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Non-Parametric Estimation of the Production Efficiency of Poultry Egg farming in Ogun State, Nigeria

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Authors' contributions

This work was done in collaboration with all the authors. Authors DAA, OFA and SOA supervised the dissertation work from which this article was written. They guided the work through all the stages of the research. Author OIA designed the research, collected the data, analyzed the data and discussed. Author TOO assisted with the report writing and read through. All authors read and approved the final manuscript.

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ABSTRACT

This study estimated the efficiency of poultry egg farming in Ogun state, Nigeria. Primary data were collected with the use of structured questionnaire from 120 farmers drawn by a multi-stage random sampling technique. Descriptive statistics, Tobit regression model and Data Envelopment Analysis (DEA) were used to analyze the data. The Data Envelopment Analysis (A Non-Parametric measure) gave the mean technical, scale, allocative and economic efficiency to be 88.9%, 96.6%, 13.95%, and 12.41% respectively, implying that inefficiency exists in the poultry (egg) enterprise. Farmers can still increase output by 11.1% and also increase revenue by 86.05% by ensuring efficient use of resources and access to price information without the need to change existing technology. The Tobit analysis showed that married farmers (P<0.05) and those that have higher flock size (p<0.05) were more efficient, while older farmers (p<0.01) were less efficient. This study

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concludes that membership of cooperative society, marital status of farmers; credit sufficiency, flock size, and age of farmers are factors affecting the production efficiency of poultry (egg) farmers.

Keywords: Efficiency; non-parametric; Nigeria; poultry farming.

1. INTRODUCTION

The poultry sub-sector of the agricultural industry in Nigeria has in recent decades experienced a trajectory but cyclical growth while translating from being predominantly subsistence and serving as a wealth reserve into a business venture with substantial impact on the income of the household or entrepreneur. Poultry products which basically comprise of 'meat and egg' are very high in protein-containing essential amino acids required for the proper functioning of the human body. They provide one of the most affordable and adequate sources of animal protein which has made the demand for them to rise thus necessitating the expansion of production. As a result, it is one of the livestock enterprises that give the highest financial returns on investment which is consistent throughout the year if involved in egg production enterprise. This incentive of high financial turnover and consistent demand of poultry products which is mostly devoid of any cultural or religious bias has been an attractive power and thus makes the enterprise one of the most practised amongst small, medium and large scale enterprises. The investment outlay for poultry egg farming is flexible and thus adaptable to any size given the capacity of the entrepreneur.

The productive resources used in poultry production are scarce and thus needs to be maximally and optimally combined to achieve the maximum output and profit possible from the available inputs and market prices. The ability to achieve the highest or maximum possible output from a given quantities of productive resources available differs from one farmer to the other. Economic theory asserts that the goal of most enterprises is profit maximization which is achieved through the efficient and optimal utilization of inputs. In most economic literatures firstly by [1], several approaches to efficiency and productivity assessment have been developed and can be classified into two broad categories: parametric and non-parametric models [2-4]. The parametric measure requires the specification of a functional form, impose certain a priori restrictions on the production technology, and statistically estimate the parameters of the production function with allowance for errors depicting the inefficiency of the farms. The non-parametric measure on the other hand construct a linear piecewise function from empirical observations of inputs and outputs quantities, thereby avoiding the need to assume functional relationships between inputs and outputs or to make distributional assumptions regarding the residuals in a regression analysis [5]. Most of the non-parametric applications are based on the DEA (Data Envelopment Analysis) model as proposed by [6]. In recent years, DEA has become a central technique in productivity and efficiency analysis, applied in different aspects of economics and management sciences [7].

Data Envelopment Analysis (DEA) is an analytical tool used for evaluating the performance of production units. It is a non-parametric mathematical programming approach which is an alternative to the Stochastic Production Frontier Analytical tool. The DEA efficiency estimation technique generates an efficiency boundary from the given sample of production units. The constructed efficiency boundary line shows the practices of the efficient farmers and the farmers below that line are called inefficient production units [8]. The relative

measure of the farm units against the frontier gives a clear picture of the performance of each farm unit. The estimation of technical efficiency through DEA can be either input or output oriented. It could also be described under constant as well as variable returns to scale (CRS and VRS). The technical efficiency scores obtained through input oriented method and through output oriented methods possess the similar values under constant returns but the values are different under variable returns to scale technology. The DEA technique has a plus point in that the functional form is not pre-specified; hence specification error does not arise [5].

The objective of the study is to estimate the technical efficiency of poultry farms under the output-oriented approach. The output-oriented approach affords one the knowledge of by how much is a farm unit away from the best frontier in terms of maximum output obtainable from combinations of inputs. The present study estimated technical efficiency of farming households under output-oriented technique. It affords one the knowledge of by how much in percentage is a farm unit away from the frontier.

1.1 Output-Oriented DEA

The technical efficiency could be estimated by how much feasible output is maximized for given level of input. According to [1] output-oriented efficiency measure could be described through Fig. 1.

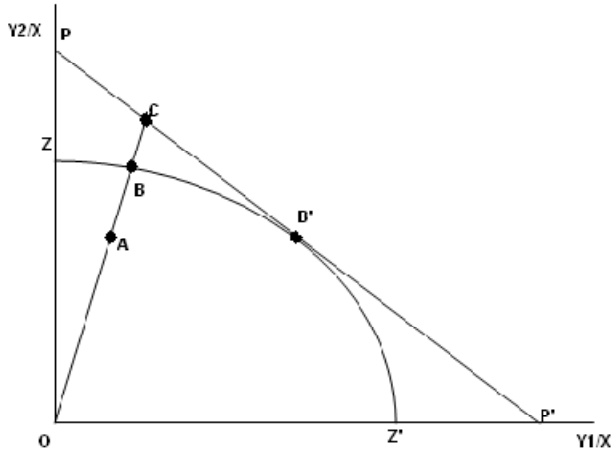

Fig. 1. Output-oriented measure of production efficiency

In Fig. 1, distance AB is technical inefficiency which is the quantity through which production could be raised with no input increase. Consequently, the technical efficiency scores under output-oriented method is TE=OA/OB. If information about price is available then price line could be drawn. As PP′ in above figure and allocative efficiency is AE=OB/OC.

And thus economic efficiency would be EE=TE*AE=OA/OC. The obtained efficiency scores of all these types were always surrounded with the closed interval 0 and 1.

To estimate the technical efficiency of the sample production units, the subsequent mathematical model of linear programming was considered:

Max y

$$y, \lambda_1, \ldots, \lambda_k$$

s.t

$$\sum_{t=1}^{n} yi\lambda i \geq y_i$$
$$\sum_{t=1}^{n} xi\lambda i \leq x^0_i$$
$$\lambda_i \geq 0$$

Where,

y = maximum production level.
y_i = the production/output of each farm
$_{Xi}{}^{n}$ = the nth factor of production
X^0_i = the nth factor of production used by the production unit being tested, and
λ_i = the weight assigned to each production unit.

The resulting technical efficiency was then estimated in form of a fraction between the examined production points of the production unit being analyzed (*yi*) and the maximum output point (*y*) i.e TE = y_i/y. The production units having 1 efficiency point were said to be technically efficient while the production units that were technically inefficient have efficiency score strictly lower than one. The estimated efficiency scores of the production units are bounded by 0 and 1. The efficiency estimates through DEA are the radial efficiency measures so they are unit indifference i.e. the estimated efficiency points do not vary with the transformation of estimation entries.

There were observed two weaknesses of DEA approach: It is only an investigative approach and does not prescribe and helpful technique to reduce inefficiency and calculated measures of inefficiency are confused with measurement error [9,10]. A number of concerns have been raised on understanding the socio-economic and farm-specific characteristics of the poultry (egg) farmers and farms. Other concerns are whether poultry egg farmers are operating at the maximum level possible and what factors are militating against the attainment of maximum output by the farmers. Owing to this, the study sought to describe the socio-economic and farm specific characteristics of the farms and farmers in the study area, estimate the technical efficiency of the poultry egg farmers and determine the factors affecting the technical efficiency of poultry egg farmers in the study area adopted for the study.

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out in Ogun state. The area was considered most appropriate because of heavy concentration of the poultry (egg) production, particularly layers production as the area is characteristically a rainforest area with some encroaching savannah.

Ogun state was created from the old western region in February, 1976 with Abeokuta as the state capital. The state has a land mass of about 1.7 million hectares and occupies about 1.9 per cent of the total land area of Nigeria and has about 2.5 per cent of the Nigerian population. It is made up of 20 Local Government Areas spread across the four main agricultural zones of the

state- Egba, Ijebu, Remo, and Yewa/Awori. Ogun state shares an international boundary with the Republic of Benin to the west and Oyo state to the north, Lagos state to the south, and Ondo state to the east.

The population of the state stands at 3.7million according to the National Population Commission of 2006. Ogun state lies within latitude 6ºN and 7ºN and 2.5ºE. There are two distinct seasons in the state namely, the rainy season and the dry season. Ogun state has two main types of vegetation, namely, tropical rain forest and the guinea savannah. The tropical rainforest is found in the coastal areas, majorly in Ogun waterside and part of the Yewa zone. Rainforests are found in some parts of the Ijebu zones of the state. Guinea and derived savannah are found in most of the western and northern parts of the state. The concentration of livestock production, poultry egg production in particular in these areas could be traceable to the perceived favourable characteristics of the vegetation in the area. The vegetation in the area is predominantly rainforest and derived savannah.

2.2 Data Source and Method of Data Collection

Primary data were used for this study. It involved the use of cross-sectional data, which was gotten with the use of a structured questionnaire. The data were obtained through the administration of the well-structured questionnaire on poultry (egg) farmers through oral interview administration method. The respondents were limited to poultry (egg) farmers in other to give the study a focus.

The choice of input values to include in the non-parametric estimation has implication on the reliability of the estimate realized. Production function specification usually requires that input quantities and not aggregated expenditure values be included in the function. The use of linearly aggregated inputs in the DEA model (i.e., use of aggregated expenditure categories rather than actual input levels) has several drawbacks. The use of value-aggregated inputs may result in failure to distinguish between technical and allocative effects and also that the ranking of the DMUs can change with different aggregation levels. On the other hand, the use of aggregated expenditure categories could be the only solution in cases where the use of actual input levels would result in either too many inputs included in the model or to the exclusion of certain inputs. In both cases, results can also be biased, given that, in the former case the inclusion of additional input variables in the DEA model results in increased efficiency scores, whereas in the latter case, the omitted variables could be of significant magnitude.

2.3 Survey Techniques and Sample Size

The multi- stage sampling procedure was used to select poultry (egg) farmers in the study area. Poultry farmers who were involved in layers production in the study area were purposively selected. Two zones namely Abeokuta and Ijebu zones were randomly selected in Ogun state. Poultry service centres (Veterinary Stores and Feed Milling Centres) were randomly selected in the two zones. These service centres were visited on randomly selected days within the week for the period assigned for each of the zones. Farm proprietors or managers who came to patronize these service centres on the days the centres were visited were interviewed. Within these zones also, the location of other poultry (egg) farms was possible with the help of farms that already had been interviewed (Snowballing). A total of 120 questionnaires were used for the study.

2.4 Method of Data Analysis

Descriptive statistics such as mean, standard error and also the frequency table was used to represent the findings on the socio-economic and farm-specific characteristics of the poultry egg farmers.

The Data Envelopment Analysis (DEA) was used to determine the efficiency level of farmers in the study area. It is a non-parametric method of efficiency measurement, a mathematical linear programming method without a specification of functional form. From the given sample of production units, an efficiency boundary line was generated against which production units were compared to determine their efficiency level. Production units below the boundary line were adjudged inefficient. The Output-Oriented DEA was used.

To estimate the technical efficiency of the sample production units, the mathematical linear programming below was used.

Max y .....(4)

y, λ_1, ..., λ_k

s.t

$\sum_{t=1}^{n} yi\,\lambda i \geq y_i$

$\sum_{t=1}^{n} xi\,\lambda i \leq x_1^0$

$\lambda_i \geq 0$

Where,

y = maximum production level.
y_i = the production /output of each farm
$_{Xi}^{n}$ = the nth factor of production
X^0_i = the nth factor of production used by the production unit being tested, and
λ_i = the weight assigned to each production unit.
Y1 = Number of crates of eggs produced
Y2 = Number of birds after laying (Spent Layer)
X1 = Annual man labour used (units)
X2 = Feed (kg/bags)
X3 = Depreciation cost on fixed items (N)
X4 = Other Direct Cost (water, electricity, rent e.t.c)
X5 = Cost of medication
X6 = Initial number of birds stocked (Number)

2.5 Tobit Regression Model

To measure the effect that farm specific and socio-economic variables have on the efficiency or otherwise of the farms, the Tobit model below was used.

The efficiency or inefficiency scores were regressed against farm specific variables by utilizing the Tobit regression model. Efficiency scores that were below 0.5 were adjudged inefficient and thus given the value zero. The management, socio-economic, and environmental characteristic of the farms that could affect their efficiency and productivity were considered.

$$Eff = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + \beta_7 X_{7i} + \beta_8 X_{8i} + \beta_9 X_{9i} + \mu_i \quad \text{.....(5)}$$

Where,

Eff = is the efficiency score for each production unit.
X_{ji} = independent farm specific variables.
μ_i = error term.
Where:
X_{1i} = Age of Proprietor (years)
X_{2i} = Sex of Proprietor (years)
X_{3i} = Marital Status of the ith farm operator
X_{4i} = the education level of the ith farm operator (in schooling years)
X_{5i} = Years of Experience (years)
X_{6i} = Membership of a Cooperative Society (No=0, Yes=1)
X_{7i} = Number of Extension contacts
X_{8i} = Credit use by the ith farm unit (No=0, Yes=1)
X_{9i} = Flock size of the ith farm in number.
ß's = the unidentified parameter to be estimated.
µi = the error term.

3. RESULTS AND DISCUSSION

3.1 Personal Characteristics of Poultry (Egg) Farmers

3.1.1 Sex, age, marital status, educational status and years of experience of poultry egg farmers

The age, gender and educational status of the poultry egg farmers are adjudged most relevant as having implications on the productivity of the farmer, access to information on technology adoption and use and the understanding of the behaviour of the credit market. The results showed that majority (90.0 per cent) of the credit constrained poultry egg farmers were male while 10.0 percent were female (Table 1).

The heavy participation of males in poultry egg production could be due to the rigor and stress which characterizes the poultry egg production business which not many females might be able to cope with, although in some cases the input of the proprietor is not physical but in coordination and direction. The gender of the proprietor is predicted to influence the efficiency of the farm unit because some of the input of the proprietor is managerial as well as physical. The distribution of the age of the respondents as revealed by the study shows that 72.5 per cent, were aged below 50 years .The study further showed that the average age of poultry (egg) farmers in the study area is 43 years, these findings agrees with the findings of [11] who reported an average age of 44 years for poultry (egg) farmers in the same study area (Ogun state).

The age of the proprietor may influence the vigour, versatility and likelihood of adoption of innovations and production technologies of the respondents which has implication on farm-level efficiency.

The field survey further showed that majority (77.5 per cent), were married. The marital status of a farm proprietor has an implication for the household size and invariably the

amount of family labour that may be readily available for farm work. Results from study also showed that majority (89.2 per cent), of the poultry (egg) farmers had post – secondary education. This high level of education of the poultry (egg) farmers could be due to the fact that success and efficiency in poultry egg production like any other livestock production enterprise require some level of educational attainment by the farmer. The assertion above is premised on the fact that innovations on efficient production and management methods are constantly evolving to meet the challenges of the poultry enterprise. The years of education of the farm proprietor is thus expected to influence the efficiency of the farm unit. The study revealed that the average years of experience of the poultry (egg) farmers in the study area is 8.72 years with majority (59.2%) of the farmers having above 5 years of experience.

Table 1. Personal characteristics of poultry egg farmers

Variables	Frequency	Percentages
Gender		
Male	108	90.0
Female	12	10.0
Total	120	100.0
Age of Respondents(years)		
Less than 30	23	19.2
31 – 40	27	22.5
41 – 50	37	30.8
Above 50	33	27.5
Total	120	100.0
Mean(Standard Error of Mean)	43.14 (1.14)	
Marital Status		
Single	27	22.7
Married	93	77.5
Total	120	100.0
Educational Status		
Primary Education	2	1.7
Secondary Education	7	5.8
Bachelor Degree	91	75.8
Postgraduate	20	16.7
Total	120	100.0
Years of Experience		
1 – 5	49	40.8
6 – 10	33	27.5
11 – 15	18	15.0
16 – 20	13	10.8
Above 20	7	5.8
Total	120	100.0
Mean (Standard Error)	8.72 (0.648)	

Field Survey, 2012

3.2 Flock Size and Total Revenue

The total revenue includes both the revenue realized from sales of eggs and also sales of spent layers. Following [12], This study categorized small scale farm as farm with less than 1000 laying birds; medium-scale size as flock size between 1000 and 5000, and large-scale size assize above 5000 laying birds. About 43 percent of credit constrained and 45 percent

of credit unconstrained farm units sampled were operating at medium-scale (Table 2). This agrees with the findings of [13], who reported that 67.4 percent of commercial poultry egg farms in Tanzania were operating on the medium-scale. The study further revealed that 16.7 percent and 28.3 percent of credit constrained and credit unconstrained farm units respectively were operating on a large-scale.

The total revenue distribution showed that 41.7 percent and 50 percent of the credit constrained and credit unconstrained farm units had annual revenue above ₦10,000,000 from sales of eggs and spent layers. This could however be adduced to the size or scale of the poultry farm units. It would however not be correct to conclude that the size or scale of a poultry farm unit is a function of its present credit constraint condition, a condition of insufficient credit necessary for business growth.

Table 2. Distribution of respondents according to flock size and total revenue from poultry egg production enterprise

Variables	Frequency	Percentages
Flock Size		
Less than 500	21	17.5
501 – 1000	22	18.3
1001 – 5000	50	41.7
5001 – 10000	8	6.7
Above 10000	19	15.8
Total	120	100.0
Mean (Standard Error)		5500.84 (1170.19)
Total Revenue		
Less than 5, 000, 000	34	28.3
5, 000, 001 – 10, 000, 000	31	25.8
Above 10, 000, 000	55	45.8
Total	120	100.0
Mean (Standard Error)		3.5982E7 (7.87733E6)

Source: Field Survey, 2011

3.3 Efficiency Estimates of Poultry Egg Farmers

The estimates of the efficiency level, a measure of the performance of the sampled poultry egg farmers in the study area against the obtainable standard (i.e the frontier) is given below. The result of the Data Envelopment Analysis, (DEA), a non-parametric approach of measuring the efficiency gives the overall mean constant returns to scale efficiency and variable returns to scale efficiency result of all the sampled farm units. The study revealed that the sampled farms operate at 88.9 percent, and 91.8 per cent constant returns to scale (CRS), and variable returns to scale (VRS) efficiencies respectively. The result revealed that farm units in the study area are not at their maximum technical efficiency, implying that there is a potential 11.1 per cent and 8.2 per cent level of output that is still obtainable when given level of input resources are better combined (Table 3). The result gives the overall mean allocative efficiency and economic efficiency of all the sampled farm units. The study revealed that the sampled farms operate at an average of 13.95 percent and 12.41 percent with regard to their allocative and economic efficiencies respectively (Table 3). The result revealed that farmers in the study area are grossly inefficient in producing the maximum output with the least cost. The result hence reveals that farmers in the study area are not at their maximum allocative and economic efficiencies. This implies that as farmers get more

access to price information and make their input purchases in bulk, farmers can substantially increase their allocative and economic efficiencies.

Table 3. Efficiency estimates of poultry egg farmers

Efficiency indices	Technical efficiency		Scale efficiency		Allocative efficiency		Economic efficiency	
	Freq	%	Freq	%	Freq	%	Freq	%
Less than 0.5	2	1.7	1	0.8	117	97.5	117	97.5
0.5 – 0.599	3	2.5	2	1.7	-	-	-	-
0.6 – 0.699	11	9.2	5	4.2	2	1.7	2	1.7
0.7 – 0.799	11	9.2	6	5.0	-	-	-	-
0.8 – 0.899	15	12.5	12	10.0	-	-	-	-
0.9 – 1.0	78	65.0	94	78.3	1	0.8	1	0.8
Mean	0.889 (0.013)		0.966 (0.009)		13.95 (0.0118)		12.41 (0.012)	
Minimum	0.353		0.435		0.03		0.02	
Maximum	1.0		1.0		1.0		1.0	

Source: Field Survey, 2011

3.4 Tobit Regression Estimates

The efficiency scores were further regressed with farm-specific variables by utilizing the Tobit regression model.

The result showed that the sigma value is statistically significant at the 1 percent level of significance which implies that the model has a good fit in identifying the factors determining the efficiency or otherwise inefficiency of the poultry egg farm units in the study area. The analysis was run for all the technical efficiencies considered with the same number and type of variables.

The efficiency scores were run against the variables considered. The coefficient of the variables that have positive signs implies that the likelihood of a farm unit to be efficient increases with an increase in that variable or as applicable. Also, variables that have a negative coefficient imply that the variables contribute to the likelihood of the farm unit to be inefficient. The level of significance then determines the severity of the effect of that variable on the efficiency or inefficiency of the farm unit.

For this study, the variables; age of the proprietor, marital status, years of experience, cooperative membership, and flock size were statistically significant with differing signs. The age of the proprietor shows a negative correlation but is statistically significant at 1 per cent ($\alpha<0.01$). This implies that older proprietors in the poultry egg business seem to be less efficient relative to younger farmers. The probable justification could be that younger farmers tends to adopt latest production technologies that can help reduce production cost, but with higher risks than the older ones besides that they have higher capacity to endure the stress and rigour that the enterprise entails.

[14,15] Reported that the age of the farm operator, years of experience and educational status of the farm operator has a negative influence on the efficiency of the farm unit. This agrees with the findings of this study on the behaviour of age and years of experience of the farm operator on the efficiency of the farm unit. Marital status is positive and statistically significant at 5 per cent ($\alpha<0.05$). This reveals that proprietors that are married do have a

high tendency of being more efficient. This could be traceable to a sociological advantage of having spouses and children that could be of help in management brainstorming, household labour, trust and invariably less pilferage on the farms. The findings of this result agrees with [16,11] who found out in their efficiency study that farm experience, access to credit and marital status significantly affect the technical efficiency of the farm unit at 1 percent level of significance. [13] Also reported that marital status, educational status, sex of the farm operator and use of credit positively influences the technical efficiency of commercial egg producers in Tanzania. The years of experience variable is negative but statistically significant at 5 per cent ($\alpha<0.05$). This sign behaviour seems contrary to expectations, particularly with regard to the crop enterprise. The only explanation to this can be linked to that on age, owing to the nature of the business, older farmers are difficult to convince in adopting new ways of production and management hence preferring to remain in their state and risk level to trying better ways**.**

The total flock (laying) size of a farm positively influences the efficiency of the farm at 10 per cent ($p<0.1$) level of significance this implies that bigger farms are conclusively more efficient than smaller farms. This is easily traceable to the benefit of economies of size, by way of bulk purchases, integration (vertical and horizontal) and invariably lesser input cost.

Tobit estimates of determinants of the efficiencies of poultry egg farmers

Independent Variable	Coefficient	T-value	Elasticity
Age of proprietor	-0.40881E-01	-2.9827***	-0.1683
Sex of proprietor	-0.55855	-1.4069	-0.0481
Educational status	0.84171E-02	0.43249	0.0103
Marital status	0.85505	2.2295**	0.0634
Years of experience	-0.35070E-01	-2.2017**	-0.0305
Credit use	0.50324	1.5149	0.0237
Flock size	0.23460E-04	1.8598*	0.0132
Extension visit	-0.26687	-1.0270	-0.0053
Membership of Cooperative Society	-1.0772	-3.0406***	-0.0524
Constant	7.7279	8.9304***	
Log-likelihood function	-14.42		
Mean square error	1.258		

4. CONCLUSION AND RECOMMENDATIONS

The result shows that majority of the proprietors were males and married. Majority of them were in their active middle-age, and have the poultry business as their main occupation. The findings of the study showed that inefficiency does exist in the study area. Age of the proprietor, marital status, years of experience, membership of cooperative society, and flock size are the factors which pertinently affects the efficiency of the sampled farm. Poultry egg farm units should aim at increasing their size or scale of operation as efficiency and profitability could be enhanced by such. Government also should encourage and aid the formation of cooperative societies for poultry egg farm proprietors as they will be able to avail themselves the opportunities of cooperative membership among which is access to credit and increased market access.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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