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Technical and Allocative Efficiency of Poultry Egg Producers in Nigeria

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Abstract: This study carried out an analysis of the determinants of efficiency among poultry egg farmers in Jos metropolis of Plateau state, Nigeria. A three stage random sampling technique was used in collecting the data used for this study. The study shows clearly that farm size and cost of drugs are the most important inputs in poultry egg production in the area. About 69% variation in the output of poultry egg production was found to be due to the technical inefficiency of the farmers. Technical efficiency of poultry egg farmers in the study area was found to be high with a mean of 94.2%. Further, analysis reveals that the intensity of output (total production), average price of feed, price of drugs, capital input and cost on utilities are the determinants of allocative efficiency while farming experience and access to credit facilities have significant impact on cost inefficiency. The study recommended the need for stakeholders in poultry egg production to intensify effort in ensuring farmers access to credit and extension services and also sensitize farmers with respect to the right level of input combinations that can improve efficiency level of poultry egg production in Nigeria.

Key words: Technical efficiency, allocative efficiency, poultry egg farmers, Jos, Plateau state, Nigeria

INTRODUCTION

The importance of food in socio-economic development of any economy cannot be over-emphasized. Over the years, a constant threat to human survival has been the apparent difference between the rate of food production and that of growth of human population. There is an increasing evidence of high infant mortality, low resistance to diseases, poor growth and development and mental retardation, etc. that comes as a result of inadequate protein in the diets of most Nigerians (Awosanmi, 1999).

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 larger livestock. A part from the fact that poultry production is being conceived to be a technically 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 products of poultry production and one of the most nutritious and complete food known to man (Orji *et al*., 1981). 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 supplies, rising prices of ingredients, poor feed quality (adulterated feed) and most importantly inefficiency in production. The net effect of all these are capacity under-utilization, curtailment of planned expansion programs and in extreme cases liquidation. According to Ali (2002), Nigeria's poultry production is expanding but is not keeping pace with rapidly increasing domestic consumption requirements.

The domestic supply shortfall is estimated at 25,000 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 challenge as far as the inadequacy of the livestock sub-sector is concerned, it then becomes imperative to quantitatively measure the current level of 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 vis-a-vis the poultry sub-sector. From the foregoing, 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 (Tadessea and Krishnamoorthy, 1997). From the available literature, only few studies have been carried out on technical efficiency of farmers in the African setting. Such studies includes Binuomote *et al*. (2008), Ojo (2003), Adepoju (2008), Adesina and Djato (1997), Ajibefun and Abdulkadri (1999) and Ajibefun *et al*. (2002). Nevertheless, all these focused on Southern Nigeria. It is for this reason that this study seeks to examine the technical efficiency of various poultry egg producers in

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Jos metropolis (North Central Nigeria) in terms of the factors that affect the poultry production and the factors responsible for technical and allocative inefficiencies among the various poultry egg producers. Alabi and Aruna also mentioned that little is known about level of technical efficiency of the Nigerian poultry industry in general. In fact, no study exists on the technical efficiency of poultry farmers in Jos, Plateau state, Nigeria. Odulaja and Kiros (1996) further stressed that despite the fact that a high percentage of the populations in Nigeria are farmers, food demand is still not being met from this source.

This suggests that policy interventions should always be linked to efficiency. There is a need therefore to study the technical and allocative efficiencies of poultry egg farmers because this will serve as a source of guide for investment decisions of farmers and the basis for policy recommendations to the government. Consequently, this study aims at assessing the determinants of efficiency among poultry egg producers in Jos metropolis of Plateau state and seeks to answer the following relevant policy questions:

- Are the poultry farmers in Jos efficient
- What factors influence (technical and allocative) efficiencies of poultry egg farmers in the study area
- What are the constraints facing poultry egg production in the study area

Theoretical framework: Efficiency measures have received considerable attention from both theoretical and applied economists. Leibenstein stated that there had been a spirited exchanger about the relative importance about the various components of firm efficiency. Farrell proposed an approach which distinguished between technical and allocative efficiencies with the former referring to the ability of producing a given level of output with a minimum quantity of inputs and given technology. The latter refers to the choice of the optional input proportion given relative prices. Economic or total efficiency is the product of technical and allocative efficiencies. Farrel's model which is known as a deterministic non-parametric frontier (Forsund *et al*., 1980) attributed any deviation from the frontier, inefficiency and imposes no functional form on the data.

MATERIALS AND METHODS

Study area: The study area for this research is Jos metropolis of Plateau state, Nigeria, formerly Bauchi Plateau. It is located at 9°56'N 8°53'E Central Nigeria, distinguished by its high bounding scarp and by bare grassland and embracing Africa's chief tin-mining region. Its central area covers about 3,000 miles^2 (8,000 km^2) and has an average elevation of 4,200 feet (1,280 m); the surrounding high plains often exceed 3,200 feet. The adjoining highland area on the east is occasionally designated the Bauchi Plateau.

The population of Jos, Nigeria is 816,824 according to the geographical database. As staple food, the people grow crops like Maize (corn), Guinea corn, Irish potato, Cassava, Yams, Acha (sometimes referred to as hungry rice, a kind of mustard seed crop). With the nature of the weather, a lot of vegetables and fruits are grown. The major activities in Jos are mining, civil service, industrial and commercial activities.

Sampling procedure and sample size: A three-stage sampling technique was adopted. The 1st stage included a selection of two local government areas in Jos metropolis, Jos North and Jos South, chosen based on preponderance of poultry farmers as contained in the information from the Poultry Association of Nigeria (PAN), Plateau state chapter. These local government areas have the highest percentage share of poultry farmers in the state.

The 2nd stage involves a random selection of five wards in each of the two selected local government areas of the state. These wards were Jenta-Adamu, Jos-Jarawa, Naraguta A, B and Tudun-Wada from Jos North local government area while Bukuru, Du, Gyel, Shen and Zawan were selected from Jos South local government area. The 3rd stage involved a random selection of eleven poultry egg farmers from each of the selected wards making a sample size of 110 respondents. The data used for this study are cross-sectional data obtained by the use of structured questionnaires through interview scheduled. The questionnaires were administered to poultry egg farmers. The questionnaire was designed to elicit information on the socio-economic characteristics of the respondents and also on the operational system adopted.

Analytical procedure: The analytical tool for this research is simply, the use of descriptive statistics for the socio-economic characteristics and stochastic frontier function for the estimation of efficiency and factors influencing poultry egg production and cost. Among the descriptive statistics used are frequency counts, percentages, mode and mean in measuring the socio-economic characteristics and the farm information data of the respondents together with some other variables. The stochastic frontier production and cost function was used to determine the factors influencing poultry egg production using the Maximum Likelihood Estimation

(MLE) method together with the farm efficiency and the sources of inefficiency given the farm sizes and input ratios.

Model specification: The parameters of the stochastic production and cost function were estimated by the method of maximum likelihood using the computer programme frontier Version 4.1 (Coelli and Battese, 1996). This method considers frontier production as a parametric function of the input.

It starts from a particular function like Cobb-douglas, CES, translog amongst other analytical techniques. The model follows cost-decomposition procedure of estimating technical, allocative and economic efficiencies. Following, Adepoju (2008) and Amos (2006), the functional form used in this study is the Cobb-douglas. The previous research on frontier approach dates back to Farrell which implies that efficient farms are those operating on the production frontier while the inefficient farms are those operating below the production frontier. The production function is represented as in Eq. 1:

$$Y_i = F(Xi, \beta) + Vi - Ui \quad (1)$$

Where:

Y_i = Output of the ith farm

X_i = Vector of inputs

β = Vector of parameters to be estimated

V_i = The symmetrical disturbance which captures the random error effects on output. It is assumed to account for measurement error and other factors not under the control of the farmer. Also, it is assumed to be independently and identically distributed as $N(0, S^2_V)$

U_i = The asymmetrical error component. It captures the inefficiency of the farm and is assumed to be non-negative truncations of $N(O, S^2_V)$ distribution (i.e., half-normal distribution)

Therefore, $V_i - U_i = C_i$ which is used in deterministic frontier but stochastic frontier was used in this study because it shows the efficiency and inefficiency levels explained by Farrell. Consequently, the Cobb-douglas function used for this study is specified by Eq. 2 as:

$$Y_i = A\prod_{i=1}^{N} X_i^{\beta i} e^{-Ui+V} \quad (2)$$

Where, A and βi are unobservable parameters including the efficiency parameter and the output elasticity coefficients, respectively. The estimating Eq. 3 becomes:

$$LnY_i = LnA + \sum_{i=1}^{n} LnX_i + e \quad (3)$$

Where, $e_i = V_i - U_i$ and Ln e = 1. Hence, Eq. 4 and 5:

$$LnY_i = LnA + \sum_{i=1}^{n} \beta i LnX_i + (Vi - Ui) \quad (4)$$

$$LnY_i = LnA + \beta_1 LnX_1 + \beta_2 LnX_2 + \ldots\ldots + \beta_4 LnX_4 + (Vi - Ui) \quad (5)$$

The MLE has however been found to be asymmetrically more efficient than the corrected OLS estimators (Coelli and Battese, 1996). Therefore, Maximum Likelihood Estimator (MLE) provides estimation for γ, λ and σ. Where Eq. 6-8:

$$\lambda = \frac{\sigma u}{\sigma v} \quad (6)$$

$$\sigma = \sigma^2 u + \sigma^2 v \quad (7)$$

$$\gamma = \frac{\lambda^2}{1+\lambda^2} \quad (8)$$

Measurement of variables: The variables used in determining the factors influencing technical efficiency are in two ways and are in line with study by Adepoju (2008) and Amos (2006):

Dependent variables:

- Yi is the output which represents the total number of eggs

Independent variables:

- X_1 = Farm size (number of birds)
- X_2 = Labour input (Man days)
- X_3 = Total feed intake (kg)
- X_4 = Cost of drug and medication (₦)

Also, the estimated stochastic cost function is explicitly specified as:

$$LnC_i = \beta_0 + \Sigma\beta_i \ln P_{ij} + \Sigma\beta_i \ln Q_i + V + U$$

Where:

C_i = Total input cost for the ith farm

P_{ij} = Unit price for input (j = 1, 2…, 6)

P_{i1} = Unit price of birds (₦)

P_{i2} = Wage rate (₦)

P_{i3} = Average price per kilgram of feed (₦)

P_{i4} = Average price per liter of drug (₦)

P_{i5} = Capital input (₦)

P_{i6} = Utilities and other expenses (made up of electricity, water supply, kerosene charcoal and transportation (₦)

Some farmers' characteristics were incorporated into the frontier functions as it is believed that they have direct influence on efficiency. The inefficiency function is specified as:

$$R = b_0+b_1Z_1+b_2Z_2+b_3Z_3+b_4Z_4+b_5Z_5+b_6Z_6+e$$

Where:
R = Inefficiency
Z_1 = Years of experience
Z_2 = Educational level
Z_3 = Marital status
Z_4 = Access to extension service
Z_5 = Access to credit
Z_6 = Sex

A priori expectations

Farm size: The output of a poultry farm is partly dependent on the number of birds in the farm (Yusuf and Malomo, 2007). According to Ukoha and Augustine, farm size should have a positive and significant impact on technical efficiency in poultry production.

Labour: Family and hire labour plays an important role in agricultural production especially in developing economies where capital is less (Yusuf and Malomo, 2007). Hence, the a priori expectation is that yield should increase with optimum labour used. However, Ukoha and Augustine reported a negative but significant value for the effect of labour on poultry production.

Feed intake: The relative importance of feed in poultry production cannot be over-emphasized. Increase in poultry production can be more experienced by increasing the feed (quality and quantity) than by increase in any other factors that influence poultry. Thus, the coefficient of feed intake should be positive and significant.

Cost on drugs and medication: Literature reviews on cost of drugs on efficiency have given mixed results. Binuomote *et al.* (2008) reported a positive and insignificant coefficient for cost of drugs in his technical efficiency study for poultry egg farmers in Oyo state while Ukoha and Augustine reported a positive and significant impact of cost of drugs on poultry production.

Farming experience: Farming experience could have negative or positive effect on the efficiency of the farmer quoted in Yusuf and Malomo (2007) reported a positive relationship between farming experience and the efficiency of farmers in Pakistan and Ethiopia, respectively. Coelli and Battese (1996) reported negative production elasticity with respect to farming experience for farmers in two villages in India.

Gender: This variable could have either a negative or positive influence as the case may be Ajani reported a negative coefficient for gender in her normalized profit function analysis for maize and yam enterprises while Awoyemi in his gender analysis of economic efficiency reported a positive coefficient in cassava-based farm holdings.

Education: Studies have shown that farmers with formal education have greater ability to adopt new technology and innovation. This is expected to have a positive influence on their level of efficiency. Coelli and Battese (1996) have confirmed the positive influence of education on farmers' production efficiency.

Extension contact: This is expected to have a positive and significant impact on efficiency.

Access to credit: This is expected to have a positive and significant impact on efficiency.

Marital status: Ukoha and Augustine reported a positive but insignificant value for the effect of marital status on efficiency on of small-scale poultry egg production in Nigeria.

RESULTS AND DISCUSSION

The mean, standard deviation, minimum and maximum level of total product and inputs are shown in Table 1. Findings reveal that on average each farmer had a farm size of 1714 birds used an average of 4560.46 kg of feed and produced about 600,806 eggs (2002 crates).

Determinants of the factors influencing poultry egg production: Table 2 shows the estimated coefficient of the production frontier and their corresponding levels of statistical significance. All the variables were significant.

Table 1: Basic statistics of poultry egg production in the study area

Output/input variables	Minimum	Maximum	Mean±SD
Total production (Y)	22265	14236500	600806±1351207
Farm size X_1	100	5500	1714±1570
Total labour input (manday) X_2	33	11355	2083±15145
Total feed intake (kg), X_3	100	10000	4560.46±2173
Drugs and medication (₦), X_4	6100	682500	183536±190705

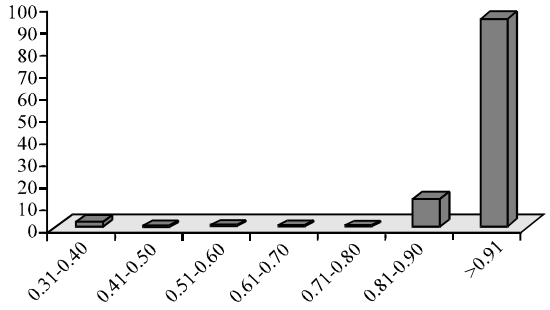

Fig. 1: Chart showing the frequency distribution of the technical efficiency estimates of poultry egg farmers

The Σ^2 of 0.04052 and γ of 0.68818 were significant at 1% level. The significant value of the Σ^2 shows the presence of inefficiency effects in poultry egg production in the area while the significant γ of 0.68818 indicates that about 69% variation in the output of the poultry egg production would be attributed to technical inefficiency effects alone while only 31% would be due to random effects (Fig. 1). The analysis of the inefficiency model shows that the signs of the estimated coefficients in the inefficiency model have important implications on the TE of the poultry farmers.

The variables that have a positive and significant coefficient include farm size (number of birds) and total cost of drugs all at 1% level of significance. The positive and significant sign of the coefficients are in line with the findings of Binuomote *et al.* (2008). The positive coefficient of total farm size and total quantity of drugs used with respect to poultry farming implies that the higher the farm size and consequently amount spent on drugs, the higher the total level of poultry production. The total labour and quantity of feed are negatively correlated with the total output of poultry production, this may be as a result of farmer employing the allocation of these resources above optimal level.

Production elasticities: Production elasticities indicate the percentage change in output relative to a percentage change in input if other factors are held constant. From the nature of the Cobb-douglas production function fitted, the regression coefficient which is also known to be the estimated parameters of each variable in Table 2 is the elasticity of production of the variables. Table 3 shows the elasticities of production with respect to the explanatory variables. From the result, the elasticity of farm size is 0.90312 meaning that 10% change in the total farm size will bring about 9.03% change in the output of poultry if other factors are held constant. Labour has an elasticity of -0.07345 meaning that for 100% change in labour input; output of poultry will change by -7.345%. The same goes for feed input with an elasticity of -0.01458 meaning that a 10% change in feed input will bring about a <1% (-1.458%) change in the output of poultry production in the study area. The cost of drugs has an elasticity of 0.2851 meaning that a 10% change in the amount spent on drugs will bring about 2.851% change in output of poultry with other factors held constant.

Table 2: Maximum likelihood estimate of the frontier function coefficients

Charactaristics	Estimated parameters	SE	t-statistics
β_0	2.01645	0.05561	36.26201***
β_1	0.90312	0.03323	27.17930***
β_2	-0.07345	0.02694	-2.72666***
β_3	-0.01459	0.02592	-5.62900***
β_4	0.28510	0.01707	16.69920***
Σ^2	0.04052	0.00406	9.98045***
γ	0.68818	0.03962	17.36838***

Log-likelihood function = 142.29; ***significant at 1%

Table 3: Elasticities of production

Input variables	Elasticity
Farm size X_1	0.90312
Labour input X_2	-0.07345
Feed input X_3	-0.01459
Cost of drugs (₦) X_4	0.28510

The estimated elasticities of the explanatory variables shows that the farm size and cost of drugs are increasing factors to the function indicating that the variables were in the stage of economic relevance of the production function. The elasticity of labour and feed used were all negative decreasing functions to the factor indicating possible excessive use of these inputs which may be a result of allocation of these economic factors above optimum level on the farm. Table 4 shows the frequency distribution of the technical efficiency estimates of the poultry egg farmers. The predicted farm specific Technical Efficiencies (TE) have a mean of 0.942. Thus in the short run, there is a scope for increasing poultry egg production by about 5.8% by adopting the technology and techniques used by the best-practiced poultry egg farms. One of such measures is addressing, the issue of negative elasticity of labour and feed.

The deciles range of the frequency distribution of the TE is shown in Table 4. It shows that about 86.4% of the farmers had TE exceeding 0.901 about 13.8% had TE ranging from 0.374-0.900.

Determination of technical inefficiency in poultry egg production: From Table 5, all the coefficients were negative indicating that these factors led to decrease in technical inefficiency or increase in technical efficiency. This agrees with the a priori expectation that TE should increase with increase in farming experience, access to extension services and credit since, access to extension services and experience is expected to be positively

Table 4: Frequency distributions of technical efficiency estimates

Efficiency level	Frequency	Percent
0.31-0.40	2	1.8
0.41-0.50	0	00.0
0.51-0.60	0	00.0
0.61-0.70	0	00.0
0.71-0.80	0	0.0
0.81-0.90	13	11.8
>0.91	95	86.4
Total	110	100.0

Mean efficiency = 0.942

Table 5: Estimates of the technical inefficiency of poultry egg production

Variables	Coefficient	SE	t-statistics
Constant	0.84860	0.16125	5.26256***
Farming experience	-0.06344	0.02007	-3.16124***
Educational level	-0.09438	0.03612	-2.62064***
Marital status	-0.39737	0.09688	-4.10185***
Access to extension services	-0.44447	0.10213	-4.35518***
Access to credit	-0.28814	0.14047	-2.05128**
Sex	-0.27005	0.06032	-4.47692***

***Significant at 1%; **significant at 5%

correlated with adoption of improved technology and techniques of production (Yusuf and Malomo, 2007).

Maximum Likelihood Estimate (MLE) values for stochastic frontier cost function: The cost function maximum likelihood estimates in Table 6 shows the relative importance of the variable inputs in the allocative efficiency of the farmers. The coefficients of the variables are interpreted as the elasticities of the variables. From the result, capital input, cost on utilities and total production were significant at 1% and were also positively correlated with the allocative efficiency of the farmers. On the other hand, cost of drugs and feed price were also positively correlated with the cost efficiency of the farmers but were significant at 5%. While the price of birds and wage rate are negatively correlated with the allocative efficiency and were not statistically significant.

This implies that the price of birds and wage rate are decreasing factors to the farmers allocative efficiency hence, farmers in the study area need to be more prudent in the allocation of resources in the purchase of birds and wages paid to hired labour. Also from the result, price of feed has a positive coefficient of 0.07973, this means that a 100% change in this variable will bring about 7.973% change in the allocative efficiency of the farmers. For drugs, capital input, utilities and total production with positive coefficients of 0.02462, 0.12436, 0.33227 and 0.48480, respectively, this means that a 100% change in each of these variables while other things are held constant will bring about 2.462, 12.436, 33.227 and 48.480% change, respectively in the allocative efficiency of the farmers, respectively.

Inefficiency function: The parameter estimates of the relationship between cost inefficiency and the socioeconomic characteristics of respondents are shown under the inefficiency function section of Table 6. This section explains the relationship between farmer specific factors and their effects on cost inefficiency. The significant value of gamma shows the presence of inefficiency effect in the allocative efficiency of the farmers and its value of 0.27480 indicates that about 27% of the variation in the cost efficiency of the farmers is due to inefficiency.

Table 6: Maximum Likelihood Estimate (MLE) of the frontier cost function coefficients

Variables	Parameters	Coefficient	t-ratio
Constant	1.11626	0.30197	3.696600***
Price of birds (₦)	-0.17905	0.15091	-1.186420
Wage rate (₦)	-0.01263	0.02133	-0.591970
Average price per kilogram of feed (₦)	0.07973	0.03456	2.307020**
Average price per liter of drug	0.02462	0.01108	2.223160**
Capital input	0.12436	0.04260	2.919020***
Utilities	0.33227	0.06420	5.175810***
Output	0.48480	0.05715	8.482900***
Inefficiency function			
Intercept	0.26628	0.05824	4.572170***
Farming experience (years)	-0.01176	0.00435	-2.70352***
Educational level	-0.01015	0.00452	-2.243990**
Marital status	-0.17357	0.03873	-4.482030***
Accessto extension service	-0.09443	0.05318	-1.776370
Accessto credit	-0.20499	0.05356	-3.827150***
Sex	-0.07626	0.04516	-1.688700
Diagnosis statistics			
Σ^2	0.00779	0.00085	9.216300***
γ	0.27480	0.05003	5.493800***

Log likelihood function = 125.31;***significantat 1%; **significantat 5%; *significantat 10%

Farming experience, marital status and access to credit were significant at 1%; educational level was significant at 5% while access to extension service and sex were not statistically significant. The result shows that farming experience and access to credit facilities have significant impact on cost inefficiency. The negative value and significant coefficient of farming experience and access to credit facilities indicates that increase in years of experience and access to credit facilities reduces cost inefficiency.

Thus, a negative sign of the parameters in the inefficiency function means that the associated variable has a positive effect on the economic efficiency and vice versa.

CONCLUSION

Arising from the findings of this study, it is founded that poultry egg farmers in Jos metropolis are technically efficient in the use of most of the inputs. Changing the input combinations can therefore increase the farm level efficiency. The farmers in the study area therefore need to use their available input intensively and rationally so as to produce better output and be technically and cost

efficient. Access to credit facilities and formal education has also been established to be veritable tool in ensuring that farmers are allocatively efficient.

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