28,520.39	0.000	106,603.92	0.495
Water tanker cost	1,275.01	0.069	2,942.93	0.052	3,356.80	0.015	14.31	0.001	0.00	0.052	2,605.50	0.012
Drum cost	27.55	0.001	721.20	0.013	5,010.43	0.023	25.28	0.002	278.22	0.013	3,595.93	0.017
Bucket cost	6.17	0.000	107.01	0.002	791.94	0.004	12.82	0.001	77.28	0.002	952.88	0.004
Debeaker cost	1.36	0.000	12.19	0.000	0.00	0.000	2.53	0.000	6.92	0.000	521.10	0.002
Total Fixed Cost (₦)	**154,159.65**	**8.318**	**458,140.98**	**8.058**	**1,831,450.77**	**8.434**	**90,085.45**	**5.660**	**328,537.54**	**8.058**	**1,480,475.31**	**6.876**
Total Cost (₦)	**1,853,373.02**	**100.00**	**568,5769.38**	**100.00**	**21,715,392.29**	**100.00**	**1,591,654.68**	**100.00**	**5,290,847.54**	**100.00**	**21,532,316.13**	**100.00**
Gross Margin (₦)	**479,154.72**		**1,925,752.30**		**4,558,856.07**		**296,064.34**		**1,541,966.41**		**3,877,226.41**	
Net Farm Income (₦)	**324,995.07**		**1,467,611.32**		**2,727,405.30**		**205,978.89**		**1,213,428.86**		**2,396,751.10**	
RROI	**17.54%**		**25.81%**		**29.50%**		**12.94%**		**22.93%**		**23.77%**	
RRFC	**310.82%**		**420.34%**		**403.99%**		**328.65%**		**469.34%**		**402.33%**	

Source: Field Survey, 2012

Maximum Likelihood Estimate of Production Function of Battery Cage and Deep litter Poultry Egg Farmers

The variance parameters for sigma-squared (δ^2) and gamma (γ) for battery cage and deep litter farmers were 0.188 ($P<0.01$) and 0.246 ($P<0.01$), and 0.885 ($P<0.01$) and 0.975 ($P<0.01$) respectively (Table 2). The sigma-squared attests to the goodness of fit and correctness of the distributional form assumed for composite error term while the gamma indicates the systematic influences that are unexplained by production function and the dominant sources of random errors. This implies that about 88.5 percent and 97.5 percent of the variation in output of battery cage and deep litter farmers are due to differences in their technical efficiency.

The parameter estimate obtained from the Maximum Likelihood Estimate for battery cage farmers revealed that stock of birds (X_1) has positive relationship and significantly ($p<0.01$) influences the total output. This is equally true for quantity of feed (X_5) at the 10% confidence level. This implies that increase in the stock of birds and quantity of feed among the battery cage farmers will result in significant increases in their outputs *ceteris paribus.* The result further showed that quantity of medication/drug (X_3), quantity of water (X_4) and size of land (X_6) also have positive relationship with the farm output. This implies that they are efficiently allocated and utilized. The quantity of labour (X_2) however had a negative relationship with output. The negative sign of the coefficient of quantity of labour showed that the total revenue from egg production decreases with increase in quantity of labour among battery cage users. The result equally shows that stock of birds had a high elasticity of production for poultry egg farmers on battery cage system. The implication is that productivity of battery cage farmers can be improved with increase in the stock of birds.

The gamma (γ) value of 0.885 which was significant at 1% level of significance confirms the presence of technical inefficiency among battery cage farmers. This indicates that 88.5% variation in output of battery cage farmers in the study area would be attributed to technical inefficiency effects alone while 11.5% would be due to random effects. The contributions of farmers' socio-economic characteristics have important policy implications as positive sign of their coefficients implies negative effect on efficiency while negative sign a positive effect. In this respect, the result of the inefficiency model showed that sex (D_4) and location of farm (D_5) negatively influenced inefficiency of the battery cage farmers at 1% significant level ($p<0.01$) while membership of poultry association (D_6) and scale of operation (D_8) also had negative relationship with inefficiency at 5% significant level ($p<0.05$). This revealed that battery cage farmers in the study area tended to be more efficient technically when there were more male involved in battery cage poultry egg farming. The coefficient of location of farm is negative and implies that the location of the poultry farm leads to increase in technical efficiency. The nearer the farm is to the urban centre, the higher the technical efficiency. It was observed that the coefficient of membership of poultry association and scale of operation were negative which imply that the involvement of battery cage farmers in poultry association will increase their efficiency in the study area. In the same vein the higher the scale of operation of battery cage farmers in the study area, the more efficient they would operate.

The Stochastic Frontier Model for the deep litter farmers however revealed that Stock of birds (X_2) had a positive and significant ($p<0.01$) with output. Size of land (X_6) also had positive and significant ($p<0.05$) relationship with output. This implies that increase in the stock of birds and size of land used for deep litter farming will result in significant increases in the egg output among deep litter farmers. However, the coefficients of quantity of labour (X_2), quantity of water (X_4) and quantity of feed (X_5) which are less than unity had negative relationships with output of the deep litter farmers. This showed that these variables do not exert significant influence on farm outputs of these categories of farmers. The result further revealed that in this production system, stock of birds also has the highest elasticity which also implies that productivity of the deep litter farmer's increase with increase in the stock of birds.

There is the presence of technical inefficiency effects among deep litter poultry egg farmers in the study area. This is confirmed by the large and significant value of the gamma coefficient (γ) at 1% level of significance. The gamma value of 0.975 indicates that 97.5% variation in output of the deep litter poultry egg farmers is attributable to technical inefficiency effects alone while only 2.5% could be attributed to random effects. The result of the inefficiency model revealed that age, experience of poultry farmers, membership of poultry association and access to loan negatively influence the inefficiency of the deep litter farmer.

Table 2: Stochastic Frontier Production Function Results for Battery Cage and Deep Litter Poultry Egg Farmers.

Variable	Regression Coefficient for Battery cage	T-Value	Regression Coefficient for Deep Litter	T-value
Production Function				
Constant	3.55*** (0.955)	3.7234	3.45*** (0.947)	3.6455
Stock of Birds (X_1)	0.98*** (0.16)	6.1723	1.067*** (0.152)	7.0333
Quantity of Labour (X_2)	-0.00255 (0.0103)	-0.2480	0.00446 (0.0141)	0.3170
Quantity of Medication/ drugs (X_3)	0.00322 (0.134)	0.0241	0.0201 (0.1059)	0.1984
Quantity of water (X_4)	0.0158 (0.0998)	0.1584	-0.0829 (0.0584)	-0.1414
Quantity of feed (X_5)	0.0714* (0.0481)	1.6645	-0.0000669 (0.0294)	-0.0022
Size of land (X_6)	0.0201 (0.1059)	0.1984	0.25** (0.1100)	2.2727
Inefficiency Model				
Constant	-3.37** (1.43)	-2.3543	-3.14** (1.33)	-2.3633
Age (D_1)	0.0150 (0.0152)	0.9904	-0.0188 (0.0177)	-1.0655
Experience (D_2)	0.0416 (0.0269)	1.5565	-0.0171 (0.0351)	-0.4762
Level of Education (D_3)	0.0523 (0.0487)	1.0734	0.833 (0.523)	1.5945
Sex (D_4)	-1.01*** (0.372)	-2.7255	0.122*** (0.0465)	2.6334
Location of farm (D_5)	-0.36*** (0.1210)	-2.9752	0.9230 (0.350)	0.2637
Membership of poultry Association (D_6)	-1.05** (0.475)	-2.1144	-0.214 (0.763)	-0.2800
Access to loan (D_7)	-0.290 (0.6223)	-0.4673	-0.384 (0.394)	-0.9744
Scale of operation (D_8)	-2.233** (1.02)	-2.1863	0.0122 (0.417)	0.2925
Diagnoistic Statistics				
Sigma-squared (δ^2)	0.188*** (0.0521)	3.6155	0.246*** (0.0401)	6.1443
Gamma (γ)	0.885*** (0.0460)	19.2344	0.975*** (0.00823)	118.3534

*** **S***ignificance at 1 percent,* ** *Significance at 5 percent,* * *Significance at 10 percent*

Figures in parenthesis are the standard errors

Source: Computed from Field Survey, 2012

Maximum Likelihood Estimate of the Parameters of the Stochastic Frontier Cost Function of Battery cage and Deep litter Poultry Egg Farmers

The result of the maximum likelihood estimates from the Stochastic Frontier Cost Function of the poultry egg farmers was presented in Table 3. It revealed the relative importance of the variable inputs in terms of the allocative efficiency of the poultry egg farmer. The sigma-squared estimate for battery cage and deep litter poultry egg farmers were 0.0601 ($p<0.01$) and 0.0329 ($p<0.01$) respectively attesting to the goodness of fit of the model. The variance ratio (gamma) also revealed that inefficiency effects exist among the poultry egg farmers as shown by the values of 0.294 ($p<0.01$) and 0.297 ($p<0.01$) for users of battery cage and deep litter farmers respectively. The significant values of the gamma show the presence of inefficiency on the allocative efficiency of the poultry egg farmers in the study area. The values of 0.294 and 0.297 with respect to battery cage and deep litter farmers respectively signify that 29.4 percent and 29.7 percent of variation in cost efficiency is due to inefficiency.

The positive signs of the coefficients of wage rate of labour ($p<0.05$), price of medication ($p<0.01$), price of feed ($p<0.01$) and price of water for battery cage poultry egg farmers, conform to the *a prior* expectation while other variables such as rent value of land ($p<0.01$) and price of day old chicks ($p<0.10$) have negative signs (Table 4). The magnitude of the wage rate of labour, price of medication and price of feed which are significant implies that an increase in the unit cost of these variables will lead to an increase in the total cost of production *ceteris paribus.* The wage rate of labour which has a coefficient of 0.0324 means that 100% change in the variable while other things are held constant will bring about 3.24% change in the allocative efficiency of the battery cage poultry egg farmers. Also, the price of the medication and price of feed has a positive coefficient of 1.78 and 1.58 respectively, this means that a 100% change in each of the variable will bring about 178% and 158% change in the allocative efficiency of the battery cage farmers respectively. The rent value of land and price of day old chicks with negative signs and significant at 1% and 10% respectively are decreasing factors to the farmers' allocative efficiency, hence battery cage poultry egg farmers in the study area need to be prudent in allocation of resources in purchase of day old chick and rent on land. On the other hand with respect to the deep litter poultry egg farmers, price of medication ($p<0.01$), price of feed ($p<0.01$), wage rate of labour and price of water conformed with the *a prior* expectation with positive signs while the other variables such as price of day old chicks and rent value of land had negative signs. The t-value revealed that price of medication and price of feed are both significant at 1% ($p<0.01$). This implies that an increase in one unit of price of feed and price of medication will increase the total cost of production with respect to deep litter farmers as well. The coefficients of price of feed and price of medication are 3.72 and 1.61 respectively, which means that 100% change in each of this variables while other things are held constant will bring about 372% and 161% change in the allocative efficiency of the deep litter poultry egg farmers. The price of day old chicks and rent value on land with their negative coefficients are decreasing factors to allocative efficiency in deep litter egg production system.

Table 3: Stochastic Frontier Cost Function Result for Battery cage and Deep litter Poultry Egg Farmers

Variable	Regression Coefficient for Battery Cage	T-Value	Regression Coefficient for Deep Litter	T-Value
Cost function				
Constant	-3.69*** (1.043)	3.5379	-18.73*** (0.975)	-19.210
Price of Day Old Chick (P_1)	-0.78* (0.445)	-1.7528	-0.690 (0.433)	1.5935
Wage rate of labour (P_2)	0.0324** (0.0135)	2.4000	0.0151 (0.0144)	1.0486
Price of Medication/drug (P_3)	1.78*** (0.599)	2.9716	1.61*** (0.51)	3.1567
Price of water (P_4)	0.0814 (0.575)	0.1410	0.0133 (0.1400)	0.0950
Price of feed (P_5)	1.58*** (0.6220)	2.5402	3.72*** (0.867)	4.2906
Rent value of land (P_6)	-0.0168*** (0.00234)	-7.1795	-0.00242 (0.0504)	0.0480
Sigma-squared (δ^2)	0.0601*** (0.0111)	5.4144	0.329*** (0.0618)	5.3236
Gamma(γ)	0.294*** (0.0457)	6.4333	0.297*** (0.0803)	3.6986

*** *implies significance at 1 percent,* ** *implies significance at 5 percent,* **implies significance at 10 percent*

Figures in parenthesis are the standard errors

Source: Computed from Field Survey Data, 2012.

Efficiency Analysis of Poultry Egg Farmers

Technical Efficiency of Battery cage and Deep litter Poultry Egg Farmers

The frequency distribution of the technical efficiency estimates of the battery cage and deep litter poultry egg farmers was presented in Table 4. About 77.3 percent of the battery cage farmers have their technical efficiency between 0.90 and 0.945, 13.3 percent have their technical efficiency between 0.85 and 0.89 while 6.7 percent of the farmers have their technical efficiency greater than 0.95. However, 2.6 percent of the farmers also have their technical efficiency to be less than 0.849. The mean technical efficiency of the battery cage poultry egg farmers was 0.911. On the other hand, the technical efficiency of the deep litter farmers has 69.3 percent of the farmers between 0.90 and 0.945 with 13.3 percent having their technical efficiency greater than 0.95. This gave a mean technical efficiency of 0.905 for the deep litter poultry egg farmers. The mean output efficiency of 91 percent and 90 percent showed that the potential exist for increase of output by 9 percent and 10 percent respectively by battery cage and deep litter poultry egg farmers under the present technology. Eventhough for both battery cage and deep litter system none of the respondents achieved a technical efficiency of 100%, which implied that improved efficiency in poultry egg production was still possible in the study area without any improvement in the resource base. But the cage system revealed the possibility for a more technically efficient and well sustainable egg production in the study area.

Allocative Efficiency Estimates of Battery cage and Deep litter Poultry Egg Farmers

The frequency distribution of allocative efficiency estimates for battery cage and deep litter poultry egg farmers was presented in Table 4. The allocative efficiency was estimated by dividing the economic efficiency by the technical efficiency i.e AE $=\frac{EE}{TE}$. The allocative efficiency ranges between 0.80 and 1.00 for battery cage farmers and 0.78 and 1.00 for deep litter farmers with mean efficiency of 0.98 and 1.00 respectively. The findings further revealed that 74.6 percent of the battery cage farmers have their allocative efficiency greater than 0.95 and 10.7 percent has their allocative efficiency between 0.91 and 0.949 while 14.7 percent have theirs to be between 0.75 and 0.90. With respect to the deep litter however, 93.4 percent of farmers have their allocative efficiency to be greater than 0.95. The mean allocative efficiency of 0.98 for deep litter poultry egg farmers revealed that there is room for 2 percent improvement for this category of farmers. Considering the battery cage system with 100 percent allocative efficiency, the farmers can potentially function as the engine for the development of poultry egg production as it is allocatively efficient and has the capacity of sustaining poultry egg production in the study area.

Economic Efficiency Estimates of Battery cage and Deep litter Poultry Egg Farmers

The frequency distribution of the economic efficiency of the poultry egg farmers which was estimated as the inverse of cost efficiency i.e $EE = \frac{1}{\text{CE}}$ was presented in Table 4. The economic efficiency of battery cage poultry egg farmers ranged between 0.73 and 0.98 with a mean efficiency of 0.922. The economic efficiency estimates of the deep litter farmers ranged between 0.77 and 1.00 with the mean efficiency of 0.887. The result of the data analysis revealed that 85.4 percent of battery cage poultry egg farmers had their economic efficiency to be between 0.85 and 1.00. In the same vein, 82.7 percent of deep litter poultry egg farmers had their economic efficiency greater than or equal to 0.95. 9.3 percent deep litter farmers have their economic efficiency to be between 0.90 and 0.949 with mean efficiency of 0.975. The mean economic efficiency for both battery cage and deep litter poultry egg farmers implies that there is room for improvement by 8 percent and 3 percent in that order respectively. This implies that battery cage is more economically efficient and sustainable for poultry egg production in the study area as compared to deep litter system.

Table 4: Distribution of Technical, Allocative and Economic Efficiency of Battery cage and Deep litter Poultry Egg Farmers

Class	Battery Cage Frequency	Percent	Deep Litter Frequency	Percent	Pooled Frequency	Percent
Technical Efficiency						
≤ 0.79	1	1.3	1	1.3	2	1.3
0.80-0.849	1	1.3	1	1.3	2	1.3
0.85-0.89	10	13.3	11	14.7	21	14.0
0.90-0.945	58	77.3	52	69.3	110	73.3
≥ 0.95	5	6.7	10	13.3	15	10.0
Total	**75**	**100**	**75**	**100**	**150**	**100**
Mean	**0.911**		**0.905**		**0.908**	
Minimum	**0.13**		**0.09**		**0.09**	
Maximum	**0.98**		**0.99**		**0.99**	
Allocative Efficiency						
0.75-0.80	2	2.7	1	1.3	3	2.0
0.81-0.849	2	2.7	0	0.0	2	1.3
0.85-0.90	7	9.3	0	0.0	7	4.7
0.91-0.949	8	10.7	4	5.3	12	8.0
≥ 0.95	56	74.6	70	93.4	126	84.0
Total	**75**	**100**	**75**	**100**	**150**	**100**
Mean	**1.00**		**0.98**			
Minimum	**0.80**		**0.78**			
Maximum	**1.00**		**1.00**			
Economic Efficiency						
0.75-0.79	6	8.0	1	1.3	7	4.7
0.80-0.849	5	6.7	0	0.0	5	3.3
0.85-0.89	14	18.7	5	6.7	19	12.7
0.90-0.949	14	18.7	7	9.3	21	14.0
≥ 0.95	36	48.0	62	82.7	98	65.3
Total	**75**	**100**	**75**	**100**	**150**	**100**
Mean	**0.922**		**0.887**			
Minimum	**0.73**		**0.77**			
Maximum	**0.98**		**1.00**			

Source: Field Survey Data, 2012

Test of Difference of Mean Economic Efficiency between Battery cage and Deep litter Poultry Egg Farmers

The test of difference of mean economic efficiency between battery cage and deep litter was achieved using t-statistics. It was based on the hypothesis that there is no significant difference between the economic efficiency of battery cage and deep litter farmers. The result of the t-test showed that there is significant difference ($P<0.01$) between the economic efficiency of the two categories of poultry egg farmers (Table 5). This revealed that battery cage farmers have the capacity to produce more output at a minimum cost than deep litter farmers; therefore, the null hypothesis was rejected in this case. Hence, battery cage system is more sustainable for poultry egg production as it will best produce the per caput protein needed in the study area and in the nation as a whole.

Table 5: Test of Difference of Mean Economic Efficiency between Battery cage and Deep litter Poultry Egg Farmers

Test	Mean Efficiency	Standard Deviation	N	Df	T-Value	Sig	Decision
Economic Efficiency							
Battery cage	0.9222	0.07537	75	148	5.234	0.00	**Reject H_o**
Deep litter	0.8869	0.04511	75				

Source: Field Survey Data, 2012

Conclusion: The result of the budgetary analysis revealed that battery cage farmers operating under small, medium and large scale production earn more profit than deep litter farmers in terms of the net farm income between total revenue and total cost. It is also clear that the profit accruing to the battery cage farmers per production period operating on small, medium and large scale is higher as against that obtained from the deep litter farmers in the study area. The paper revealed the battery cage farmers perform better than their deep litter counterpart. There is the need to popularize the battery cage among existing farmers who practise deep litter system of egg production. By changing over to cage system, it could be possible to save feed cost and increase feed efficiency. The poultry farm output increases with stock of birds and quantity of feed for battery cage farmers. In the case of deep litter farmers, output increases with stock of birds and size of land. The magnitude of the wage rate of labour, price of medication and price of feed implies these variables are over-utilised among battery cage users. The magnitude of price of medication and of feed implies these variables are over-utilised among deep litter farmers as well. The rent value on land and price of day old chicks is under-utilised by this category of poultry egg farmers. The mean technical efficiency of 91 percent and 90 percent showed that the potential exist to increase output by 9 percent and 10 percent by battery cage and deep litter poultry egg farmers respectively with the present technology. The mean allocative efficiency of 0.98 for deep litter poultry egg farmer revealed that there is room for 2 percent improvement for this category of farmers while battery cage is allocatively efficient. In addition, the mean economic efficiency for both battery cage and deep litter poultry egg farmer implies that there is room for improvement by 8 percent and 11 percent respectively. The t-test of mean efficiency revealed that battery cage farmers are more economically efficient when compared to their deep litter counterparts.

Policy Recommendations

As battery cage was discovered to be more profitable under various scale of operation, it is recommended that it should be popularized among poultry egg farmers in the study area. Increasing the stock size of birds will go a long way to improving the efficiency in both farming systems. The varying levels of technical efficiency in poultry egg farming in both systems give ample opportunities to improve on the current levels of efficiency. Poultry farmers should be encouraged to participate in membership of poultry association and soft loans should be made available to the various farmers as this will go a long way to increase their efficiency. Feed has a significant contribution to egg production in both systems. In order to make feed available to poultry egg farmers, commercial feed millers should collaborate with relevant institutes and other applied agricultural research centres to work out alternative substitutes to the current cereals in feed formulation. Such alternatives will assist in avoiding the high cost of maize and other ingredients which leads to high feed cost. It is only when these policies are implemented and the battery cage systems put in place that sustainable path of poultry egg production can be said to being treaded.

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