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ANALYSIS OF TECHNICAL EFFICIENCY OF POULTRY EGG PRODUCTION IN AGRICULTURAL ZONE C, KOGI STATE, NIGERIA: PARAMETRIC APPROACH

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ABSTRACT

This research was on the analysis of technical efficiency of poultry egg production in agricultural zone C of Kogi State, Nigeria. Multistage sampling procedure was used to select 90 poultry egg producers in the study area through the use of structured questionnaires and interview schedule. Data were analyzed using stochastic frontier production model. The technical efficiency analysis showed that stock size(X_1) and drugs and medication(X_5) were positively significant at 1% and 5%, respectively while utility(X_6) was negatively significant at 5%. The findings of the inefficiency factors showed that household size (Z_4), and cooperative society (Z_6) were significant at 5% and 1%, respectively. The value of the sigma squared (δ^2) was 0.208 while gamma (γ) was 0.7853 and were both statistically significant at 1% level, respectively. The mean efficiency score of 0.823 showed that the farmers were not operating at the optimum level that is, they were not technically efficient as none of the farmers operated at the efficiency score of 1. Based on the findings of this research, it is recommended that solar power as an alternative power source should be introduced and installed for farmers at affordable rate by State government to reduce the operating cost of the farm.

KEYWORDS: Efficiency, poultry, parametric, production

INTRODUCTION

Agriculture is a key to economic development of Nigeria because of its role in the production of food, provision of raw materials for industries, as source of foreign exchange earnings and, provision of employment for over 65% of the population in Nigeria (Ajibefun *et al.,* 1996). Moreover, agriculture is also paramount in meeting the daily protein needs of an average Nigerian through the rearing of poultry for its meat and or, for its egg.

Poultry, usually refers to as domesticated birds which are nutritionally and economically useful to man, is a sub-sector of livestock

industry. It includes turkey, guinea fowl, ducks, pigeon, geese and chicken. Among these birds, rearing of chicken as broilers for meat or, as layers for egg is the most common in Nigeria livestock industry because they are a good converter of feed (Food and Agriculture Organization (FAO), 2005). Animal protein, especially egg and meat, is the most essential aspect of human nutrition because of the presence of amino acids as its major nutritional component. These include lysine, threonine, the sulphur-bearing amino acids (methionine and cysteine) and occasionally tryptophan. Eggs are also high in lutein which lowers the risk of cataracts and macular degeneration (FAO, 2013). Infact, apart from rice with net protein utilization (NPU) of 60, NPU of grains is generally less than 40, whereas NPU of chicken eggs is as high as 87 (FAO, 2013). Furthermore, an egg of average size (60g) contains an approximate value of 7 grams of protein such that two eggs contain as much protein as 100grams of meat. Egg is also rich in energy, lipid, vitamins especially A, D and E. Some trace element such as zinc and iron are also contained in egg (European Food Information Council (EFIC), 2015). Aside providing nutrition values, egg is also useful in the manufacturing of vaccines against infectious diseases and also useful in confectionery, bakery, ice cream, and cosmetics industries (Chukwuji *et al.* 2006, Tijani, Alimi, and Adesiyan (2006) and Nmadu *et al.,* 2014).

Despite the significance of protein in ensuring balanced diet for an average Nigerian, many Nigerians still suffer from protein deficiency causing retardation in the building and repair of their body tissues, inability of the body cells to replace the worn out tissues, lack of immunity against infectious diseases and prevalence of kwashiorkor among young people thereby leading to retarded growth and in severe cases, death. This is in consonance with the report of Tijjani *et al.* (2012) and FAO (1998) who reported that the current average level of animal protein consumption in Nigeria was 15g/head/day, which is grossly below the FAO recommended level of 35g/head/day. Therefore, there is the need for research focus on how production of eggs can be increased to meet the protein needs of ever increasing population as well as ensure that resources are combined optimally to ensure minimal wastage and maximum output. This can be achieved by examining the level of efficiency in the production process.

Efficiency measure is a very important concept in agricultural sector of the economy. It measures the relative performance of the processes used in transforming inputs into output given the best production techn ology available. Technically, it exami

nes how output could be maximized w ith a given set of inputs while ensuring minimum wastages in the use of these resources. Technical efficiency (TE) involves a comparison between the operational and optimal level of farmers in terms of the values of their output and inputs. This will assist in determining the extent to which the existing use of these resources deviates from the optimal-use level. Hence, appropriate recommendations could be made in terms of the means and methods adoptable in moving from the existing levels to the optimum-use of their resources so as to bridge the gap between demand and supply of poultry eggs and, ensure the sustainability of poultry egg production in the study area. It is against this backdrop that the research paper attempted to answer the question of how technically efficient are the farmers in the area.

METHODOLOGY

The study was carried out in Kogi State. It is one of the 36 states of the Federal Republic of Nigeria which is located in the central region of Nigeria. It has a total land mass of 3426km^2 with a total population of 722023 people according to the 2006 national census (Sunday, 2014). Agricultural Zone "C" of Kogi occupies a hilly sketch of guinea savannah grassland, The Zone shares common boundaries with the Yoruba speaking people of Owe, Akoko, Ijumu and Oworo; to the south - west. It is bounded by Ososo and other Akoko-Edo settlements; the Hausas, Nupes, and Ebiras are bounded to the north and river Niger to the east while the Igala and Bassa-nge settlements are fond across the river (Salami, 2011). The study area consists of five Local Government Areas (LGAs), namely Okene, Adavi, Okehi, Ajiakuta and Ogori-Magongo. The predominant ethnic group in the study area is Ebira while the minority group is Ogori-Magongo. The predominant occupations of the people are farming and cloth weaving while the major crop grown in the study area include yam, cassava, guinea corn, rice, cowpea and groundnut while the major livestock includes goat, ship, pig, poultry and dogs (Akomodi, 2006).

Sampling Procedure: A multistage sampling technique was used to select the poultry farmers in the study area. The State has four agricultural zones, namely, A, B, C and D. The first stage involved the random selection of three wards from Agricultural Zone "C" of the State while the second stage involved the random selection of four cells from each of the wards. The third stage involved the selection of 7 farmers from each cell making a total of 90 selected poultry farmers in the area.

Method of Data Collection: Primary data were collected for a one production season and relevant information was elicited from the farmers through the use of structured questionnaires. Data collected included farm size, labor input, capital input, feed cost, medication, stock capacity, utility, output and price.

Analytical Techniques: The technical efficiency of poultry egg production was achieved using the Stochastic Frontier Model. The stochastic frontier production function was developed by Farrel 1957 and has been used in previous studies (Oladeebo and Fajuyigbe, 2007; Ogundari, 2008; Binuomote, *et al.,* 2008; Ojo, 2013) to analyze the technical, allocative and economic efficiencies of farmers for different crops and livestock in Nigeria.

The general form of the model is expressed as:

$$Q_1 = \beta_0 + \beta_1 X_1 + (V_I - U_I) \ldots \quad (9)$$

Where

Q_i is the production (the logarithm of the production) of the *ith* firm;

X_i is a vector of (transformations of the) input quantities of the *ith* firm;

β is a vector of unknown parameters;

V_i are random variables which are assumed to be iid $(N, \delta^2 v)$, independent of U_i, identical and normally distributed with zero mean and constant variance that captures the stochastic effects outside the farmer's control, measurement control and other statistical noise while U_i are non-negative random variables which are assumed to account for technical inefficiency in production (*i.e* U_i measures the shortfall in output Q from its maximum value) and are often assumed to be iid $(0, \delta^2 u)$. The inefficiency of production, U_i was modeled in terms of the factors that are assumed to affect the efficiency of production of the farmers. Such factors are related to socio-economic variables of the farmers. Given functional and distributional assumptions, the value of unknown coefficients in equations (9) was obtained jointly using the maximum likelihood method (MLE). An estimated value of technical efficiency for each observation was calculated as:

$$TE_I = \exp(-U_i). \quad \ldots\ldots\ldots\ldots\ldots\ldots (10)$$

The Cobb-Douglas frontier model is assumed to describe the production function of the farmers on which data was obtained. The model in which the determinants of efficiency are incorporated was estimated simultaneously with the Cobb-Douglas stochastic frontier model. The model is represented as:

$$\ln Y_i = \beta_0 + \sum \beta_j Ln X_{ij} + (V_i - U_i)$$

.....(11)

Where
ln = Natural logarithm;
i = ith sampled smallholder farm;
Y_{ij} = Vector of Output of poultry egg (measured in physical output as the No of crates of eggs)
X_{ijs} = Vector of inputs.
The X_{ijs} are specified as:
X_1= Stock size (No of birds)
X_2= Labour used in poultry production (Man-day)
X_3= Capital input (depreciation)
X_4= Feed (kg)
X_5= Drugs and medication (₦)
X_6= Utilities (electricity, water etc) (₦)
β_j = Input coefficients for the resources used in production;
U_i = Farmer specific characteristics related to production efficiency;
Vi = Statistical disturbance term
Technical inefficiency model in addition to the general model, is defined to estimate the influence of some farmer's socio-economic variables on the technical and allocative efficiencies of the farmers.
The explicit form of the Cobb-Douglas functional form is written thus:

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + V_i - U_i \quad \ldots\ldots (12)$$

Where Y, X_1, X_2, X_3, X_4, $X_5$and X_6 are as defined earlier. The V_i's are assumed to be independent and identically distributed (iid) normal random errors having zero mean and unknown variance. U_i's are non-negative random variables called technical efficiency of production of the respondent farmers which are assumed to be independent of the Vi's such that U_i's are the non-negative truncation (at zero) at the normal distribution with mean μ and variance σ^2

$$\mu = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_{5i} + \delta_6 Z_{6i} + \delta_7 Z_{7i} + \delta_8 Z_{8i} + \delta_9 Z_{9i} + \delta_{10} Z_{10i}$$

.... (13)
Where:
Z_1 = Farmer's sex (1, if male; 0, if female)
Z_2 = Years of experience
Z_3 = Level of involvement in poultry farming (0, if part-time; 1, if full-time)
Z_4 = Household size (No. of people available for farm work)
Z_5 = Education (Years)
Z_6 = Membership of cooperative society (1 if respondent is a member; 0 otherwise)
Z_7 = Age (Year)
Z_8 = Extension contact (1, if extension contact; 0 if not)
Z_9 = Credit usage (1, if credit is taken for farming; 0, if not)
δs= unknown scalar parameters to be estimated
∂'s, β's and γ coefficients are unknown parameters to be estimated along with the various parameters which are expressed in terms of $\delta s^2 = \delta v^2 + \delta u^2$; γ (gamma) = $\delta u^2 / \delta s^2$
Where
The γ - parameter has value between zero and one, ($0 \leq \gamma < 1$).

RESULTS AND DISCUSSIONS

Determinants of Technical Efficiency among Poultry Egg Producers in the Study Area: The summary statistics of the variables for the stochastic frontier model for poultry egg production was as presented in Table 1. They include the sample mean and the standard deviation for each of the variables. The larger size of the standard deviation confirmed that most of the farmers operated at different scales of operation. Analysis of the inputs also revealed an average stock size of 3,456.67 birds, the average labour/manday was 328.11 which implied that the farmers depended on families and hired labour or both for their farming operations The average capital input (depreciation), feed, drugs and medication, utilities (electricity and water) were ₦28,932.97, 4,483.22kg, ₦7,154.4 and 12,011.00, respectively, which further confirmed that the most of the farmers operated at medium scale of operation. However for Nigeria to be self-sufficient in poultry egg production, farmers need to expand their stock size.

Table 1: The summary statistics of the variables for the stochastic frontier model for poultry egg production

Variables	Mean	Standard deviation	Minimum	Maximum
Stock size (No)	3456	7,948	200	42,000
Labour (Man day)	328.11	961	456	22,204
Capital input (₦)	28932.97	43761.19	1150	232650
Feed (kg)	4,483.22	10,384.31	136	56,546
Drugs and Medication (₦)	7,154.44	5,377.19	300	40,800
Utility (₦)	124011.00	287971.4	8247	1524872

Source: Field Survey, 2015

Maximum likelihood estimates of the Cobb-Douglas frontier function for the poultry farmers: The maximum likelihood estimates (MLE) for the stochastic production (Table 2) was used to determine the determinants of technical efficiency of poultry egg production in the area as well as the effect of farmer specific characteristics on technical inefficiency of production. The parameters were estimated simultaneously using frontier 4.1c developed by Coelli (1996). The result showed that the coefficient of stock size (X_1) was statistically significant at $P < 0.01$ while drugs and medications (X_5) and, utility (X_6) were statistically

significant at $p < 0.05$, respectively. This showed that a percentage increase in these variables will lead to percentage increase in the crate of eggs produced. That is, 1% increment in the stock size and, drug and medication, will translate into 1.260% and 0.196% increment in the crates of eggs, respectively, while for utility (electricity & water), percentage increase in this variable will lead to percentage decrease in the crate of eggs produced. This might result from epileptic power and water supply by the government. The farmers may have resulted into alternative sources of power (use of generators) and water (Boreholes/wells) which are expensive to maintain.

The estimated coefficient of the inefficiency function provides some explanation for the relative efficiency levels among individual farms. Since the dependent variables of the inefficiency function represent the mode of inefficiency, a positive sign of an estimated parameter implies that the associated variable has a negative effect on efficiency while a negative sign indicates the reverse. Hence, household size ($P < 0.05$) which had negative coefficient implied that the farmers with high number of household size were more technically efficient than those who were otherwise. Therefore, these variables reduced the technical inefficiency of the farmers. However, the positive coefficients of membership of cooperative society ($P < 0.01$) showed that farmers' level of technical efficiency decreased with increase in cooperative membership. This may occur when a farmer (though a member of cooperative) could not access a substantial loan that could aid the farmer's business expansion as a result of low membership and hence, low capital base of the cooperative society. The accumulated interest on loan (in case of default) may also cause the farmers to lose some of the assets required to boost his farm operations to the society in order to settle his bill.

The value of sigma squared (δ^2) was 0.208 and was statistically significant at 1% level. This indicates a good fit and the correctness of the specified distributed assumption of the composite error term. It was also an indication that 20.8% of the observed variation in the output of poultry egg production in the study area was explained by the included explanatory variables. The variance ratio gamma was 0.557 and that was statistically significant at 1% level, was an indication that 55% of the observed variation in the output of poultry egg production in the study area was due to their technical inefficiencies which was explained by the included explanatory variables. This study is in conformity with the study conducted

Table 2: Maximum likelihood estimates of the Cobb-Douglas frontier function for poultry farmers in the study area.

Variables	Parameters	Coefficient	Standard error	T-ratio
Constant	β_0	10.905	1.085	10.053***
Stock size (x_1)	β_1	1.260	0.260	4.839***
Labour(x_2)	β_2	-0.139	0.120	-1.161
Capital (x_3)	β_3	0.088	0.074	1.202
Feeding (x_4)	β_4	-0.033	0.168	-0.198
Drugs and medication (x_5)	β_5	0.196	0.081	2.413**
Utility(electricity & water) (x6)	β_6	-0.429	0.186	-2.230**
Inefficiency model				
Constant	δ_0	0.083	1.121	0.074
Farmer's sex (z_1)	δ_1	-0.503	0.415	-1.210
Years of experience (z_2)	δ_2	0.012	0.026	0.462
Level of involvement (z_3)	δ_3	0.130	0.568	0.229
Household size (z_4)	δ_4	-0.198	0.078	-2.537**
Education (z_5)	δ_5	0.076	0.070	1.082
Membership of cooperative society (z_6)	δ_6	1.074	0.375	2.859***
Age (z_7)	δ_7	-0.024	0.023	-1.067
Extension contact (z_8)	δ_8	0.241	0.451	0.534
Credit usage (z_9)	δ_9	-0.369	0.423	-0.873
Variance parameter				
Sigma square	δ^2	0.208	0.072	2.870***
Gamma	γ	0.557	0.174	3.199***
Log likelihood function		–24.173		
L R test		28.701		

Source: computer output from frontier analysis

*** Significant at 1% level, ** significant at 5% and * significant at 10% level.

by Ohajianya *et al.,* (2013) in Imo State, Nigeria who reported that feeds, flock size, labour, drugs and medication, capital, management, and other inputs were all significant factors affecting the output of the farmers in the area but at variance with the study conducted by Alabi and Aruna (2006) who reported that expenses on feed, medicine/vaccine and capital were the main determinants of family poultry output in Niger-delta, Nigeria with a mean efficiency of 22%.

Technical Efficiency Indices of the Farmers: The technical efficiency indices were derived from the MLE results of the stochastic production function. The result of technical

efficiency indices was as indicated in Table 3. The highest efficiency class index was between 0.91 and 1.00 of 55.6% while the minimum index was between 0.21 and 3.00 (2.2%). Only 11% operated between 0.01 and 0.50 while 89% of the farmers operated between 0.51 and 1.00 with particular reference to class index of 0.91 and 1.00 of 55.6%. According to Yusuf and Malomo (2007), this high degree of technical efficiency suggests that very little marketable output was sacrificed to resource waste (i.e. only a small fraction of the output was attributed to resource wastage). This implied that the farmers utilized their resources proficiently. The overall mean efficiency class index of 0.823 (82%) indicated that on the average, the farmers were 82% efficient in the use of combination of their inputs. This implied that an average poultry egg farmer observed output was 0.18 less than the maximum output which can be achieved from the existing level of inputs. Hence, in the short run, there is an opportunity for improvement of the present level of efficiency of the poultry egg farmers by about 18% if they adopt the technology and techniques used by the best-practiced poultry egg farms.

Furthermore, an average poultry egg farmer would enjoy input savings of 17.7% if he attains the technical efficiency level of the most efficient farmer in the area. And in addition, the most inefficient farmer would have an efficient gain of 30.6% for the farmer to attain the efficiency level of the most efficient farmer.

Table 3: Technical efficiency indices of the farmers

Eff. Class index	Frequency	Percentage
0.11 – 0.20	0	0.0
0.21 – 0.30	2	2.2
0.31 – 0.40	3	3.3
0.41 – 0.50	5	5.6
0.51 – 0.60	6	6.7
0.61 – 0.70	7	7.8
0.71 – 0.80	8	8.9
0.81 – 0.90	9	10.0
0.91 – 1.00	50	55.6
Total	90	100.0
Mean	0.823	
Maximum	0.986	
Minimum	0.684	

Source: Computed from MLE Result

CONCLUSION AND RECOMMENDATIONS

The research was carried out on the analysis of production efficiency of poultry egg production in agricultural zone “C” of Kogi State, Nigeria. The technical efficiency analysis showed that stock size, drugs and medication and utility (electricity & water) were main determinants of technical efficiency of poultry production in the area. The finding of the inefficiency factors showed that, high household size ($P < 0.05$) reduced the technical inefficiency of the farmers while

membership of cooperative society (P < 0.01) showed that farmers' level of technical efficiency decreased with increase in cooperative membership. The value of the sigma squared (δ^2) was 0.208 while gamma (γ) was 0.557 and were statistically significant at 1% level, respectively. The mean efficiency score of 0.823 showed that the farmers were not operating at the optimum level (they were not technically efficient) as none of the farmers operated at the efficiency score of Based on the findings of this research, the following recommendations are proffered:

i. Poultry egg producers should encourage more of their colleagues to join cooperatives for strong capital base and easy access to credit facilities.
ii. Solar power as an alternative power source should be introduced and installed for farmers at affordable rate by State government to reduce the operating cost of the farm
iii. State and local government should provide farmers with modern technology at subsidized rate to boost their technical efficiency.

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