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Application of Stochastic Production Frontier in the Estimation of Technical Efficiency of Poultry Egg Production in Ogbomoso Metropolis of Oyo State, Nigeria

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Abstract The study analyzed the Technical Efficiency (TE) of poultry egg production in Ogbomoso metropolis of Oyo state, Nigeria from a sample of 60 poultry farmers selected from two Local Government Area in Oyo state. Stochastic parametric technique was used to analyse the technical efficiency of poultry farmers. Estimated technical efficiency of the poultry egg farmers ranged from 18.3% to 92.7% with a mean technical efficiency of 66%. The variation in the level of technical efficiency indicates that more opportunities exist for poultry egg farmers to increase their egg productivity and income through improvements in their technical efficiency. Determinants of technical efficiency of poultry egg farmers were found to be credit accessibility, education level, farming experience, flock size, extension contact and farmers' associations membership, since all these variables were found to be positive and significantly related to technical efficiency.

Keywords: *egg production, technical efficiency, allocative efficiency*

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1. Introduction

One of the challenges of Nigerian agriculture is its ability to feed the ever-increasing population with adequate calorie and protein [1]. The Federal Government of Nigeria (FGN) had tried in the past to offset the huge deficit in animal protein consumption by embarking on massive importation of chilled beef and chickens [2]. For many reasons, this policy was counter-productive; hence, the recent ban on importation of frozen poultry products.

The ban of poultry products by the Federal Government of Nigeria (FGN) has caused a turn-around in poultry which grew by 10.3 percent as compared to 0.3 percent in 2003. This growth was partly due to the ban and also due to the use of veterinary services by lots of farmers [3].

Livestock farming is part of a dynamic development process. Cattle and sheep herds have been reported to grow at a rate slower than the human population growth [4]. Chickens and pigs, raised in intensive farming are becoming more important in developing countries with high annual growth rates [5]. It is now very well known that very rapid increase in poultry products can be achieved in a short time compared to beef production.

However, the need to meet protein requirement from domestic sources demands intensification of production of meat and eggs, derived from prolific animals like poultry birds. Poultry has a shorter life cycle and is much more prolific than large livestock. A part from the fact that poultry production is being conceived to be a technical easy venture and of the available sources of animal protein such as milk, poultry, egg, beef, pork and mutton, poultry egg which is one of the major production of poultry production and one of the most nutritious and complete food known to man [6]. However, in recent years rate and level of performance in the livestock industry has fallen below expectation among other factors to high feed cost arising from fluctuations in feed supplied, rising prices of ingredients, poor feed quality (Adulterated feed) and most importantly inefficiency in production. The net effect of all these are capacity underutilization, curtailment of planned expansion programs and in extreme cases liquidation.

According to [7], Nigeria's poultry production is expanding but is not keeping pace with rapidly increasing domestic consumption requirement.

The domestic supply shortfall is estimated at 25000 metric ton per annum. Despite the supply shortfall, the

government of Nigeria imposed a ban on legal poultry import in July 2002. Given the fact that Nigeria is faced with a great challenges as far as the livestock subsector is concerned, it then becomes imperative to quantitatively measure the current level and determinants of efficiency and policy options available for raising the present level of efficiency given the fact that efficiency of production is directly related to the overall productivity of the agricultural sector, there is a crucial need to raise agricultural productivity, as such growth is the most efficient means of achieving food security and alleviating poverty.

The measurement of farm efficiency is an important area of research both in the developed and developing world [8]. Efficiency is an important factor of productivity growth especially in developing agriculture where resources are meagre. The analysis of efficiency is generally associated with the possibility of farms producing a certain optimal level of output from a given level of resources or certain level of output at least cost. [13,14,15,16], distinguished between at least two types of efficiencies.

Technical efficiency refers to the ability of firms to employ the "best practice" in an industry so that not more than the necessary amount of a given set of inputs is used in producing the "best" level of output [12,17,18,19,20]. Criticisms have been raised about the interpretation of efficiency measures [21,22,23]. To avoid many of these criticisms levied upon efficiency concepts, Ellis (1988) advised that the producers' performance should be estimated only in terms of technical efficiency. This according to him is because measures of technical efficiency rely less heavily on assumptions of perfect knowledge, perfectly competitive markets and the profit maximization objective.

[24] reported that efficiency can be estimated by separately estimating technical and allocative efficiencies from a production frontier using farm survey data. Technical efficiency is defined as the ratio of farmer's actual output to the technically maximum possible output, at given level of resources. Allocative efficiency is expressed as the ratio of the technically maximum output, at the farmer's level of resources to the output obtainable at the optimum level of resources [25].

The major objective of this study is to estimate the technical efficiency of table – egg producers in Ogbomoso metropolis of Oyo State, Nigeria. The specific objectives are to:

(i) Examine the socio economic features of table egg producers in Oyo State,

(ii) Estimate the technical efficiency of table egg producers in Oyo State, and

(iii) Estimate the determinants of technical efficiency of table egg producers in Oyo State.

2. Materials and Methods

The study was carried out in two local government areas in Oyo state. They are Ogbomoso North Local Government and Ogbomoso South Local Government Area with both in Oyo state. The data was collected through random selection of poultry farmers in those 2 local governments which gives the opportunity for 30 poultry farmers from each local government making a total of 60 poultry farmers that were sampled. Data collection was done by means of structured questionnaire using interview schedule for those who could neither read nor write as well as those who were too busy to fill questionnaire themselves while some readily filled theirs. Stochastic frontier production function was used as inferential statistic. The information gathered includes detailed modules on inputs and output in table egg Production. Data were analyzed using Descriptive statistics and Stochastic Production Frontier Model. Descriptive Statistics was used to achieve objective one and they include mean, frequency distribution and percentages. Stochastic production frontier model was used to analyze objectives two and three because it overcomes the limitation of the ordinary least squares (OLS) by providing numerical measures of technical efficiency of individual farmers in a sample.

2.1. The Theoretical Model

A Stochastic Production Function is defined by

$$Yi = F\left(Xi, B\right)exp\ \left(Vi - Ui\right), i = 1, 2 - n \qquad (1)$$

where Yi is output of the ith farm, Xi is the vector of input quantities used by the ith farm, B is a vector of unknown parameters to be estimated, f(.) represents an appropriate function (e.g., Cobb – Douglas, translog, etc). The term Vi is a symmetric error, which accounts for random variations in output due to factors beyond the control of the farmer e.g., weather, disease outbreaks, measurement errors etc, while the term Ui is a non negative random variable representing inefficiency in production relative to the stochastic frontier. The random error Vi is assumed to be independently and identically distributed as N(δ, δi2) random variables independent of the Uis which are assumed to be non – negative truncations of the N(0, δi2) distribution. (i.e., half – normal distribution) or have exponential distribution. The Stochastic Frontier model was independently proposed by [28,29]. The technical efficiency of an individual farmer is defined in terms of the ratio of the observed output to the corresponding frontier output, given the available technology.

$$\begin{aligned} TE &= Yi / Yi* \\ &= f\left(Xi,\ B\right)\ exp\left(Vi - Ui\right) / \ f\left(Xi, B\right)exp\left(Vi\right) \\ &= Exp\left(-Ui\right) \end{aligned} \qquad (2)$$

Where Yi is the observed output and Yi* is the frontier output.

The parameters of the stochastic production frontier function are estimated using the Maximum Likelihood Method (MLE) [28].

2.2. The Empirical Model

For this study, the production technology of egg producers in Oyo State, Nigeria is assumed to be specified by the Cobb – Douglas frontier production function defined as follows;

$$Y = \beta_0 \times X_1^{\beta 1} \times X_2^{\beta 2} \times X_3^{\beta 3} \times X_4^{\beta 4} \times X_5^{\beta 54} \times e^{v}{}_1{}^{-u}{}_1 \quad (3)$$

which, when linearized, becomes:

$$Log\ Y_i = log\ \beta_0 + \beta_1 logX_1 + \beta_2 logX_2 + \beta_3 logX_3 + \beta_4 logX_4 + \beta_5 log\ X_5 + (V_1 - U_1) \quad (4)$$

Whereby β_0 is the intercept; X_1 represents number of birds in numbers; X_2 represents labour (family and hired labour) in man-days; X_3 represents drugs and vaccine in litres; X_4 represents chemicals in litres; X_5 represents feed in kg; u_i represents the specific technical efficiency factor for farm *i*; and v_i represents a random variable for farm *i*. In addition, Ui is assumed in this study to follow a half normal distribution as is done in most applied Frontier production literature. It is expected a priori that the parameters b1, b2, b3, b4, b5, will be Positive because increases in the magnitude of variables x1 to x5 will lead to increases in technical efficiency of the farmers.

2.3. Determinants of Technical Efficiency

In order to determine the contributing factors to the observed technical efficiency, the following model was formulated and estimated jointly with the stochastic frontier model in a single stage maximum likelihood estimation procedure (frontier version 4.1) [30].

$$TEi = a0 + a1Z_1 + a2Z_2 + a3Z_3 + a4\ Z_4 + a5Z_5 + a6Z_6 + a7Z_7 \quad (5)$$

where TEi is the TE of the ith farmer, Z_1 is credit access, a binary variable which takes the value of one if the farmer has access to credit and zero if otherwise, Z_2 is the farmer's age (years), Z_3 is farmer's level of education (years), Z_4 is farmer's farming experience (years), Z_5 is stock size (number of birds), Z_6 is number of extension contacts made by the farmer in the year, and Z_7 is membership of farmers associations/cooperative societies, a dummy variable which takes the value of one for membership and zero if otherwise, while a0, a1,----a7 are parameters to be estimated. It is expected a priori that a1, a3, a4, a5, a6, a7 will be positive, and a2 will be negative.

3. Results and Discussion

3.1. Socio-Economic Features of Poultry Egg Farmer

Table 1. Mean value of selected socio-economic variables for egg production in Ogbomoso metropolis, Oyo state, Nigeria

Flock variable	Mean value
Size	354 layers
Feed	6,120kg
Labour	209 Mondays
Capital	₦2,609.43
Medication	₦703.22
Other variable inputs	₦ 152.61
Credit access	0.41
Age	42 years
Level of education	7.3 years
Farming experience	18 years
Extension contacts	0.36 visits
Membership of Farmers Associations	0.72
Household size	8 persons

The Socio-economic characteristics of the sampled poultry egg farmer in Ogbomoso metropolis of Oyo State are presented in Table 1. On the average, a typical poultry egg farmer has 354 layers, used 6120 kg of feed, 209 man-days of labour, N2609.43 amount of capital, N703.22 amount of medication, and N152.61 amount of other variables inputs per layer. Also, a poultry egg farmer is 42 years old, with 7.3 years of education, 18 years of farming experience, household size of 8 People, credit access of 0.43 and 0.36 extension visits. These results suggest that a typical poultry egg farmers in the study area is a small scale farmer, has poor credit access, is young, literate, highly experienced in egg production, has poor extension contact, and has a large household size. However, the results showed that some of the farmers did not belong to farmers' associations/cooperatives.

3.2. Estimated Stochastic Frontier Production Function

The maximum likelihood estimates for parameters of the Cobb-Douglas production function (equation 3) are shown in Table 2. These parameters represent percentage change in the dependent variable as a result of percentage change in the independent variables, and as such show the relative importance of these variables to egg productivity in Ogbomoso metropolis. Among the poultry farmers, the variables that were significant included drug used (significant at 1%) and chemical used (Significant at 1%), feed used (Significant at 1%). By implication, the above findings revealed that the major productive input that has great impact on the poultry (egg production) output of poultry farmers were the drug, chemical used, feed. Feed had the highest coefficient, with a value 7.121 in the preferred model and by implication the feed used existed as the most important input that has a great impact on poultry output of the poultry farmers. All the variables in the model had positive coefficients, implying that any increase in such variable would lead to an increase in output in the egg production enterprise.

The ratio of the standard error of Ui (δu) to that of Vi (δv) (called lambda (λ) is estimated at 1.638 and it is statistically insignificant at 5% level. Gamma (γ) derived at (λ2/1+λ2) is equal to 0.149. This implies that 14.9% of the total variation in egg output is due to technical inefficiency.

Table 2. Maximum likelihood estimates for egg production in Ogbomoso metropolis, using the Cobb-Douglas frontier production function

Variable	Parameters	Coefficient	T ratio
Constant	β_0	0.437	0.915
Log (Number of birds)	β_1	8.427	0.370
Log (Labour)	β_2	0.162	1.152
Log (Drug)	β_3	3.137	8.011***
Log (Chemical)	β_4	2.631	8.188***
Log (Feed)	β_5	0.265	2.683***
Sigma Squared	σ^2	2.340	2.742
Lamda	λ	1. 638	
Gamma	γ	0.149	
Log Likelihood Function		-1.763	

Notes: *** =1%; ** = 5%; * = 10%

3.3. Technical Efficiency of Poultry Farmers

The frequency distribution of technical efficiency of poultry egg farmer is presented in Table 3. Individual technical efficiency indices range between 18.3% and 92.7% with a mean technical efficiency of 66%. This implies that the level of technical inefficiency of the table egg producers is 38% Seventy percent of the table egg producers had a technical efficiency index of above 50%. The mean technical efficiency of 62% obtained in this study compares favourably with the 66.06% obtained by [12] for poultry egg in Nasarawa State of Nigeria. The level of technical efficiency obtained in this study suggests that opportunities exist for increasing productivity and income through increased efficiency in resource utilization by poultry egg farmer in Oyo State, Nigeria.

Table 3. Frequency distribution of technical efficiency of poultry egg farmer in Oyo State, Nigeria

TECHNICAL EFFICIENCY		
Percentage Range	**Frequency**	**Percentage**
≤ 30	2	3.3
31 – 40	5	8.3
41 – 50	8	13.3
51 – 60	12	20.0
61 – 70	19	31.6
71 – 80	4	6.6
81 – 90	6	10.0
91 – 100	4	6.6
Total	**60**	**100.0**
Mean Technical Efficiency		*66.0%.*
Minimum Technical Efficiency		*18.3%.*
Maximum Technical Efficiency		*92.7%.*

3.4. Determinants of Technical Efficiency

The sources of technical efficiency in poultry egg production are presented in Table 4. Credit accessibility is significant and positively related to technical efficiency. This implies that availability and use of adequate capital shifts the production frontier upwards resulting in higher levels of technical efficiency. Credit is needed to improve production of poultry eggs and hence the positive relationship between credit access and technical efficiency.

Table 4. Estimated determinants of technical efficiency in poultry egg production in Ogbomoso Metropolis of Oyo State, Nigeria

Variable	Parameters	Coefficient	T ratio
Constant	Z_0	0.513	3,107***
Credit Accessibility	Z_1	0.046	2.391**
Age	Z_2	-0.055	-1.443
Educational level	Z_3	0.094	3.176***
Farming Experience	Z_4	0.069	3.042***
Flocks Size	Z_5	0.087	3.185***
Extension Contact	Z_6	0.066	2.415**
Association Membership	Z_7	0.038	2.337**

Notes: *** =1%; ** = 5%; * = 10%

The above result is congruent with those of [31] in Imo State, Nigeria. [32] in Northern Nigeria, [33] in Eastern Paraguay, and [34] in Philippines. This result, however, is at variance with that of [35] who found a negative relationship between credit and technical efficiency in Northern Nigeria. Level of education is positive and significantly related to technical efficiency. Education enhances farmer's ability to derive, decode and evaluate useful information as well as improving labour quality.

The result obtained in this study concur with those of [31,32,36] in Nigeria; [37] in Nepal; [38] in Malaysia; and [39] in Dominica. Farming experience is positive and significantly related to technical efficiency. The more experienced a farmer is the more efficient his decision making processes and the more he will be willing to take risks associated with the practice of improved technologies. This result is consistent with those of [31]; [32] in Nigeria; [40] in India, and [41] in Philippines. However, this result differs from that of Onu, et al. whose result showed a negative relationship between farming experience and technical efficiency in cotton production in Nigeria.

Flock size is positive and significantly related to technical efficiency. Large scale farmers are supposed to be more educated, risk takers, to have greater accessibility to credit and to adopt agricultural technologies more than small scale farmers. This result is in consonance with those of [31,32,41].

However, this result contrasts from those of [37,41] [34,39], which found no significant relationship between farm size and technical efficiency. Membership of farmers' association/cooperative is positive and significantly related to technical efficiency. Members of farmers associations have more access to agricultural information, credit and other production inputs as well as more enhanced ability to adopt innovations, and is consistent with the result of [31] in Ebonyi State, Nigeria and [35] in Northern Nigeria. Extension contact is positively and significantly related to technical efficiency in accordance with the a priori expectation that extension contact leads to more efficient transmission of information to farmers as well enhancing the adoption of innovations. This result concur with those of [31,32,40,41]. However, age shows no significant relationship with technical efficiency.

4. Conclusion and Recommendations

Poultry egg production can play a vital role in the socio-economic development of Oyo State. The technical efficiency of poultry egg farmer range from 18.3% to 92.7% with a mean of 66%, and suggests that there are substantial opportunities to increase productivity and income of table egg producers in Oyo State by increasing the efficiency with which resources are used at the farm level.

Based on the major findings of the study, the following recommendations are made for effective resource and increased local production of egg in Nigeria.

More agricultural extension effort should be devoted to the dissemination of improved technology in egg production to the farmers.

Appropriate technology should be developed from the point of view of users. This will go a long way to improve the level of resource use efficiency among the poultry farmers.

Poultry farmers should organize themselves into cooperatives and this will enable them to purchase modern inputs such electric cages and hire additional labour.

Government should organize formal education imparting programmes for the farmers, this will go a long way in improving their technical knowledge and hence their efficiency.

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