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Profit efficiency of layer production in Ghana

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ABSTRACT

This study assesses profit efficiency and its determinants of intensive housing system of layer production in Ghana. A normalized translog stochastic profit frontier model is employed using cross-sectional data of 300 layer producers in nine districts of Brong Ahafo and Greater Accra regions. The results show that the costs of feed and labour are the most significant factors negatively affecting the profit levels of layer producers. All the input variables respond positively to layer output. Layer producers are about 54% profit efficient and characterized by increasing returns to scale. However, training in poultry farming, farmer-based organization membership, provision of extension service, gender, experience, housing type and mortality rate are the key factors that significantly explain the variations in profit efficiency. The study concludes that on average, layer producers are operating with profit gap of about 46%. The implication of the findings is that training of layer producers by extension services (veterinary officers) in early detection of poultry disease and control are key to reducing inefficiency level to achieve higher profits. Membership of associations by layer producers is key to increasing efficiency in poultry production.

1. Introduction

The livestock sector in Ghana is primarily dominated by poultry production which contributes 37% of total domestic meat production in 2018 [1]. Poultry's role in rural livelihoods, food security, poverty reduction, as well as a supply of protein requirements is enormous. The poultry industry is a significant component of the livestock sub-sector of the agricultural sector in Ghana [1]. Poultry production has some advantages over other livestock because they are excellent converters of feed to protein useable in the form of meat and eggs which have high nutritional value [2]. The poultry component serves as a 'safety net' providing an essential source of ready cash for emergency needs [3]. Even though livestock contributes only 6.2% to the agricultural GDP in Ghana, its impacts in terms of employment and food security is substantial. Therefore, the sector over the years has received significant support such as removal of duties on imported inputs, a special tax of 20% on import of poultry products, training of farmers, facilitation of capitalization and marketing of broiler, subsidies on yellow maize, and day-old chicks from both the government, NGOs and facilitation of improved access to veterinary services [4,5,6,7].

Several works [7,8,9] show that Ghana is still trailing with animal protein intake of 53 gram per head per day compared to the recommended 65 gram. The estimated poultry products consumption in Ghana is 12 eggs and 1.2 kg meat per person per annum which is also far less than the world average of 154 eggs and 9.7 kg meat [10]. The implication is that the shortfall in animal protein intake is attributable to either low production of animal protein-giving products or inadequate patronage of these products by consumers. According to the [11], the demand for poultry products far exceeds its local production. Thus, explicitly the shortfall in animal protein intake is not a demand problem but a supply problem. In line with this, the domestic poultry sector contributes only 10% of local demand [12]. Despite all these interventions by government and NGOs to increase returns to layer production, the growth in domestic poultry (layer) sector remains low. The downward trend of the poultry industry in Ghana has been attributed primarily to the high cost of production [7,13,14]. [13] indicates that high production cost makes domestic production uncompetitive relative to imported poultry products. One limitation is that, the views are not based on any rigorous and time tested empirical approach.

One issue that comes to fore on the inability of local production to meet domestic demand is whether producers are producing efficiently. The high cost of poultry production engendered a drift from broiler production (for chicken meat) to layer production (for eggs) [1,9,15]. This situation raises the issue of how productive and profit efficient layer

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producers are operating in light of the high cost of poultry operation in Ghana. Are layer producers profit effiecient in the light of high cost of poultry operation?.The study therefore hypothesize that layer producers are profit efficient.

The measurement of efficiency remains an important area of research in developing and developed countries. This is because measurement of efficiency goes a long way to determine the profitability of an enterprise by linking agricultural growth to profit [16]. The relationships between market indicators and household characteristics have not been well studied in Ghana. The knowledge of these could provide policymakers with information to design programmes that can contribute to measures needed to expand the food production potential of a country [17]. [18] stressed that determining the level of efficiency of producers is very important from a policy perspective in an economy where new or improved technologies are not fully exploited. Therefore, in a developing economy where a significant number of rural populace derives their livelihood and jobs from layer production and its related activities, the importance of profit efficiency study cannot be overstressed. This is because knowing the efficiency level of layer producers in Ghana will help develop a more sustainable and high productive system and also, help layer producers to improve upon the use of their scarce resources.

Some notable studies on poultry production in Ghana are those of [19] investigated the role of poultry and the impact of HPAI on livelihoods, and [20] focused on formal credit on the performance of poultry industry in urban and peri-urban areas in the Ashanti region. Further, [21] assessed economic efficiency in small-scale broiler production; [22] estimated profit efficiency of Broiler Production in Greater Accra Region; [23] focussed on small-scale broiler farms in Ashanti region to estimate determinant of cost inefficiency in Poultry production and recently, [24] also focussed on broilers to assess consumers attitudes and perceptions towards the consumption of imported versus domestic chicken in Ghana. These renewed interests were all concentrated on broiler production in Greater Accra and Ashanti regions, whilst less attention was given to layer production. This study, therefore focusses on layer producers who are majority in the poultry industry in Ghana. It also extends the geographical scope to the Brong-Ahafo Region of Ghana in addition to Greater Accra because they represent the hub of layer production. Though efficiency measurement is essential in an industry, no comprehensive work has been done in Ghana to estimate the profit efficiency of layer producers. This study fills the gap in the Ghanaian case by assessing the profit efficiency of layer production, estimating productivity and factors that influence profit inefficiency.

The study contributes to the literature in three folds: (1) first the study provides empirical evidence on the profit efficiency of layer production in Brong Ahafo and Greater Accra regions; (2) the study areas provide a unique setting for studying profit efficiency of layer production given that the regions represent the most significant production hubs in the country.; (3) the findings of the study will provide vital insights for individual producers and managers when making operational decisions on possible inputs combination to maximize profit.

The rest of the paper is structured as follows: Section 2 describes the study and data used for the study, followed by methodology. Section 3 presents the empirical results and discussion, while Section 4 provides the concluding remarks and recomendation.

2. Materials and methods

2.1. Study area and data

The study covers the layer producers using the intensive system of production in the Greater Accra and Brong Ahafo Regions of Ghana. The Greater Accra Region is found in the coastal belt of Ghana with a total land size of 3245 km^2s. Brong Ahafo Region lies on the forest zone covering an overall land size of 39,557 km^2s. These two regions were chosen as a result of their large share in layer production in the country [7,19]. The Greater Accra Region is chosen for the study because of the area has larger layer population in the country which present the potential of increasing layer production, as well as the presence of Greater Accra Poultry Farmers Association which is the most vibrant in the country. Moreover, due to the cosmopolitan nature of the region, it has a vast market for poultry products. Brong Ahafo Region on the other hands is chosen because it has the largest number of layer farmers' coupled with having easy access to poultry inputs at a relatively lower cost due to its closeness to the La Cote D'Ivoire. It has good vegetation with high rainfall that favours maize production, which forms an integral part of layer feed formulation. Besides, the poultry laboratory to help identify and diagnose diseases to reduce the rate of mortality of birds in the layer farms is sited in the region.

2.2. Data collection

The study used cross-sectional data from layer producers collected through a field survey using a structured questionnaire. Multistage sampling approach was employed in the selection of layer producers. The first stage involved purposive sampling of nine districts comprising five districts from Brong Ahafo Region[1] namely, Sunyani West, Dormaa East, Dormaa West, Dormaa Municipal and Sunyani Municipal and four districts from Greater Accra region namely, Ga East district, Ashaiman Municipality, Ledzokuku-Krowor Municipality and Ga South. The dominance of commercial layer production in these districts was the basis for their consideration. The second stage involved a purposive sampling of communities within the districts in which layer producers were and visited. The data were collected based on the layer producers' proportion in each district. Finally, simple random sampling technique was used to identify layer producers within the communities at random and the data collected from the list of proportionally selected producers in each district for a total of 138 layer producers in Greater Accra region and 162 layer producers in the Brong Ahafo region summing up to a total of 300 layer producers in the two regions.

2.3. Analytical framework

The stochastic profit frontier model developed by [25,26] is adopted for the paper. The framework integrates the managerial ability, farm operational factors and environmental factors of layer producers who practice the intensive production system into a stochastic profit frontier model.

2.3.1. A theoretical framework of stochastic frontier model

For over four decades of efficiency literature, the Stochastic Frontier model is extensively used in analyzing two main components of production efficiency - technical and allocative. However, technical and allocative efficiencies can be merged into one concept where more efficient estimates can be obtained through simultaneous estimation [27]. The famous frontier production function approach is used to measure the technical component of efficiency [28]. Despite the intensive use of a production function approach in literature, it still fails to capture inefficiencies associated with different factor endowments and different input and output prices across farms. In this perspective, [29-30] argued that a production function approach in measuring efficiency may not be appropriate when producers face different prices and have different factor endowments. This view is also shared by [31] and serves as the main motivation for the application of the stochastic profit function approach. It dictates that farm-specific prices and levels of fixed

[1] [1]the administrative regions of Ghana at the time of the study was 10 but currently 16 as new regions have been added (through division of some already existing regions of which Brong Ahafo region was one and further divided into three regions-Bono, Bono East and Ahafo). The selected districts within the Brong Ahafo Region then now in Bono region.

factors are incorporated into efficiency estimation directly [27]. The profit function approach integrates both concepts of technical and allocative efficiencies its profit relationship and any errors in the production decisions are assumed to be translated into lower profits or revenue for the producer [32]. This approach is widely applied because of its procedural, flexibility in analyzing various agricultural problems [33]. Profit efficiency is therefore defined as the ability of a farm to achieve highest possible profit given the prices and levels of fixed factors of that farm. Alternatively, profit inefficiency is the loss of profit for not operating on the frontier [31]. [25] further expanded 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 merit of this method is that input and output prices are treated as exogenous to farm household decision making, and they can be used to explain input use.

Following [26], this paper adopts the model by [25] which specifies a profit function that is assumed to behave in a manner consistent with the stochastic frontier concept. This model fits the background of the study areas as producers are faced with different inputs prices and resource endowments.

The stochastic profit function model which is assumed to be "well-behaved'' can be expressed as:

$$\pi_i = f(P_i, Z_i).\exp\varepsilon_i \quad (1)$$

Where $i = 1....n$ is the number of farms in the sample, π_i is the normalized profit of the i^{th} farm, computed as gross revenue less variable cost, divided by farm-specific output price; P_i is the vector of variable input prices of the i^{th} farm divided by output price; Z_i is the vector of a fixed factor of the i^{th} farm, 'exp' is an exponential function, and ε_i is an error term which is assumed to behave in a manner consistent with the frontier concept [31], thus specified as,

$$\varepsilon_i = \nu_i - u_i \quad (2)$$

Where ν_i's are a symmetric random error (noise error) term that is assumed to account for exogenous factors beyond the control of the layer producer (e.g., outbreaks of diseases, measurement error, extreme weather, and also assumed to be independently and identically distributed (i.i.d) as $[N(0,\sigma_V^2)]$ and the u_i's are a non-negative random variable, associated with the inefficiency in production, which is distributed as truncation at zero (0) of the normal distribution with mean $\mu_i = \delta 0 + \sum_{d=1}^{n} \delta_d Z_{di}$ and variance $\sigma_\mu^2 = (u \sim N(\mu_i, \delta^2{}_u))$ where $Z_{di}$is the d^{th} explanatory variable associated with inefficiencies on farm i and δ_0 and δ_d are the unknown parameters to be estimated.

The profit efficiency of farm, i in the context of stochastic frontier profit function is defined as:

$$PE_i = E[\exp(-\mu)|\varepsilon_i] = E\left[\exp\left(-\delta_o - \sum \delta_d Z_{di}\right)|\varepsilon_i\right] \quad (3)$$

where PE is the profit efficiency of farmer i and lies between 0 and 1 and is inversely related to the level of profit inefficiency. E, which is the expectation operator, is achieved by obtaining the expressions for the conditional expectation μ_i upon the observed value ofε_i. The method of maximum likelihood is used to estimate the unknown parameters under a framework where the Stochastic Profit frontier and the inefficiency effects functions are estimated simultaneously. The likelihood function is expressed in terms of the variance parameters, $\gamma = \delta^2{}_u/\delta^2$, where$\delta^2 = \delta_u{}^2 + \delta_v{}^2$ [25].

2.3.2. Empirical model specification for profit efficiency estimation

In Specifying the empirical model,we incorporate the profit inefficiency effects in a modified translog profit frontier model as:

$$In\pi_i = \beta_0 + \sum_{j=1}^{6} \beta_j InP_{j_i} + 0.5 \sum_{j=1}^{6} \sum_{k=1}^{6} \beta_{jk} InP_{j_i} InP_{k_i} + v_i - u_i \quad (4)$$

where, In denotes natural logarithm; i denotes the i^{th} $_{farm,}$ π_i is normalized gross profit per bird for i^{th} layer farm defined as gross revenue per bird less variable cost per bird divided by the farm-specific average price of eggs and spent layer (P_y) and then re-scaled by its sample mean per bird. $P_{i's}$ are the normalized variable input prices obtained by dividing variable input prices by farm-specific average price of eggs and spent layer (P_y) and then re-scaled by the sample mean of the normalized input prices; P_k represents the price of input k used by the i^{th} layer producers ($i = j = 1, 2, 3, 4{,}5$ and 6); P_6 is the fixed input. $\beta_0, \beta_i, \beta_{ik}, \beta_{im}$ and β_z are parameters to be estimated. The output is measured as profit earned at the end of the production year, in Ghana, cedi per bird.

2.3.3. Empirical model to estimate determinants of profit efficiency

To explain variations in the profit efficiency levels of sample layer producers, the factors hypothesized as the determinants of profit efficiency are incorporated into a model specified as:

$$\mu_i = \delta 0 + \sum_{d=1}^{12} \delta_d Z_{di} \quad (5)$$

where $\delta$is the parameter to be estimated, μ is a non-negative error term that captures profit inefficiency effects relative to the stochastic profit frontier, Z is a vector of variables explaining inefficiency effects and $\delta 0=$ is constant in the equation. Variable in the models (profit function and inefficiency) are presented in Table 1.

Table 1
Description of variables employed in the Frontier profit function models and a priori expectation.

Variable	Descriptions	Expected sign	Source
π'	Normalized profit of the j^{th} layer producer defined as gross revenue less variable cost divided by farm specific price (dependent). Note the j is suppressed.		
P_1	Normalized Price of birds stock (for example day-old chicks)	-ve	[21]
P_2	Normalized Price of feed	-ve	[22,42,43]
P_3	Normalized Price of labour (Wage rate of labour)	-ve	[22,44,47, 55]
P_4	Normalized Price of Drug and Medication	-ve	[21]
P_5	Normalized cost of "other inputs" (other inputs; electricity, water, wood shaving, transportation, fuel)	-ve	[21]
P_6	Capital input (depreciated value of poultry house/ building, equipment) and value of land used in poultry	-ve	[21,22]
δ_0	Intercept term		
Zd	Variable explaining Inefficiency effects ($d = 1.....12$)		
Z_1	Gender (male=1, female=0)	-ve	[28,51]
Z_2	Age of farmer in years (Primary decision maker)	-ve/+ve	[17,21,38, 45,49,50]
Z_3	Farming experience in years	-ve	[22,26,44]
Z_4	Age*Experience (interaction) in years	-ve /+ve	[28,42]
Z_5	Formal poultry farming training/education (specialization) (1=yes, 0=no)	-ve	[16,28]
Z_6	Extension contact/visit with(1=yes,0=no)	-ve	[21,23,50, 51]
Z_7	Membership of Farmer Based Organization (FBO)(1=if a member, 0=otherwise)	-ve	[23,28,38]
Z_8	Access to credit (1=access,0=no access)	-ve/+ve	[21, 51]
Z_9	Housing type (1=deep litter, 0=otherwise)	+ve	[45]
Z_{10}	Mortality rate (Percentage)	+ve	[48]
Z_{11}	Land ownership (leased=1,0=otherwise)	-ve	
Z_{12}	Regional effect (1=Greater Accra, otherwise=0)	-ve	

Note: Man-days calculation in the model was done following Coelli and Battese (1996) rule; one adult male and one female, working for 1 day(8hours) equal to 1 and 0.75 man-days, respectively. The straight line depreciation method is employed.

2.4. Tests for hypotheses

(I).H_o: $\beta_{ij} = 0$; the null hypothesis that Cobb-Douglas(C-D) production function is a statistically valid representation of the data and C-D is an adequate representation of the profit frontier function. The alternative hypothesis is H_A: $\beta_{ij} \neq 0$

(II).H_o: $\gamma = \delta_o = \delta_1 = \delta_2 =,\ldots,\ldots, = \delta_{12} = 0$; the null hypothesis that inefficiency effects are absent from the model at every level (each poultry farm is operating on the profit frontier). The alternate hypothesis is H_A: $\gamma \neq \delta_o \neq \delta_1 \neq \delta_2 \neq,\ldots,\ldots, \neq \delta_{12} \neq 0$.

(III).H_o: $\gamma = 0$; inefficiency effects are non-stochastic. The alternate hypothesis is H_A: $\gamma \neq 0$

(IV).H_o: $\delta_o = \delta_1 = \delta_2 =,\ldots,\ldots, = \delta_{12} = 0$; states that the simpler half-normal distribution is an adequate representation of the data. The alternate hypothesis is H_A: $\delta_o \neq \delta_1 \neq \delta_2 \neq,\ldots,\ldots, \neq \delta_{12} \neq 0$

(V).H_o: $\delta_1 = \delta_2 =,\ldots,\ldots, = \delta_{12} = 0$; states that farm-specific factors do not influence the inefficiencies (variables included in the inefficiency effect model have no effect on the level of profit efficiency). The alternate hypothesis is H_A: $\delta_1 \neq \delta_2 \neq,\ldots,\ldots, \neq \delta_{12} \neq 0$

(VI).H_o: $\delta_{12} = 0$, states that there is no regional effect on profit efficiency of production. The alternate hypothesis is H_A: $\delta_{12} \neq 0$.

The hypotheses are validated using the generalized likelihood-ratio test, (LR), which is specified as:

$$LR = -2[ln\{L(H_o)\} - ln\{L(H_1)\}] \tag{6}$$

where $L(H_o)$ and $L(H_1)$ are values of likelihood function under the null (H_o) and alternative (H_1) hypotheses respectively. The *LR* has approximately a Chi-square (or mixed Chi-square) distribution if the given null hypothesis is true with a degree of freedom equal to the number of parameters assumed to be zero in (H_o). [35] proposed that all critical values can be obtained from appropriate Chi-square distribution. However, if the test of hypothesis involves $\gamma = 0$, then the asymptotic distribution necessitates mixed Chi-square distribution. The critical value for such a test is obtained from Table 1 of [36], page 1246.

2.4.1. Model for estimating productivity of layer production (Production input elasticity)

This is achieved by estimating the profit elasticity and converting it into indirect production elasticity. Using the translog function, profit elasticity with respect to various input prices are functions of input prices. Therefore, profit elasticity are obtained by differentiating the translog function with respect to input prices specified in Eq. (4). However, when the normalized profit and input prices variables have been re-scaled by their respective sample means, the first-order coefficient can be interpreted as the elasticity of profit with respect to the different input prices [37-38]. Therefore, the first-order coefficients of the estimated translog function were only used to explain the extent of the effect of changes in input prices on profit levels of layer producers.To achieve the objective of determining the productivity of various inputs used in production by layer producers, the production elasticity of inputs from the profit function is estimated. Since the profit function is a dual of the production function, the productivity of both variables and fixed inputs used in production can be indirectly estimated [39-40] . The identities used are:

$$\beta'_j = -\beta_j^*(1-u^*)^{-1} \tag{7}$$

$$\alpha'_j = \alpha^*_j(1-u*)^{-1} \tag{8}$$

where, the parameters $\beta^*_j$and$\alpha_j{}^*$are estimates from the stochastic translog profit function model (4), whilesβ_j' and α_j' are the indirect production elasticity for variable and fixed inputs respectively to be estimated. The $u^*$is the summation of the coefficients of all the variable inputs prices in the normalized profit function (the estimates from the model 4 above). The return to scale is computed by summing the indirect elasticity (productivity) estimates.

2.5. Results and discussions

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3. Outcome of hypotheses testing

The results of the various tests of hypotheses for the statistical validity of the dataset and the adequacy of the specified stochastic frontier profit function and inefficiency models using the generalized likelihood ratio test are presented in Table 2.

Firstly; the translog functional form is adequate and valid representation of the data. This is evidenced by the rejection of the null hypothesis at 1% significance level as shown in Table 1. Secondly, the rejection of null hypothesis which specifies the profit inefficiency effects are absent in the model at every level (that is layer producers are efficient and have no room for efficiency growth) in favour of the alternative hypothesis is obvious that there is profit inefficiency among producers in layer production. Thus, implying the inclusion of the profit inefficiency model is a significant addition to the estimation. The third hypothesis which specifies that inefficiency effects are not stochastic is rejected inferring that the traditional average (OLS) function is not an adequate representation for the data. The fourth hypothesis that there are no changes in the intercept term, and the coefficients associated with socioeconomic and farm-specific characteristics in the profit inefficiency model are zero is also rejected. The fifth null hypothesis that the farm-specific profit inefficiencies are not affected by farm-specific factors included in the inefficiency model is also rejected indicating that the explanatory variables in the profit inefficiency model do contribute significantly to the explanation of profit inefficiency for the sampled producers. This implies that the joint effects of these variables on profit inefficiency are statistically significant. The sixth null hypothesis that there are no regional effects on profit efficiency is accepted, indicating that there is no locational effect on the profit efficiency of the layer producers in the study areas. This may be a result of the extension agents (veterinary agents) being mobile and effective in delivering their services to the layer producers.

3.1. Socioeconomic characteristics of layer producers sampled

The descriptive statistics of the socio-economic characteristic of layer producers sampled are presented in Table 3. It is shown that majority (84%) of the three hundred layer producers sampled are male which is due to the nature of the layer production as well as their ability

Table 2
Hypotheses tests for model specification and statistical assumptions of stochastic Frontier model.

Null Hypothesis	Test statistic (λ)	Degree of freedom	Critical value $\lambda^2_{0.001}$)	Decision
1. H_0: $\beta_{ij} = 0$	306.38***	21	38.93	Rejected H_o
2. H_0: $\gamma = \delta_0 = \delta_1 = \delta_2 =,.,.,= \delta_{12} = 0$	306.07	14	23.06 [a]	Rejected H_o
3. H_0: $\gamma = 0$	3.88	1	2.71 [a]	Rejected H_o
4. H_0: $\delta_0 = \delta_1 = \delta_2 =,.,.,= \delta_{12} = 0$	303.08***	13	27.69	Rejected H_o
5. H_0: $\delta_1 = \delta_2 =,\ldots,\ldots,= \delta_{12} = 0$	296.71***	12	26.22	Rejected H_o
6. H_0: $\delta_{12} = 0$	−0.47***	1	6.64	Accept H_o

[a] Value of test of one sided error from the Frontier 4.1 output file. The correct critical values for the test of hypothesis are tests of one-sided error is obtained from Table 1 of [36], (p. 1246), whilst the rest are obtained from chi-square Table. All the critical values are obtained at 1% significant level. *** 1% significant level.

Table 3
Summary statistics of output and input variables used in the layer production.

Variable	Unit of measurement	Minimum	Maximum	Mean	Std. deviation
Profit	Ghana cedi(GH¢)/bird	1.0682	9.4971	2.6345	1.1701
Price of DOC	Ghana cedi(GH¢)/bird	0.1176	0.4459	0.2644	0.0605
Price of Feed	Ghana cedi(GH¢)/bird	1.3186	9.2723	5.6947	1.3026
Price of Vaccine &Medicine	Ghana cedi(GH¢)/bird	0.0444	0.0795	0.0635	0.0059
Wage of Labour	Ghana cedi(GH¢)/bird	0.0121	1.1818	0.2676	0.1830
Other operating costs	Ghana cedi(GH¢)/bird	0.3849	3.1453	1.1328	0.3272
Capital input	Ghana cedi(GH¢)/bird	0.1972	13.0910	2.0470	1.9357
Gender	Dummy (male=1, female=0)	0	1	0.84	0.3670
Age	Years	20	73	45.91	9.5980
Experience	Years	1	43	9.68	7.1660
Training/Education	Dummy(Yes=1, No=0)	0	1	0.86	0.3510
Extension Contact	Dummy(Yes=1, No=0)	0	1	0.66	0.4730
Member of Farmer Based Organization (FBO)	Dummy(Membership=1, No=0)	0	1	0.70	0.459
Credit	Dummy(access=1, no access =0)	0	1	0.28	0.4480
Housing type	Dummy(deep litter=1,otherwise=0)	0	1	0.96	0.1960
Mortality rate	Percentage	0.1	38	6.5818	6.5106
Land ownership	Dummy (leased=1,0=otherwise)	0	1	0.3400	0.4730
Regional Effect	Dummy(1=BA, 0=GA)	0	1	0.5400	0.4990

Source: Author's field survey, 2013.

to access credit easily as compared to their female counterpart. The average age of layer producers is 46 years. This implies that middle-aged people in the study area relatively dominate layer production, this was also observed by [41] in Nepal among the poultry producers.

On the degree of specialization with regards to skills acquisition, it is found that the majority (86%) of layer producers have formal training/education in the layer production and on average has been producing layers for the past 10 years. This level of experience is seen high enough for layer producers to optimally combine and utilize production inputs at least cost to achieve high output.This is consistent with [23] in their broiler production work. On average, 66% of the layer producers receives extension (veterinary) advice. This is good because extension agents /veterinary advisory services officers assist in the diffusion and adoption of new technologies which is essential in gearing towards the achievement of the frontier output. This also enables the application of best farming practices to reduce bird mortality rates to help increase

Table 3a
Maximum likelihood estimates of the stochastic profit frontier model.

Variables	Parameters	Coefficients	Standard error	t-ratio
Constant	β_0	0.5541***	0.1334	4.153
LnPrice of Day-Old Chick/bird	β_1	0.0936*	0.0714	1.311
LnPrice of Feed/bird	β_2	−0.6215***	0.0507	−12.21
LnPrice of Medicine/Vaccines/bird	β_3	0.6626***	0.1923	3.445
LnWage of Labour/bird	β_4	−0.0838***	0.0193	−4.354
Ln Other cost/bird	β_5	−0.0407	0.0486	−0.838
LnCapitalcost	β_6	0.0447**	0.0235	1.902
0.5(LnPDayOldChick)^2	β_7	0.3531	0.3045	1.159
0.5(LnPFeed)^2	β_8	−0.4234***	0.1636	−2.588
0.5(LnPMedicine/Vaccines)^2	β_9	2.7309	2.4361	1.121
0.5(LnWage of Labour)^2	β_{10}	−0.0379	0.0462	−0.821
0.5(LnOthercost)^2	β_{11}	0.1256	0.1307	0.961
0.5(LnCapitalcost)^2	β_{12}	0.0223	0.0373	0.599
LnPDayOldC*LnPFeed	β_{13}	0.2531	0.2238	1.131
LnPDayOldChick*LnPMedicine/VaccinesLnPDayOldChick*LnWageofLabour	β_{14}	−0.8606	0.6951	−1.238
	β_{15}	0.0950	0.1051	0.904
LnPDayOldChick*LnOthercost	β_{16}	−0.1458	0.2153	−0.677
LnPDayOldChick*LnCapitalcost	β_{17}	−0.0052	0.0738	−0.071
LnPFeed*LnPMedicine/Vaccines	β_{18}	0.4761	0.5508	0.865
LnPFeed*LnWageofLabour	β_{19}	0.2056**	0.0915	2.246
LnPFeed*LnOthercost	β_{20}	0.2579*	0.1830	1.409
LnPFeed*LnCapitalcost	β_{21}	0.0324	0.0698	0.464
LnPMedicine/Vaccines*LnWageofLabour	β_{22}	−0.3372	0.2836	−1.189
LnPMedicine/Vaccines*LnOthercost	β_{23}	−0.6753**	0.3018	−2.237
LnPMedicines/Vaccines*LnCapitalcost	β_{24}	0.1067	0.2056	0.512
LnWageofLabour*LnOthercost	β_{25}	0.0933	0.0881	1.059
LnWageofLabour*LnCapitalcost	β_{26}	0.0445*	0.0324	1.373
LnOthercost*LnCapitalcost	β_{27}	0.0789	0.0659	1.197
Sigma squared	ζ^2	0.0378***	0.0020	18.788
Gamma	Γ	0.9999***	0.0081	123.635
Mean VIF(multicollinearity)		2.24		
Log-likelihood		70.769		

Source: Author's field survey, 2013 *, **, and*** = statistically significant at levels at 10%, 5% and 1% respectively.

poultry production and promote profit efficiency among layer producers. It is observed that the majority (70%) of the producers belong to Farmer Based Organization (FBO). This is good because being a member FBOs benefit farmers through sharing of ideas and good practices as this enhance sharing of information on improved technologies as well as easing inputs acquisition and utilization. It is realized that 28% of layer producers receive credit, indicating that they face difficulties in accessing credit for their activities. It is also observed that 96% of layer producers use deep litter housing system.

The results in Table 3 indicate a wide variation in profit earned by the layer producers, ranging from a minimum of GH¢ 1.07 to GH¢ 9.49, and the mean profit earned per bird is GH¢2.63, means that most of the layer producers produce below the maximum profit per bird. This might be due to inefficient methods of farming at the given technology. The profit gap between the mean and the minimum profit is GH¢ 1.57 per bird, and that between the mean and the maximum profit is GH¢ 6.86 per bird. This also suggests that there is potential for increasing the mean profit per bird of layer production in the study area.

3.2. Determinants of profit

The estimates of the determinants of profit using the stochastic translog profit frontier model are presented in Table 3a. However, Table 3b provides a statistical summary of the profit elasticity.

The estimated sigma square (ζ^2) is 0.0378 is significantly different from zero at 1%, indicating a good fit of the model and the correctness of the specified distributional assumptions. From [34], sigma square (ζ^2) also advocated that the profit efficiency equation can explain the profit with reference to each decision making unit as well as the profit of the frontier function. The estimated gamma (γ) is 0.999 is significant at 1%, meaning that the profit inefficiency effects are significant in determining the level and variability of layer production in the study area. The observed variations in profit efficiency among the layer farmers are due mainly to differences in farm practices and characteristics of sampled layer farmers rather than random factors. The mean Variance inflation Factor(VIF) (2.24) is small, revealing that the model has no problem with multicollinearity as also posited by [51].

The estimated elasticity of day-old chicks,feed,medicine,labour and capitial inputs with respect to gross profit of layer producers reveals that the five out of six independent variables are significant. These show the relative importance of these variables to profit. Table 3b reveals the profit elasticity with respect to various input prices and capital inputs used. These profit elasticities are directly obtained from the coefficient estimates of the profit frontier model which measures the sensitivity of profit of layer producers to changes in layer input prices.

The profit elasticity with respect to price of day-old chicks and price of medicine/vaccines have a positive and significant relationship with profit which has not met the a-priori expectations.

Table 3b
Estimated profit elasticity with respect to input prices.

Variables parameter	Profit elasticity standard error
Price of Day-old Chicks/bird β_1	0.0936* 0.0714
Price of Feed/bird β_2	−0.6215*** 0.0507
Price of Medicine/Vaccine/bird β_3	0.6626*** 0.1923
Wage of Labour/bird β_4	−0.0838*** 0.0193
Other costs/bird β_5	−0.0407 0.0486
Cost of capital inputs β_6	0.0447** 0.0235
Variance parameters	
Sigma squared (ζ^2) 0.0378***	
Gamma (γ) 0.9999***	
Mean VIF(multicollinearity) 2.24	
Log-likelihood test 70.769	

Source: Author's field survey, 2013 *, ** and *** = statistically significant levels at 10%, 5% and 1% respectively.

The profit elasticity of price of feed, and wage rate (both hired and family) had a negative and significant relationship with gross profit of the layer producers with price of feed being the most important variable decreasing gross profit of the producers in the study areas. This implies that a one per cent increase in the price of feed would lead to 0.6626% reduction in the profit level of the layer producers. This finding is consistent with that of [21] also found a similar result in their economic efficiency of broiler production in Ghana. [22,51] only found that strong relationship with wage rate and profit in their profit efficiency study among boiler farmers in Ghana. [42-43] who also found a strong negative relationship between the price of feed and profit. [44], found a negative relationship with the price of feed and wage rate with profit, the wage rate having a significant relationship.

An increase in the amount of money invested into layer production in the form of capital input that is through land acquisition, the building of housing equipment translates to the higher returns. The profit elasticity of capital input is positive and significant but has not met the a-priori expectations. However, this finding is consistent with the results of [42] also found a positive relationship between capital cost and profit.

4. Distribution of profit efficiency scores by layer producers

Distribution of the profit efficiency scores as presented in Fig. 1, shows that profit efficiency varies widely among producers, ranging from a minimum of 21.43% to a maximum of 99.97%. The wide variation in the profit efficiency estimates can be associated with differences in inefficient allocation and use of inputs among the producers. The mean estimated profit efficiency of 54.23% means that layer producers in the study areas have the scope of increasing their profit by 45.77% by adopting the available production techniques used by the most efficient farmer.

In Fig. 1, it is observed that majority (20%) of the layer producers have profit efficiency scores ranging from 31 to 40, followed by 19% of layer producers having their profit efficiency score between 51 and 60. Out of the 300 producers, 18.7% have their profit efficiency score ranging from 41 to 50. Eighteen per cent of layer producers have their profit efficiency score ranging from 61 to 70. About 7.7% of layer producers have their scores ranging from 71 to 80, followed by 7% layer producers have their scores been less than and equal to thirty. About 6.3% of layer producers have their scores ranging from 81 to 90. The remaining 3.3% of layer producers have the profit efficiency scores greater than ninety. If the least efficient layer producer is to achieve the efficiency status of the most efficient layer farmer, then that layer farmer must reduce their cost by 78.56%. On average, a layer producer can achieve their optimal profit efficiency, in the short run by increasing their profits by 46% via adoption of best layer practices that are allocative efficient. Similar results have been reported by other researchers elsewhere. [44] worked on poultry (eggs) producers in Nigeria and had a mean efficiency of 84.34%. In Kenya, [45] worked on smallholders' milk producers and obtained a mean efficiency of 60%. For broiler production in Ghana, [22] obtained a mean profit efficiency of 54%.

4.1. Productivity (Indirect production elasticity) estimates of inputs used

Table 4 present the results of indirect production elasticity (equation 7&8). The estimate of the elasticity of output is highest for medicines/vaccines (0.6694), followed by feed with 0.6279, day-old chicks with 0.0946, labour with 0.0847, capital inputs with 0.0452 and other costs of 0.0411. All the input factors contribute positively to output.

The positive estimate for medicine/vaccine indicates that an increase in the use of this input increases layer output. Layer production involves a high level of risk and for the producer to achieve minimal mortality requires that medication is provided to protect the layer against disease and pathogen attacks. The 0.67 indirect production elasticity estimate which is the highest contributor to output implies that a 1% increase in medicine/vaccines use per bird would result in 0.67% increase in layer

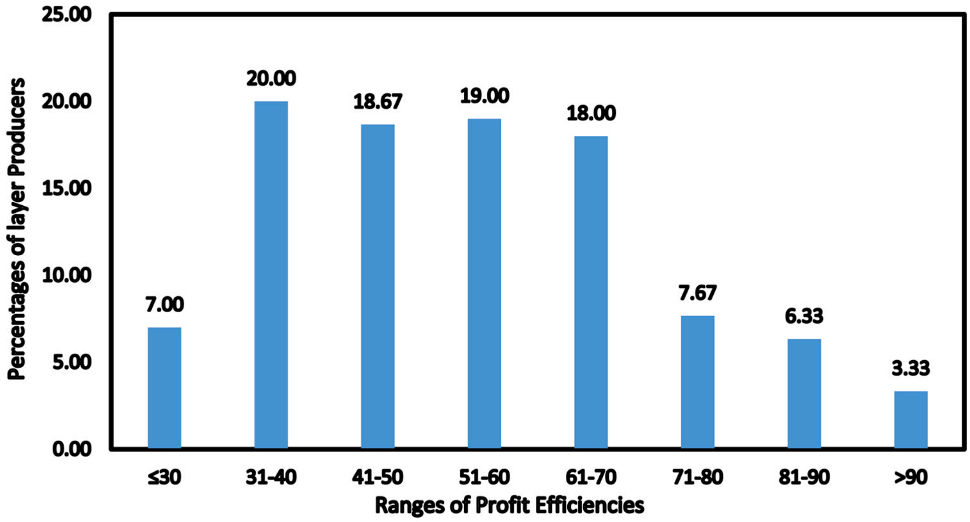

Fig. 1. Distribution of profit efficiency of layer producers source: author's field survey, 2013.

Table 4
Indirect production elasticity estimates of inputs used (Productivity of inputs).

Production factors (variables) parameters	Indirect Elasticity estimates
Variable factor	
Day-old Chicks/bird β'_1	0.0946*
Feed/bird β'_2	0.6279***
Medicine/Vaccine /bird β'_3	0.6694***
Labour/bird β'_4	0.0847***
Other costs/bird β'_5	0.0411
Fixed factor	
Capital inputs α'_6	0.0452**
Indirect Input Elasticity (RTS)	1.5629

Source: Author's field survey, 2013 *, ** and *** = statistically significant levels at 10%, 5% and 1% respectively.

output per bird. These results agree with the findings of [2] who also reported a positive and significant relationship between medicine/vaccine cost and output in its poultry efficiency study in Nigeria.

The study also find a positive relationship between the feed and layer output with feed being the second-highest to have a positive impact on layer output indicating that increase in feed used per bird would lead to an increase in the layer output. The indirect production elasticity estimate for feed implies that a 1% increase in the feed usage will increase layer output by 0.63%. Feed is absolutely a necessary resource in layer production and that increasing its usage is expected to increase layer output. Apart from its quantity, the quality of Feed that contains all the required nutrients is essential in increasing layer output. This also is in agreement with the study of [46] who noted a positive significant response with output.

The quantity of day-old chick used has a positive effect on the mature layer output produced by layer producers. The result shows that 1% increase in the quantity of day-old chick use will increase layer output by 0.095%. This result is consistent with [2] who also found a positive effect on output and argued that the positive sign implied that an increase in the stock of birds would lead to an increase in the level of poultry output.

The positive and significant relationship with the quantity of labour (both family and hired) measured in man-days implies that the number of labour man-days used is significant in influencing the number layer output. The result from Table 4 shows that 1% increase in the number of man-days of labour usage will lead to 0.085% increase in layer output. This finding is consistent with the [47] who also found a positive relationship with both families and hired labour and argued that they are each productive.

The indirect production elasticity of capital input such as the poultry equipment, housing unit usage has a positive impact on layer output. By this, a 1% increase in the capital input use will lead to 0.045% of layer output. The reason might be because the layer producers are using their fixed cost input very efficiently, so they are not feeling the impact of the fixed cost of reducing their output.

Specific insight is gained into the nature of return to scale (RTS) in layer production in the study area. This is obtained by summation of all elasticities in Table 4 equal to 1.56, implying that on average, layer producers exhibits increasing returns to scale. The econometric interpretation of increasing return to scale is that in a long run, as all inputs jointly increase by 1%, layer producers output will increase by 1.56%. this indicates that layer producers in study area operate in the stage one of production which calls for increase in layer bird stock (5659 birds) to take advantage of economics of scale. This finding is similar to [48] that found increasing returns to scale of 1.19 among the poultry egg (layer) production which modelled production efficiency in Chikun and Igabi of Kaduna State, Nigeria.

Table 5
Maximum likelihood estimates of the profit inefficiency model.

Variables	Parameter	Coefficient	Standard errors	t-ratio
Constant	Z_0	0.8579***	0.0619	13.839
Gender	Z_1	−0.0828***	0.0326	−2.543
Age	Z_2	0.0039**	0.0023	1.752
Experience	Z_3	0.0171**	0.0099	1.713
Age*Experience	Z_4	−0.0003**	0.0002	−1.820
Training in poultry farming	Z_5	−0.1527***	0.0568	−2.687
Extension contact	Z_6	−0.4354***	0.0439	−9.919
Membership of FBO	Z_7	−0.0852**	0.0419	−2.028
Credit	Z_8	0.0138	0.0133	1.038
Housing type	Z_9	0.1065*	0.0719	1.482
Mortality rate	Z_{10}	0.1262***	0.0010	12.265
Landownership	Z_{11}	−0.1435	0.0331	−0.434
Regional effect	Z_{12}	−0.0311	0.0318	0.979

Source: Author's field survey, 2013 *,**and*** statistically significant levels at 10%, 5% and 1% respectively.

4.2. Determinants of profit inefficiency of layer production

Table 5 present the results of factors that explain the variations in the profit efficiency among layer producers interviewed. With the inefficiency model, it is essential to note that the positive coefficient implies an increase in profit inefficiency whilst a negative coefficient leads to a decrease in profit inefficiency otherwise increase in Profit efficiency. From that score, producers' gender, age, experience, interactive term of age and experience, training in poultry farming, contact with extension service agents(veterinary agent), membership of a farmer-based organization, housing type, and mortality rate are statistically significant in explaining the variation in the profit efficiency among sampled layer producers. Except for age, experience, housing type and mortality rate being positive, other significant variables in the inefficiency model have negative signs as expected.

The result in the inefficiency model reveals that male layer producers are more profit efficient than their female counterparts; this is confirmed by the negative sign of gender, which is statistically significant at 1%. This may stem from the fact that male producers devote most of their time working on the farm as well as having more strength or more energetic than their female counterpart. This result is in agreement with the findings of [28,51] that being a male farmer reduces inefficiency. Age had a positive and significant relationship with profit inefficiency at 5%, meaning that aged layer producers are less profit efficient than the younger ones. This result is not surprising because young producers are very progressive and willing to implement new production technologies and systems to increase their profit. This underpins the need to encourage the Youth to take up layer production. This finding is consistent with the result of [21,45,49,50].

Experience has a positive and significant relationship with profit inefficiency at 5%. This implies that layer producers who have more years in layer production business are less profit efficient than the less experienced ones. This may be so because more experienced producers may tend to rely on their technical know-how and thereby tend to shun any innovative ideas being brought forward. The young ones may tend to learn more and thus look forward to embracing the new technologies and ideas hence may tend to be more efficient than the older producers. This finding is similar to the result of [28,49,50]. However, the finding is contrary to the conclusions from [22] who argued that the more experienced the producer is, the more profit efficient the producer become. Contact with extension service agents (veterinary agent) is negative and statistically significant at 1%, implying that it has a positive effect on profit efficiency.The more the layer producers have contact with veterinary service advisory, the more profit efficiency it becomes. The veterinary services include advisory services(accurate and timely information on layer health) and training of the producers to improve upon their farmer's ability to adopt productivity-enhancing inputs and utilize them efficiently. This finding is consistent with those of [21,23,50,51] reported that, access to extension services(veterinary agent) improved upon the technological know-how of the producers and thereby make them perform significantly better in terms of earning profit and incurring less profit loss and hence operating on the higher level profit efficiency. Membership of farmer-based organization has a negative coefficient and is statistically significant at 5% implying that, producers that belong to the farmer groups or associations such as Poultry Farmers Association tend to be more profit efficient than their counterpart who does not belong to any other groups. This may be as a result of producers having the opportunity to attend seminars, workshops and other training activities, share ideas, information with other producers on layer production practices through interaction with other producers. These tend to improve upon their technical, allocative and managerial capability and efficiency hence improving their profit efficiency. This finding confirms result of [23] who argues that, farmers that belong to the Poultry Farmer Association records lower cost inefficiencies due to sharing of ideas and experiences as well as intermittent workshops members attend. Training in poultry farming is negative and statistically significant at 1% indicating that, producers having formal training on poultry production tends to be more profit efficient than their counterpart who does not have any training in the poultry business. Skills acquisition and enhancement leads to development and thereby make producers understand how to go about the management of their farms. This finding is consistent with the observations revealed by [28] among fish farms in Ghana where they argued that formal training in fish farms enlightens farmers technical aspects and hence reduces their inefficiencies in production.

Albeit age and axperience on their individual effects were found to increase profit inefficiencies among layer producer, their joint effect significantly enhance profit efficiency by reducing the inefficiencies. The interactive term of age and experience has the negative coefficient, and significant at 5% suggesting that aged layer producers with several years of experience in layer production are relatively more profit efficient as against aged layer producers with less experienced or experienced young farmers. This result reveals that people who go into layer production at old age (as after pension work) are less profit efficient as opposed to those who enter at the younger age and as they grow with experience on the job tend to acquire more skills in the layer production can better manage their resources and so tend to be more profit efficient. Besides, younger layer producers are ready to take risks and are receptive to new ideas and gain more experience to become more profit efficient. This is because as the producers remain longer in the industry they tend to know how to treat some diseases and symptoms which enable them to notice any such symptoms early in their birds thereby quickly try to deal with them and by so doing reducing the mortality rate and enhancing their profitability. This has also been noted by [42] who found age and experience to positively influencing economic efficiency. [28] also had a similar finding among fish farmers in Ghana.

5. Conclusion and policy recommendation

This study assessed profit efficiency and its determinants of intensive housing system of layer production among 300 layer producers in nine districts of Brong Ahafo and Greater regions of Ghana using a stochastic profit frontier model. The result shows that the costs of feed and labour are the most significant factors that reduced profits of the layer producers, therefore reducing the prices of these two inputs would significantly lead to increase in layer production. Alternatively, the cost of medicine/vaccine, day-old chicks and capital inputs increased profit level in layer production in the study area. The estimated indirect productivity of inputs used indicated that four of the input variables; medicines and vaccines, feed, day-old chicks, labour, and capital inputs (poultry houses/buildings, equipment and the land) have a positive impact on layer output meaning that a unit increase in any of the variables would result to an increase in output. Results based on the coefficients of input variables and the overall productivity of layer production (RTS) indicate that producers are operating in stage one of production thus the increasing returns to scale region (inefficient stage). This suggests that there is opportunity to expand output by increasing input use.

The study concluded that layer producers in the study area are 54% profit efficiency, hence not fully profit efficient. This suggests that substantial 46% of the prospective maximum profit was lost due to inefficiency. Therefore, an opportunity exists to increase the profit efficiency of the producer through allocative and technical efficiencies by 46% without changing the profit frontier. Layer producers contact with extension agents, formal training/education in poultry farming, membership of a farmer-based organization, gender, the type of housing the farmer is using and joint effect of age and experience of the layer producers are the main factors that significantly influence profit efficiency of layer producers. There is the need for appropriate policy recommendations to ensure those layer producers use their available technology to improve their resource use to enhance their profit level.

The study therefore recommends that layer producers should be continually trained by extension agents (Veterinary officers) other stakeholders through workshops, conferences on the need to pay critical attention to the biosecurity and safety measures such as timely removal of the old litters on their farms to help reduce high mortality rate of birds on their farms. Second, layer producers should improve upon their technical and managerial efficiency level to achieve a higher profit. Policies that would improve men's access to productive inputs (land, capital and labour), credit and more education should be pursued to increase profit efficiency of layer production.

The study further recommends that policies aimed at reducing the cost of inputs such as feed, medicines/drugs and day-old chicks must be enacted by government and vigorously pursued by MoFA since this would significantly enhance the competitiveness and profitability of the layer production sector. Also, the study advice layer producers to consider an alternative way of preparing quality feed at a cheaper cost. Government through its Flagship rearing for Food and Jobs program should support and encourage Youth to venture into layer production to enhance employment in this country.

Declaration of Competing Interest

We declare that there no conflict of interest observed during the study and among the authors.

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