Global Journal of Agricultural Research
Vol.3, No.4, pp.1-11, December 2015
Published by European Centre for Research Training and Development UK (www.eajournals.org)

APPLICATION OF A STOCHASTIC FRONTIER PRODUCTION FUNCTION TO THE MEASUREMENT OF TECHNICAL EFFICIENCY OF COMMERCIAL POULTRY EGG PRODUCTION IN NIGERIA

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ABSTRACT: *Some studies on poultry production in Nigeria focused on problems and prospects of poultry production, part time commercial poultry farming, technical efficiency of small scale poultry-egg production and none on the technical efficiency of commercial poultry egg production in Nigeria This study therefore examined the technical efficiency of commercial poultry egg production in Sapele Local Government Area of Delta State, Nigeria. Primary data were collected using a set of well-structured questionnaire and interview schedule. Multi-stage sampling technique was employed in the study. First, five (5) major towns were randomly selected from the nine (9) major towns in the Local Government Area. Secondly, six (6) commercial poultry egg farmers were randomly selected from each of the five (5) major towns to make a total sample size of 30 farmers for the 2011 production cycle. Data collected were presented and analyzed using tables, frequency count, percentages and stochastic frontier production function. The stochastic frontier production function was specified and estimated, using maximum likelihood estimation. The results showed that majority of the respondents were found to be between the age range of 31-50 years old (60%), 56% of them were males, 50% of them had first leaving school certificates and 50% of them had 5-6 family members, 60% had 3-5 years of poultry rearing experience and 53% of them used hired labour for their operations; 60% of the respondents adopted the deep litter system of management. The results also revealed that the coefficients of expenditure on flock size (0.755), expenses on feed intake (0.851), expenses on medication and vaccination (0.220), expenses on labour (0.201), and cost of capital (0.562) were significant determinants of output of commercial egg production at 5% level of significance in the study area. The mean technical efficiency was 58% and ranges between 0.559 and 0.909. The sigma squared (σ^2) of 0.65 for the commercial poultry farmers were statistically significant and different from zero at 5% level of significance. The variance ratio (gamma) was estimated as 0.52 for the farmers and were also significant at 5% level which implied that about 52% variations in the output of the farmers were due to the inefficiency of inputs. The study revealed that a national policy and programme to strengthen the commercial poultry production is required in the area of finance and inputs. It can therefore be recommended that capital should be channelled to commercial poultry production through the provision of macro-credits and formulation of policies and programmes by the Government to direct financial institutions to grant a definite and a reasonable proportion of loan-able funds to commercial poultry farmers. Programmes on economic production of major poultry feed ingredients like maize and soya-beans be instituted for least cost poultry feed production. Potent medicine and vaccine should be provided in sufficient quantities, easily accessible and enlightenment programme on mode of administration be embarked upon by the government to commercial poultry farmers in the study area. Exotic poultry parent stocks and fertile eggs imported should be screened and certified to be of good quality at the point of entry into the country by controlling bodies. Poultry equipment manufacturers should be encouraged by the Government with provision of credit facilities and subsidies.*

ISSN 2053-5805(Print), ISSN 2053-5813(Online

KEYWORDS: Commercial poultry eggs, farmers, technical efficiency, stochastic frontier production, Nigeria.

INTRODUCTION

The importance of poultry to the national economy cannot be overemphasized, as it has become popular industry for the small holders that have great contribution to the economy of the nation. The profession has assumed greater importance in improving the employment opportunities and animal food production in Nigeria. (Adebayo and Adeola, 2005)

Poultry production had significant effect on the national economy of NIgeria. An earlier report by Okonkwo and Akubuo (2001) shows that about ten (10) percent of the Nigerian population are engaged in poultry production, mostly on subsistence and small or medium-sized farms. Presently, the industry had been adversely affected by stringent government economy measures. The measures have been very pronounced on poultry production due to high level of sensitivity of the industry to management factor and resultant effect on live and productivity of the birds.

Study by Ojo (2003) revealed that the industry falls short of its aim of self sufficiency in animal protein consumption in the country that is put at 5gm/caput per day which is far below the Food and Agriculture Organization (F.A.O.) recommended level of 35gm/caput per day.

The poultry sub-sector is the most commercialized of all the sub-sectors of the Nigerian agriculture. The types of poultry that are commonly reared in Nigeria are the chickens, ducks, guinea fowls, turkeys, pigeons, and more recently ostriches. Those that are of commercial or economic importance given the trade in poultry, however, are chickens, guinea fowls and turkeys, amongst which the chicken predominate. They are reared under two district poultry production systems in Nigeria, as in most developing countries of Africa and Asia, namely, commercial poultry and rural poultry. Each of these two systems is associated with features of scale, stock density, husbandry, and productivity. However, between these two rather distinct prototypes, intermediate grades have evolved over time in response to the natural agro-economy and consumer demands. This is referred to as the family poultry production *which* comprise of the rural and indigenous poultry types in some cases or a mixture of both indigenous and exotic hybrids and even totally exotic breeds. (Alabi and Aruna, 2005)

The ban of poultry products by the Federal Government of Nigeria (FGN) has coursed a turn-around in poultry industry which grew by 10.3 percent in the recent year 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.

Bhasin (2002) defined technical efficiency as the ability of a farmer to obtain maximum output from a given set of inputs. Thus, a firm is considered to be more technically efficient than another when given the same quantity of measurable inputs, it consistently produces a larger output, (Odii, 1998). Three types of efficiency are identified in literature. These are technical efficiency, allocative efficiency and overall or economic efficiency, (Olayide and Heady, 1982). Technical efficiency is the ability of a firm to produce a given level of output with minimum quantity of inputs under a given technology. Allocative efficiency is a measure of the degree of success in achieving the best combination of different inputs in producing a specific level of output considering the relative prices of inputs. Economic efficiency is a

ISSN 2053-5805(Print), ISSN 2053-5813(Online

product of technical and allocative efficiency, (Olayide and Heady, 1982). The efficiency of a farm is its success in producing a large amount of output as possible from given sets of inputs. Maximum efficiency is attained when it becomes impossible for a firm to reshuffle a given resources combination without decreasing the total output.

Several studies have been conducted in Nigeria and other parts of Africa on productive efficiency of farmers in different enterprises of crops or livestock. These studies have employed several measures of efficiency. These include production functions, programming technique and efficiency frontier. Ojo (2003) examined the productivity and technical efficiency of poultry egg production in Osun State, Nigeria. He adopted a stochastic frontier production analysis and observed that location of farms (nearness to urban centres) positively affected technical efficiency (TE) while increase in other socio-economic variables such as age, experience and education led to decrease in technical efficiency. Abang, Ekpeni and Usani (2006) estimated technical and allocative efficiencies as well as resource elasticity's of small scale cassava growers in five selected Local Government Areas of Cross River State, Nigeria, and employed Ordinary Least Square (OLS) method of estimation. They observed an inverse relationship between productivity and farm size from the result of marginal value product. Also, technical and allocative efficiencies for land shows that the relatively smaller farm sizes were more efficient. Resources were also found to be inelastic. Nkereumem, Okorie, Udom and Idiong (2001) estimated the determinant of output in commercial egg production in Calabar, Nigeria, using Ordinary Least Square (OLS) method and observed a significant and positive effect of feed intake on egg output in farms in the area. Their result further showed that farmers were not rational in their production decisions with regard to the amount of feed given to the birds.

Various authors have identified a number of factors influencing technical efficiency. Coelli and Battese (1996) stressed that the number of years of schooling, farm size and age of farmers are positively related to technical efficiency. Ajibefun and Daramola (2003) found that the age of farmers, level of education and level of investment are the most significant determinants of technical efficiency.

Some studies on poultry production in Nigeria focused on problems and prospects of poultry production in Nigeria by Ndubuisi (1992), part time commercial poultry farming by Ohajianya (2003), technical efficiency of small scale poultry-egg production in Nigeria by Oji and Chukwuma (2007). None of these studies used the stochastic frontier production function to analyse commercial poultry egg production in Nigeria. This study becomes important to analyze the technical efficiency and the sources of inefficiency in commercial poultry egg production using the stochastic frontier production in Sapele Local Government Area of Delta State in order to fill the gap in the previous studies. This study become imperative to apply the stochastic frontier production function of commercial poultry egg production in the study area. The specific objectives of the study are: to describe the socio-economic characteristics of the commercial poultry egg farmers in the study area; to determine the technical efficiency of poultry egg production using the stochastic frontier production function and to identify the technical inefficiency factors that affect commercial poultry egg production in the study area.

ISSN 2053-5805(Print), ISSN 2053-5813(Online

METHODOLOGY

The study was carried out in Sapele Local Government Area of Delta State, Nigeria. Sapele Local Government Area is one of the twenty-five (25) Local Government Areas in Delta State. Sapele Local Government Area was created on 3rd May, 1989 out of the defunct Okpe Local Government Area with its headquarters at Sapele. It is made up of five indigenous districts, namely Urhiapele (Sapele Okpe), Amukpe, Elume, Okokporo (Ozue), and Ugborhen. The major towns in the Local Government Area include Sapele, Amukpe, Amuogodo, and Okirighwre; others are Elume, Egbeku, Okuovwori, Ogiedi and Ugborhen. The 1991 census gave the population of the Local Government as 142,652, made up of 71,286 males and 71,366 females; Delta Beckons (2011). Multi-stage and purposive sampling techniques were employed in the study. The study covered five (5) major towns in the Local Government Area namely: Uriapele, Amukpe, Elume, Okokporo and Ugborhen which were randomly selected based on the prevalence of commercial poultry farmers in the study area. A total of thirty (30) poultry farmers, six (6) from each town, were selected at random and interviewed using well-structured questionnaire for the 2011 production cycle. Data presentation and analysis were carried out using descriptive statistics such as tables, frequency distribution, and percentages, for the socio-economic characteristics. The study on productive efficiency started with the pioneering works of Farrel in 1952. He identified three types of efficiency – technical, allocative and economic efficiencies. Technical Efficiency (TE) is the achievement of the maximum potential output from a given inputs under a given technology. To estimate the TE, the parametric stochastic frontier method is the most favoured. This method looks at the error term of the regression model as composed of two parts, V and U. The V is the 'white noise' and covers random effects on production outside the control of the decision unit. It is symmetrically independent and normally distributed with zero mean and constant variance (0, σ^2). The U is an asymmetrical component which measures technical inefficiency and is assumed to be the result of behavioural factors which come under the control of the decision unit, Apezteguia and Garate (1997). It is non-negative, half normal and is independently distributed with zero mean and constant variance (0, σ^2), (Tadesse and Krishnamoorthy 1997). The stochastic frontier production function was specified and estimated using maximum likelihood method in this study. The modelling estimation and application of stochastic frontier production functions to economic analysis assumed prominence in econometrics and applied economic analysis in the past two decades. Early applications of stochastic frontier production function to economic analysis include those of Aigner et al. (1977) in which they applied the stochastic frontier production function in the analysis of the U.S. agricultural data. Battese and Corra (1977) applied the technique to the pastoral zone of Eastern Australia. And more recently empirical applications of the technique in efficiency analysis have been reported by Battese et al. (1993), Ajibefun and Abdulkadir (1999), Ojo and Ajibefun (2000). The stochastic frontier production model was used to determine the production function in this study as specified by CEPA (2003)

$$\text{In } Y_i = b_o + b_1 \text{In} X_1 + b_2 \text{In} X_2 + b_3 \text{In} X_3 + b_4 \text{In} X_4 + b_5 \text{In} X_5 + Vi - \mu_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where

In = Natural logarithm
Y_i = Value of commercial poultry egg production (₦)
X_1=Expenditure on flock size (₦)
X_2= Expenses on feed intake (₦)
X_3 =Expenses on Medication (₦)

ISSN 2053-5805(Print), ISSN 2053-5813(Online

X_4= Expenses on Labour (₦)
X_5= Cost of Capital (₦)

Bs'=Coefficients to be estimated

Where

b_0 = Constant
V_i= Random error assumed to be independent of μ_i, identical and normally distributed with zero mean and constant variance $N(0, \sigma^2)$
μ_i = Technical inefficiency effects which are assumed to be independent of V_i, they are non-negative truncation at zero or half normal distribution with $N(0, \sigma^2)$
If $\mu_i = 0$ no allocative inefficiency occurs, the production lies on the stochastic frontier; If $\mu>0$, then production lies below the frontier and it is inefficient

The parameters of stochastic frontier production function model was obtained by Maximum Likelihood Estimation Model (MLEM)

In order to determine the socio-economic characteristics contributing to the observed output, the inefficiency model was estimated jointly with the general model; (Coelli and Batesse, 1996). The technical inefficiency model (μ_i's), is composed of vector variables (Z) which where hypothesized to affect the technical efficiency of the commercial poultry egg farmers and are assumed to be independent of V_is such that μ_i is the non-negative truncation (at zero) of the normal μ_i, and variances σ^2. Where μ_i is defined by:

$$\mu_i = \partial_o + \partial_1 Z_1 + \partial_2 Z_2 + \partial_3 Z_3 + \partial_4 Z_4 \quad (2)$$

Where:

μ_i is the technical inefficiency effect.
Z_1 = Age of farmers
Z_2 = Farmers' years of formal education
Z_3 = Household size (number of persons)
Z_4 = Farming experience (in years)
∂'s = Parameters to be estimated.

The maximum likelihood estimates for all the parameters of the stochastic frontier and inefficiency model defined by equations (1) and (2), are simultaneously obtained by using the program, FRONTIER version 4.1 Coelli (1994) which estimates the variance parameters in the following equations

$$\sigma^2 = \sigma^2 v + \sigma^2 u \quad (3)$$

$$\gamma = \sigma^2 u / \sigma^2 \quad (4)$$ (Jondrow, et. al. 1982).

where the γ- parameter must take a value between zero and one.

ISSN 2053-5805(Print), ISSN 2053-5813(Online

RESULTS AND DISCUSSION

Social Economic characteristics of commercial poultry eggs farmers. (N=30).

The socio- economic characteristics of the commercial poultry eggs farmers are presented in Table 1. The result shows that majority of the farmers were males (87%) and only 13% were females. This shows that male gender is predominant in commercial poultry egg production in the study area. The highest proportions of the farmers (37%) were within the age range of 40>50 years, while the least proportion (7%) were 60 years and above. This shows that majority of the farmers were in their active productive age group.

Distribution of farmers according to educational level shows that the highest proportion (57%) had tertiary education and the least proportion (7%) had primary education. This is an indication that majority of the farmers were holders of tertiary school leaving certificates but did not study agriculture as a discipline and only few (7%) had first school leaving certificate that were involved in commercial poultry eggs production in the study area. Majority (53%) of the respondents had family size of above seven (7) while the least (7%) had family size of less than three (3) persons.

The poultry husbandry experience distribution of the respondents' shows that (60%) had eight (8) years and above while the least (7%) had experience of between 2 to 5years. Furthermore, the findings revealed that the major source of labour was hired (93%), while minor source of labour of 7% used family labour. The result of the study also shows that 67% of the respondents adopted the battery cage system while 33% adopted the deep litter system of management. The flock size which is an indication of scale of production of the study showed that 13% of the farmers had less than 2000 birds; 50% had 2000 to 3000 birds; 17% had 3001 to 4000 birds; 10% had 4001 to 5000 birds and 10% also had above 5000 birds respectively. This agreed with the classification of Omostosho and Ladele (1988), which classified small scale poultry farm as having up to 1000 birds, medium scale farm has between 1001 to 4999 birds and large scale farm has above 5000 birds.

Table 1: Social Economic Characteristics of Commercial Poultry Eggs Farmers. (N=30)

Variable	Category	Frequency	Percentage (%)
Sex	Female	04	13
	Male	26	87
Age group (years)	<40	07	23
	40>50	11	37
	50>60	10	33
	>60	02	7
Educational level	No formal education	01	3
	Primary	02	7
	Secondary	10	33
	Tertiary	17	57
Family size	<3	02	7
	3>4	06	20
	4>6	06	20
	>6	16	53
Farming experience	<2	04	13
	2>5	02	7
	5>8	06	20
	>8	18	60

ISSN 2053-5805(Print), ISSN 2053-5813(Online

Source of labour	Family Hired	02 28	07 93
Management system	Battery cage Deep litter system	20 10	67 33
Flock Size (Number of birds)	<2000 2000>3000 3001>4000 4001>5000 >5000	04 15 05 03 03	13 50 17 10 10

Table 2 shows the maximum likelihood estimates of commercial poultry egg production in the study area. The table indicates that the coefficients of expenditure on flock size (0.755), expenses on feed intake (0.851), expenses on medication and vaccination (0.220), expenses on labour (0.201), and cost of capital (0.562) were significant determinants of output of commercial egg production at 5% level of significance in the study area. Affordability and efficient allocation of these variables (resources) would lead to high productivity and increase source of available animal proteins to the populace. More so, the coefficients of flock size, feed intake, medication and vaccination, and cost of capital had positive signs which imply that they have positive relationship with output. Thus, an increase in the use of these variables would lead to an increase in output by the farmers thereby leading to balanced diets and healthy people. Since feed has highest coefficient, it means that increase in feed intake can enhance the income of commercial poultry egg producers by increasing the quantity and quality of feed given to the birds than by increase in any other factors that influence commercial poultry egg output as specified in this study. The relative important of feed in commercial poultry egg production cannot be over-emphasized. The important of feed in stimulating poultry production in Nigeria has been expressed by Oluyemi and Robert (1988). According to Sonaiya [2000], energy is the first limiting nutrient as food available on the range contains a lot of crude fibre. That is why energy supplements may increase production significantly. The sigma squared (σ^2) of 0.55 for the commercial poultry farmers were statistically significant and different from zero at 5% level of significance. This shows a goodness of fit of the model and the correctness of the specified distributional assumptions of the composite error term.

The ratio of the likelihood function, which determines the effect of efficiency parameters on the outputs of farmers was estimated. The variance ratio (gamma) estimated as 0.61 for the farmers were significant at 5% level which implied that about 52% variations in the outputs of the farmers were due to the inefficiency factor (μ_i). Simply put, variations in the output of the farmers were due to inadequate allocation and utilization of production inputs and not due to random or stochastic error. The mean technical efficiency was 51% and ranges between 0.04 and 0.90. This shows that farmers in the study area were 51% on the average efficient in the use and allocation of farm inputs.

The results of the diagnostic statistics confirm the relevance of the SFPF using the Maximum Likelihood Estimator. The result compares favourably with the findings of Onyenweaku and Uwaru (2005), who applied the use of SFPF to measure technical efficiency in food crop production in Imo State in which it was shown that the coefficients of the estimated parameters had positive signs in both functions and were all statistically significant in the frontier function.

ISSN 2053-5805(Print), ISSN 2053-5813(Online

Table 2: Maximum Likelihood of the Parameters of Production Functions

Variables	Parameters	Coefficient	t-ratio
Constant	b_0	1.751	1.102
Flock Size	b_1	0.755**	5.877
Feed intake	b_2	0.851**	1.060
Medication/vaccination	b_3	0.220**	1.470
Labour	b_4	0.201**	1.461
Cost of capital	b_5	0.562**	2.247

Source: Computed from Field Survey Data, 2011
** Significant at 5% level

Technical Inefficiency Analysis

The analysis of the inefficiency model (Table 3) shows that the signs and significance of the estimated coefficients in the inefficiency model have important implications on the TE of the farmers. The coefficients of age of farmers and household size were positive, indicating that these variables led to increase in technical inefficiency or decrease in technical efficiency of commercial egg production in the study area. Age contributed positively to inefficiency because the older the farmer the less efficient supervision-wise. Inefficiency parameters establish the fact that inefficiency of commercial poultry egg production increased with increase in family size. This may be due to the fact that cost of living would increase with more dependants in the family. The coefficients of years of formal education and farming experience were negative and significant at 5% level of significance. These findings agree with a- priori expectation that technical efficiency should increase with increase in years of schooling and farming experience since education and experience are expected to be positively correlated to adoptions of improved technology and technique of production, (Ojo and Ajibefun, 2000). The negative effect of level of education of farmers on technical inefficiency and the significance follows a prior expectation given that education is an important factor in technology adoption. Educated farmers are expected to be more receptive to new improved husbandry techniques and technologies and hence make more productive use of improved poultry management practices than uneducated farmers.

Table: 3 Inefficiency Model of Commercial Poultry Farmers

Variables	Parameters	Coefficient	t-ratio
Constant	z_0	0.917	0.213
Age of farmers	z_1	0.092**	0.736
Years of formal education	z_2	0.186**	0.312
Household size	z_3	0.002**	0.0005
Farming experience	z_4	0.641**	2.513
Sigma-squared	σ^2	55.12	2.54
Gamma	γ	0.61	2.275
In (Likelihood)		21.66	
LR Test		14.52	

Source: Computed from Field Survey Data, 2011
** Significant at 5% level

ISSN 2053-5805(Print), ISSN 2053-5813(Online

Table 4 shows that the majority (50%) of the respondents belonged to the most efficient category (60<70) while 6.67% belonged to the least efficient category (<50), and also another group of 6.67% belong to the most efficient category of (90<100). The implication of this is that half of the sampled population of the commercial poultry farmers were technically efficient given the existing technology. The mean technical efficiency of 0.51 suggests that the commercial poultry farmers are 51% efficient in the use of combination of their inputs. . This means that the poultry farmers are moderately efficient at their level of production and that their output and income can be improved if more of feeds, capital, vaccine and medicine are used and more innovation related to improved management are adopted.

Table 4: Technical Efficiency Distribution of Respondents

Efficiency	**Frequency**	**Percent (%)**
<50	2	6.67
50> 60	4	13.33
60> 70	15	50.00
70> 80	4	13.33
80> 90	3	10.00
90> 100	2	6.67
Total	30	100
Mean efficiency	0.51	
Min efficiency	0.04	
Max efficiency	0.90	

Source: Computed from Field Survey Data, 2011

SUMMARY, CONCLUSION AND RECOMMENDATION

The study applied a stochastic frontier production function to analyse technical efficiency of commercial poultry egg farmers and ascertained variation in technical efficiency due to technical inefficiency effects on egg production in the study area. The sigma squared (σ^2) of 0.55 for the commercial poultry farmers were statistically significant and different from zero at 5% level of significance. This shows a goodness of fit of the model and the correctness of the specified distributional assumptions of the composite error term. The variance ratio (gamma) estimated as 0.61 for the farmers were significant at 5% level which implied that 61% variations in the outputs of the farmers were due to the inefficiency factor (μ_i). Simply put, variations in the output of the farmers were due to inadequate allocation and utilization of production inputs and not due to random or stochastic error. The mean technical efficiency was 51% and ranges between 0.04 and 0.90. This shows that farmers in the study area were 51% on the average efficient in the use and allocation of farm inputs. The coefficients of age of farmers and household size were positive, indicating that these variables led to increase in technical inefficiency or decrease in technical efficiency of commercial egg production in the study area. The coefficients of years of formal education and farming experience were negative and significant at 5% level of significance.

It can therefore be recommended that capital should be channelled to commercial poultry production through the provision of macro-credits and formulation of policies and programmes by the Government to direct financial institutions to grant a definite reasonable proportion of loan-able funds to commercial poultry farmers. Programmes on economic production of major

ISSN 2053-5805(Print), ISSN 2053-5813(Online

poultry feed ingredients like maize and soya-beans be instituted for least cost poultry feed production. Potent medicine and vaccine should be provided in sufficient quantities, easily accessible and enlightenment on mode of administration be embarked upon by the Government to commercial poultry farmers in the study area. Exotic poultry parent stocks and fertile eggs imported should be screened and certified to be of good quality at the point of entry into the country by controlling bodies. Poultry equipment manufacturers should be encouraged by the Government with provision of credit facilities and subsidies in the study area.

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ISSN 2053-5805(Print), ISSN 2053-5813(Online