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ADEOTI Samuel Oluwafemi and BARUWA Olayinka Isiaka

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ABSTRACT

The study was conducted in Southwestern Nigeria, to analyze the technical and allocative efficiencies of quail egg producers in the study area (Southwestern Nigeria). A multistage sampling technique was used in selecting 90 respondents used for the study. The study assessed the technical and allocative efficiencies of quail egg farmers in southwestern Nigeria. The technical efficiency estimate shows that the technical efficiency of quail egg farmers ranges between 62% and 83%, with mean of 71.70% and their allocative efficiency range between 131% and 100% with mean of 111.02% which indicates that on the average, the respondents are efficient in the use of combination of their resources. The elasticity estimates of 1.0551 indicates that the quail egg production is operating at stage one in production curve where increasing return to scale occur. This study concludes that the output and technical efficiency of the quail egg production can be increased by the use of more feed, capital, bird stocked and involvement in other farm enterprise. Also a reduction in the amount of money spent on drugs and vaccine and improvement in their education level will help the farmers in being efficient in the allocation of their resources.

INTRODUCTION

Poultry are domesticated birds kept by humans for their eggs, meat and feathers, sometimes they are kept as pets. Poultry birds include chicken, turkey, duck, quail and geese. Ojo (2003) reported that poultry birds are good converters of feeds into usable protein in meat and eggs, the production cost per unit is low relative to other types of livestock and return to investment is high, thus farmers need just a small amount of capital to start a poultry farm. Poultry meat is very tender. Its palatability and acceptability to consumers is very high. It has a short production cycle (payback period) hence, capital is not tied down over a long period. However, rearing of domestic chickens has hitherto dominated the poultry sub-sector of Nigeria economy. In recent times there are new entrants into the sector, one of the birds slowly gaining prominence are the quail birds. Quail birds are hardy birds which are suited for commercial rearing for meat and egg production under intensive management (Egbeyale *et al*., 2013).

Quail *(Cortunix cortunix japonica)* was introduced to Nigeria in 1992 by the National Veterinary Research Institute of Nigeria (NVRI, 1994) in Vom, Plateau State. Quails are small game birds that are used for eggs and meat (Daff, 2013). The birds have early sexual maturity resulting in a short generation interval, high rate of lay, much lower feed and space requirements than the domestic fowl (Hemid *et al*., 2010, Ijaiya *et al.*, 2013). *Coturnix cortunix japonica* make excellent quail for beginners because they start laying eggs at a young age of approximately six weeks (Chelmonska *et al.*, 2008) and reach table size by five weeks of age. They thrive well in small cages and can be reared at a cheaper cost within a relatively short time (Ojo *et al.*, 2011). Quails have no known morbid diseases and are resistant to most poultry diseases except respiratory disorder with very low mortality rate, hence they require less vaccination, they have a high rate of egg production between 200 – 300 eggs in 360 days (Oluwatomi, 2010). Their meat and eggs are renowned for their high quality protein, high biological value and low fat content. They are tastier than chicken, making it a choice product for hypertensive patients, people with stress problems, digestive disturbance, gastric ulcer, liver problems, bronchitis, depression, panic and anxiety illness for a greater positive effect (Tuleun *et al.*, 2011).

It is generally believed that quail production system is more economically efficient than family poultry systems that was assumed to be efficient because of the lower inputs (resources) required (Sonaiya, 2001). The assertion has not been properly investigated using econometric model(s) in the study area, this is necessary because for quail production to grow, the present level of efficiency and productivity must be known and improved upon. There are little studies on the economic efficiency of quail egg production in southwestern Nigeria.

Efficiency and productivity, although referring to distinct concepts derived from the production function, are interrelated and are common performance measures by which agricultural units are evaluated. The everyday meaning of the term 'efficiency' refers to a situation where resources are used to their capacity so that no resources are wasted. The efficiency of an economic unit is a 'holistic measure', in that it takes account of all resources used and all outputs produced in determining 'how well' or 'how effectively' the decision making unit combines inputs to produce output. Traditionally, there are three types of efficiency, namely; Technical efficiency, Allocative efficiency and Economic efficiency.

Technical efficiency (TE) involves a comparison between observed and optimal values of outputs and inputs. Using an input orientation to compare the actual or observed input level to the optimal input level with the corresponding output, the level of technical efficiency can be determined. A technically efficient farm will operate on the isoquant representing the efficient quantity. Adopting an output orientation, technical efficiency occurs when the maximum output is obtained from the given inputs, a technically efficient farm will be located on the production frontier. Technical efficiency is achieved when a high level of output is realized given a similar level of inputs. It is therefore concerned with the efficiency of the input to output transformation. Technical efficiency is a measure of effectiveness in which maximum output is obtained from a given combination of inputs i.e. the ability to operate on the production frontier.

According to Battese and Coelli (1995) technical efficiency can be defined as the ability to successfully produce maximum amount of output from a given set of inputs, it deals with productivity in relation to factor- product transformation. For a farm to be technically efficient, it has to produce at the production frontier level. However, this is not always the case due to random factors such as bad weather, animal destruction and/ or farm specific factors, which lead to producing below the expected output frontier (Battese and Coelli, 1998). Efficiency measurement therefore attempts to identify those factors that are farm specific which hinder production along the frontier. Technical efficiency goes beyond evaluation based on average production to one that is based on best performance among a given category (Battese and Coelli, 1995) though, it is related to productivity where inputs are transformed into outputs. Also efficiency measurement provides an opportunity to separate production effects from managerial weakness (Ogundari and Ojo, 2005). It is therefore concerned with the efficiency of the input to output transformation.

Measurement of technical efficiency

Technical efficiency can be measured by two main approaches:

1. The input approach, if one is considering the ability to avoid waste by producing as much output as input usage allows, i.e. we evaluate the ability to minimize inputs keeping outputs fixed.
2. The output approach, if one is considering the ability to avoid waste by using as little input as output production allows, i.e. we evaluate the ability to maximize outputs keeping inputs fixed.

According to Koopmans (1951) and Debreu-Farrell (1951), technical efficiency is measured as the ratio between the observed output and the maximum output, under the assumption of fixed input, or, alternatively, as the ratio between the observed input and the minimum input under the assumption of fixed output.

Essentially there are two main methodologies for measuring technical efficiency: the econometric (or parametric) approach e.g. Stochastic Frontier Analysis (SFA), and the mathematical programming (or non-parametric) approach e.g. Data Envelopment Analysis (DEA). The two techniques use different methods to envelop data, and in doing so they make different accommodation for random noise and for flexibility in the structure of production technology.

Hence they differ in many ways, but the advantages of one approach over the other lead to two characteristics:

• the econometric approach is stochastic and attempts to distinguish between the effects of noise and the effects of inefficiency, while the linear programming approach is deterministic and under this the effect of noise and real inefficiency are melt together;

• the econometric approach is parametric and as a result suffers from functional form mis-specification, while the programming approach is non-parametric and so it is immune to any form of functional misspecification.

The popular approach of measuring technical efficiency is the stochastic production frontier, it is an econometric method of efficiency measurement in production systems and it is built around the premise that a production system is bounded by a set of smooth and continuously differentiable concave production transformation functions for which the frontier offers the limit to the range of all production possibilities (Sharma *et al.*, 2000). It has the advantage of allowing simultaneous estimation of individual technical efficiency of the farmers as well as determinants of technical efficiency (Battese and Coelli, 1998).

However, this production objective cannot be carried out in isolation since a farm can be considered as an economic unit with scarce resources. When a producer with the aim of maximizing profit makes allocation mistakes that result in inefficiency, then the farmer is considered allocatively inefficient (Kumbhakar, 2001). Therefore, technical efficiency cannot be achieved in isolation but other considerations (efficiencies) are always at play.

Allocative efficiency

If information on relevant market prices is available and an economic objective, such as revenue or cost efficiency is assumed, allocative efficiency (AE) of the farm can be determined. AE reflects the ability of the farmer to use inputs, or produce output, in the most profitable manner, given their respective prices and the production technology. In other word allocative (or price) efficiency refers to the ability to combine inputs and outputs in optimal proportions in the light of prevailing prices. It is measured in terms of behavioral goal of the production unit like, for example, observed cost versus optimum cost or observed profit versus optimum profit.

Allocative efficiency is a measure of firms' success in choosing an optimal set of inputs. It is an indication of the gains that can be obtained by varying the input ratios on the bases of goals of the farm. Farrell (1957) and Inoni (2007) defined allocative efficiency as the ratio of total cost of producing one unit of an output, using actual factor proportion in a technically efficient manner, to total cost of producing the same unit of output, using optimal factor proportions in a technically efficient manner. According to Yotopoulos and Lau (1973), a firm is said to be allocatively efficient if it maximizes profit, which implies that it was able to equate the value of Marginal Product (MP) of each resource employed to its unit cost. This is the condition for profit maximization under perfectly competitive markets, which requires that the extra revenue generated from the employment of an extra unit of a resource must be equal to its unit cost (Chukwuji *et al*., 2006). Also, allocative efficiency relates to the degree to which farmer utilizes input in optimal proportion, given the observed input price (Battese and Coelli, 1995). It also refers to the situation where resources are given in profit maximizing sense so that the marginal value products of resources are equal to their unit prices.

Economic efficiency

Combining AE with TE gives a measure of overall economic efficiency. Economic efficiency provides a measure for whole farm comparisons independent of the level of inputs used, or output produced, and can be used as a benchmark to make comparisons across many producers. Relative efficiencies can be determined as well as the identification of the factors that are responsible for variations between units.

Graphical representation of technical and allocative efficiency

The technical and allocative efficiency are graphically demonstrated in Figure1. This Figure is used to illustrate the concept of input-oriented measures. It is assumed that a set of farms use two inputs ($x_1$and x_2) to produce output (y), under the assumption of constant returns to scale.

Point P is a technically inefficient farm.

Q = a technically efficient farm (any point on SS^{l})

Q^{l}= an allocatively efficient farm (Slope = ratio of price of x_1 and x_2)

AA^{l}= the isocost line (where SS' is tangential to isocost line)

SS^{l} = the isoquant of efficiency

The unit isoquant of technically efficient input combinations is represented by SS' and permits the measurement of technical efficiency. Where the farm uses quantities of inputs defined by point P to produce a unit of output, the technical inefficiency of the farm can be represented by the distance QP, which is the amount by which all inputs could be proportionally reduced without a reduction of the output level. Technical efficiency is expressed in percentage terms by the ratio QP/OP, which represents the percentage by which all inputs need to be reduced to achieve technically efficient production. Technical efficiency is commonly measured by the ratio OQ/OP which is equal one minus QP/OP.

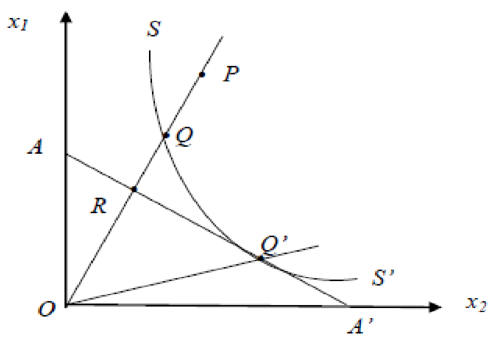

Figure: An input-oriented measures of technical and allocative Efficiencies

Source: Coelli *et al*, 1998.

Technical Efficiency: TE = OQ/OP = 1- QP/OP ………………………………. ……………...(1)
AA^1 is the input price ratio, represented by the slope of the isocost line. The allocative efficiency (AE) of the firm operating at P is defined to be the ratio OR/OQ since the distance RQ represents the reduction in production cost that would arise if production were to occur using the allocative (and technically) efficiency input proportion at point Q^1, instead of the allocatively inefficient input proportion at point P.
Allocative Efficiency: AE = OR/OQ ………………………………………………………..(2)
The total economic efficiency is defined to be the ratio OR/OP where the distance RP can also be interpreted in terms of cost reduction. The product of technical and allocative efficiency measures provides the measure of overall economic efficiency which is mathematically expressed as:
Economic Efficiency: EE = OR/OP = (OQ/OP) x (OR/OQ) = TE x AE……………………….(3)
On the other hand, productivity is a measure of the efficiency with which inputs are used to produce output; it is a ratio of output to input(s). It can be measured in relation to one single input, such as labour or capital, to yield a partial productivity measure, or to multiple inputs to provide a wider total factor productivity measure. Productive efficiency essentially measures the extent to which production at a particular time reflects the best possible practice. Reasons why productivity may vary between productive units over time include differences in the technology used by the productive units, differences in the efficiency of the production processes in the use of inputs to produce output, or variations in the environment in which production takes place.
This paper seeks to estimate the economic efficiency of production and the factors, which influence the level of efficiency in Quail egg production in Southwestern, Nigeria. This study becomes important in analyzing the economic efficiency of quail egg production, since increased production and productivity are direct consequences of efficiency of production resulting from efficiency of inputs combination, given the available technology, Ajibefun and Daramola (1999). The broad objective of this study is to determine the level of efficiency of quail egg production in southwestern Nigeria.
The specific objectives are; to estimate the technical and allocative efficiencies of quail egg production; and return to scale of quail egg enterprise in southwestern Nigeria.

METHODOLOGY

The study was carried out in the southwestern region of Nigeria that comprises Oyo, Osun, Ogun, Ondo, Ekiti and Lagos States. The study employed multistage sampling technique with the first stage involving the purposive selection of three States from the study area (Osun, Ogun and Oyo States) based on prior survey on their quail egg production potentials through the Poultry Farmers Association and the National Veterinary Research Institute (NVRI) Ikire, Osun State. At the second stage, six Local Government Areas (LGAs) were purposively selected from each State based on their quail egg production. At the third stage, five quail egg farmers were selected from each LGA using snowball technique to have a total of ninety respondents.
The stochastic frontier production function and cost function were used to analyse technical and allocative efficiency respectively
The stochastic frontier production function was specified
$\ln Y_i = \beta_o + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + (U_i - V_i)$…………………………...(4)
Where, ln = the natural logarithm;
β_o = the intercept
i = the i-th sample farm;

Y = output from quail (eggs);

X_1 = total number of bird stocked;

X_2= total quantity of feeds (kg);

X_3 = total amount of drugs and veterinary services (₦);

X_4 = total number of labour (in man-days) both family and hired labor;

X_5=capital inputs (₦) made up of depreciation charges on buildings and equipments;

$\beta_1, \beta_2, \ldots \beta_5$ = Vectors of unknown parameters.

V_i = random error, assumed to be independent of U_i, identical and normally distributed with zero mean and constant variance N $(0, \sigma v^2)$. They represent random variations in output as a result of factors outside the control of farmers as well as effects measured error in output variables from the model and a statistical noise.

U_i = random variables that accounts for technical inefficiency effects which are assumed to be independent of V_i and non-negative truncation at zero or half normal distribution with N $(0, \sigma u^2)$

The inefficiency model is defined by:

$$U_i = \partial_0 + \partial_1 Z_1 + \partial_2 Z_2 + \partial_3 Z_3 + \partial_4 Z_4 + \partial_5 Z_5 \qquad (5)$$

Where: U= farmers technical inefficiency;

∂_s= parameters estimated;

i = i-th farm in the sample;

Z_1= education (years);

Z_2= age of the farmers (years);

Z_3= household size; (number)

Z_4= experience in quail production (years)

Z_5= other farm enterprise (number);

If $U_i = 0$, no technical inefficiency occurs, the production lies on the stochastic frontier.

If $U_i > 0$, production lies below the frontier and it is inefficient.

The production cost function was specified as

$$\ln Y_i = \beta_o + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + (U_i + V_i) \qquad (6)$$

Where, ln = the natural logarithm;

β_o = the intercept

i = the i-th sample farm;

Y = total cost (₦);

X_1 = output (₦);

X_2= cost of feed (₦);

X_3 = cost of drugs and vaccine (₦);

X_4 = total cost of bird stocked (₦);

X_5 = cost of labour (₦) both family and hired labor;

$\beta_1, \beta_2, \ldots \beta_5$ = Vectors of unknown parameters.

The inefficiency model is defined by:

$$U_i = \partial_0 + \partial_1 Z_1 + \partial_2 Z_2 + \partial_3 Z_3 + \partial_4 Z_4 + \partial_5 Z_5$$

Where: U= farmers allocative inefficiency;

∂_s = parameters estimated;

i = i-th farm in the sample;

Z_1= education (years)

Z_2= age of the farmers (years);

Z_3= household size;

Z_4= experience in quail production (years);

Z_5= other farm enterprise (number);

If U_i =0, no allocative inefficiency occurs, the production lies on the stochastic frontier.

If $U_i > 0$, production lies below the frontier and it is inefficient.

RESULTS

Table 1: Maximum-likelihood estimates for parameters of the Cobb-Douglas stochastic frontier production for quail egg farmers in the southwestern part of Nigeria

Variable	Parameter	Coefficient	t-ratio
Production function			
Constant	β_o	-0.0060	-0.0222
Ln(bird stocked)	β_1	0.2354	2.9170***
Ln(quantity of feed)	β_2	0.7306	8.8360***
Ln(drug & vaccines)	β_3	0.0081	0.8076
Ln(labour)	β_4	0.0563	1.3860
Ln(capital input)	β_5	0.0249	2.4900**
Inefficiency model			
Constant	δ_0	0.2731	0.1007
Education	δ_1	0.0099	0.2199
Age	δ_2	0.0005	0.05803
Household size	δ_3	-0.0015	-0.0735
Year of experience	δ_4	0.0283	1.3830
Other farm enterprises	δ_5	0.1494	-2.1330**
Diagnostic statistic			
Sigma-square ($\sigma^2 = \sigma_v^2 + \sigma_\mu^2$)	σ^2	0.0928	6.4280***
Gamma ($\gamma = \sigma_\mu^2/\sigma^2$)	γ	0.0139	0.0033
Log of likelihood	λ	-20.7200	
LR Test		7.2710	

Source: Computed from survey data, 2015

***Significant at 1per cent and ** Significant at 5per cent.

Table 2: Maximum-likelihood estimates for parameters of the Cobb-Douglas stochastic frontier cost for quail egg farmers in the southwestern part of Nigeria

Variable	Parameter	Coefficient	t-ratio
Cost function			
Constant	β_o	0.6517	2.9616***
Ln(total revenue)	β_1	0.4444	2.7644***
Ln(cost of feed)	β_2	0.1963	14.4741***
Ln(cost of drug & vaccines)	β_3	-90.8705	-3.8739***
Ln(cost of bird stocked)	β_4	91.4440	3.8956***
Ln(cost of labour)	β_5	0.21027	15.1136***
Inefficiency model			
Constant	δ_0	0.3151	2.8289***
Education level	δ_1	-0.0067	-1.6901*
Age	δ_2	-0.0030	-0.7568
Household size	δ_3	0.0016	0.1359
Year of Experience	δ_4	0.0166	1.0331
Other farm enterprises	δ_5	-0.0653	-1.1198
Diagnostic statistics			
Sigma-square ($\sigma^2 = \sigma_v^2 + \sigma_\mu^2$)	σ^2	0.0077	2.3041**
Gamma ($\gamma = \sigma_\mu^2/\sigma^2$)	γ	0.9000	12.2279***
Log of likelihood	λ	134.1675	
LR Test		28.9924	

Source: Computed from survey data, 2015

***Significant at 1percent, **Significant at 5percent and * Significant at 10 percent

Table 3:Frequency distribution of the technical efficiency of various farmers

Efficiency Range (%)	Frequency	Percentage
≤ 60	2	2.20
60-70	39	43.30
70-80	43	47.80
>80	6	6.70
Total	90	100
Mean (%)	71.7	
Std Devi. (%)	6.5	
Minimum (%)	56.0	
Maximum (%)	83.0	

Source: Data analysis, 2015

Table 4

Frequency distribution of the allocative efficiency of various farmers

Efficiency Range (%)	Frequency	Percentage
100-107	56	62.20
108-114	21	23.30
115-121	10	11.10
>122	3	3.30
Total	90	100
Mean (%)	107	
Std Devi. (%)	8.23	
Minimum (%)	101	
Maximum (%)	128	

Source: Data analysis, 2015

Technical and allocative efficiency

The coefficient of the stock of birds is 0.2354 significant at 1 percent, this results shows that a unit increase in the number of birds stocked will increase the output of egg by 0.24 (Table 1). This positive significant coefficient is in line with the findings of Bamiro (2008) and Adepoju, (2008). The quantity of feed used in feeding the quail birds has coefficient of 0.7306, significant at 1 percent, this indicates that, a unit increase in the amount of feed(kg) supplied to the birds will increase the output by 0.73. This implies that the more feed given to the bird, the more eggs produced. Feed intakes have a constant marginal efficiency until a maximum egg output per bird is attained (Olayide and Heady, 1982). With constant feed-egg transformation rate, the limit of bird's capacity to produce eggs lies in its ability to assimilate feed. The positive sign and significance of the coefficients of feed is in line with the findings of Oji and Chukwuman (2007); Binuomote *et al*. (2008) and Adedeji *et al*. (2013). The coefficient of capital input is 0.0249 significant at 5 percent, this result reveals that a unit increase in the amount of capital input invested will lead to a 0.02 increase in the egg output. This suggests that farm can still increase their quail egg production substantially by increasing their capital input. The positive coefficients of both labour and drugs/vaccines imply that a unit increase in their use would increase the output of quail egg production by about 0.06 and 0.01 respectively but they are statistically insignificant probably because the farmers are over using both labour and drugs which is contrary to what is popularly believed that quails do not need drugs and vaccine and that production of quail egg is not labour intensive.

In the inefficiency model, involvement in other farm enterprise is statistically significant at 1% and also positively related to technical efficiency while household sizes in the model is statistically insignificant but have a positive relationship with technical efficiency.

The significance of the estimated variance parameter (σ^2) of 0.09 at 1%, the Log likelihood (λ) of -20.72 and LR test of 7.27 shows that the model is fit for the analysis, while the gamma (γ) of 0.01 which is not significant cannot dispute the fact that the model is fit because Adewuyi *et al.*, (2013) in their study on technical efficiency analysis of cassava farmers in ogun state, had a similar case. The σ^2 on the other hand was significant at one percent level, indicating a good fit and correctness of the specified assumptions of the distribution of the composite error term. The observed significance of σ^2 confirms to Bamiro (2008), Adepoju (2008) and Binuomote *et al*. (2008). The log of likelihood function was estimated to be 20.72, shows that the values represent the value that maximizes the joint densities in the estimated model. The coefficients of the variables used in the Allocative efficiency model were all found to be significant at one percent while only education level was found to be significant at ten percent among the variables used in the inefficiency model. Also the sigma square and gamma were found to be significant which shows that the model is best fit for the analysis. The average value of allocative efficiency of the farmers was found to be 107% which is more than 100, this looks strange but there has been other works on allocative efficiency of farmers that have similar situation like Benjamin *et al*. (2011).

Table 5

Elasticities and returns to scale of the parameters of SFP function

Variables	**Elasticties**
Bird stocked	0.2354
Feed	0.7306
Drugs and Vaccines	0.0081
Labour	0.0561
Capital input	0.0249
RTS	**1.0551**

Source: Data analysis, 2015

The return to scale estimate (1.0551) on table 5, which indicates that quail production in the study area was in stage one of production curve, stage one is a region of increasing return to scale. This is an inefficient stage because increase in the use of input will lead to more than proportional increase in output.

CONCLUSION AND RECOMMENDATION

With respect to the result of the technical efficiency model the significant nature of the variables; number of bird stocked and quantity of feed used show that an increase in the quantity used will lead to an increase in the level of technical efficiency of the farmers also involvement in other farm enterprise will reduce the level of farmers inefficiency.

The significance of the variables; cost of feed, cost of drugs and vaccine, cost of bird stocked, cost of labour and the price of output shows that the farmers are allocatively efficient. The value of return to scale also show that the farmers are in stage one of the production curve where increase return to scale occur, so an increase in the application of inputs will lead to an increase in output so the farmers are encouraged to increase the use of their input.

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