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FORMULATION AND ESTIMATION OF STOCHASTIC FRONTIER PRODUCTION MODELS IN EGG-LAYING ENTERPRISE IN AKWA IBOM STATE, NIGERIA

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ABSTRACT

The stochastic frontier production function was applied in formulating and estimating the technical efficiency of livestock farmers involved in egg-laying enterprise. The Maximum Likelihood Estimation Technique, asymptotically consistent and efficient ML estimates were obtained as well as factors determining efficiency levels in the study area. The analysis of data revealed the mean technical efficiency (MTE) of 91.0% implying that the scope could be increased by 9.0% through efficient use and utilization of available resources. The sum of output elasticities which denotes returns to scale (RTS) was 1.246 denoting increasing returns to scale. The study therefore suggest that production efficiency could be enhanced through good and adequate utilization of improved livestock inputs and recommended livestock production technologies. Farmers in these sector need educational exposures.

KEYWORDS: Stochastic Frontier, Technical Efficiency, Egg-Laying, Akwa Ibom State, Nigeria.

INTRODUCTION

Efficiency as a concept itself is based on the neo-classical theory of production which indicates the use of production function that results in maximum output given a set of inputs (Kumbhakar, 2001). He opined that differences exist in observed output of different producers which could be explained with their productive efficiency. Improved level of efficiency implies getting more of the outputs for the same inputs by allocating them in a better way. The failure on the part of the farm to produce on the frontier level of output given the level of inputs and available technology is therefore attributed to inefficiency (Kumbhakar, 2001).

Parikh & Shah,1995, Battese and Coelli (1996) stressed that recent research concerning the estimation and explanation of variation in technical efficiency in agriculture focused mainly on developing nations like Pakistan, India and China. Heshmati (1997) in support of this assertion opined that measurement of technical efficiency in European Agriculture has received less attention. The non-availability of recent research in developed economies like in UK agriculture may be explained by the general perception that efficiency of production in more developed countries is not an issue that warrants investigation. This may be argued that better systems for information transfer allow UK farmers to become aware of the productive potentials of new technologies relatively quickly.

Empirical investigation of technical efficiency in areas like banking, education and public sector in developed economies suggests that there is a large amount of variation in the ability of different firms to translate resources into end product. Lee (1999) emphasized that agricultural policy makers especially in developing nations face difficult tasks in their choice of agrarian structure to achieve the dual goals of growth and equity in the agricultural sector.

Successive governments in Nigeria at the national, state and local levels had embarked on policies and programmes aimed at boosting sustainable egg production but unfortunately the sector remains undeveloped as a result of low technology and lack of implementation of agricultural policies by government and its agents. Obioha (2002) reported that the distribution of agricultural production turn over in Nigeria was 88.0% for crop production and 12.0% for livestock production. Ademosun (2000) stressed that with the economic downturn from 1984 characterized by rising inflation and weakened consumer purchasing power, many egg farmers in the industry collapsed. Common observation indicates that rising costs of livestock feed and animal health drugs are major constraints to growth and efficiency in these livestock sub-sector. Farmers in these sector need to improve the efficiency of egg production so that output could be raised to meet the growing demand which would translate to an improvement in the welfare of farmers and consequently a reduction in their poverty level and food insecurity. Egg farmers in Akwa Ibom State have continued to resist structural changes and the emergence of real commercial farmers have continued to elude the sector. It is therefore imperative for researchers and other stakeholders in the industry concerned with increasing animal protein through efficient use of resources to seek ways or solutions compatible with the socio-cultural and economic make up of the people. There is a need to enhance efficiency through efficient use of the existing technologies, reallocation of resources and adoption of new technologies.

This study is intended to determine the socio economic characteristics of respondents, determine the technical efficiency of production for egg enterprise in the study area, identify factors influencing technical efficiency levels and make policy recommendations towards improving the technical efficiency of egg production in the state.

THEORETICAL FRAMEWORK

Efficient transformation of inputs into outputs is characterized by the production function f(x) which shows the maximum output obtainable from various input sources. This approach favoured the presence of measurement error in the specification and estimation of the frontier production function. It should be made clear that the first error term (Vi) accounts for the existence of technical efficiency while the second error term (Ui) accounts for factors such as measurement error in the output variable, diseases and the combined effect of unobserved inputs in production.

The model is expressed thus:

$Y1 = f(X1\beta) \exp(Vi - Ui)$, i=1,2------n (eqn.1.0)

Where;

Y1 = production or the logarithm of the production of the i^{th} farm.

X1 = Vector of input quantities used by the ith farm.

β = Vector of unknown parameters to be estimated.

f ( ) represents an appropriate function (e.g. Cobb- Douglas, trans-log)

The Vi is a random variables which are assumed to be N

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$(0,\delta v^2)$, and independent of the Ui which are non-negative random variables and are assumed to account for technical inefficiency in production and are often assumed to be N $(0,\delta u^2)$

The computer program, Frontier Version 4.1 was used to obtain maximum likelihood estimates of a subset of the stochastic frontier production function which have been proposed in the literature. The program can accommodate panel data, time varying and invariant efficiencies, cost and production functions half normal and truncated normal distributions and functional forms which have a dependent variable in logged or original units. Using the method by Bravo-Ureta and Pinheiro (1997), individual efficiency can be measured using adjusted output as shown below.

$Y^* = f(X1;\beta) - U$ --------------------(eqn.1.1)

Where:

Y^* is defined as the farms observed output adjusted for the statistical noise contained in V.

The maximum likelihood estimates for the parameters of the stochastic frontier obtained from computer program Frontier 4.1 (Coelli,1995) in which the variance parameters were expressed in terms of sigma- squared $(\delta^2) = (\delta u^2 + \delta v^2)$ and gamma $(\gamma) = \delta u^2 / \delta u^2 + \delta v^2)$. The term γ represents the ratio of the variance of inefficiencies error term to the total variance of the two error terms defined earlier. It is important to emphasize that the variance of γ range between 0 and 1.

Battese and Corra (1997) was the first to apply the stochastic frontier production function to farm level agricultural data. Their empirical study involved data in Australian grazing industry survey and both deterministic and stochastic Cobb-Douglas production frontiers were estimated for the three states in the pastoral zone of Eastern Australia. They concluded that the variance of the inefficiency effect was found to be a highly significant proportion of total variability of the logarithm of the value of sheep production in all states.

Bravo – Ureta and Rieger (1999) estimated both deterministic and stochastic frontier production functions for a large sample of dairy farms in the North Eastern States of USA for the years 1982 and 1983. The stochastic frontier model had significant inefficiency effects for 1982 but not significantly different from the deterministic frontier in 1983.

With respect to the stochastic production frontier for panel data study, Battese (1992) defined panel data as time series observations for the sample farms. Given that the frontier production function is associated with N farms over T- time periods, Battese and Coelli (1996) defined the model as:

$Yit = f(Xi;\beta) \exp(Vit - Uit)$ --------I = 1, 2-------n,t=1---T---- (eqn1.4)

Where:

Yit represents the production of the ith farm, Xit is the vector of factor inputs and t is the period of observation, β is a vector of unknown parameters to be estimated and Vit is assumed to be independently and identically distributed non-negative truncations of the $N(0,\delta^2)$ distribution. T is the set of time periods among the T periods involved for which observations for the ith farm are obtained, n is the sample size. The model above are such that the non –negative farm effects, Uit decrease, remain constant or increase as t increase if n>0, n = 0 or n< 0 respectively.

Battese and Coelli (1996) however indicated that the exponential specification of the behaviour of the farm over time is a rigid parameterization in that the technical efficiency must increase at a decreasing rate (n> 0) , decreasing at an increasing rate (n < 0) or remain constant (n =0).

RESEARCH METHODOLOGY

Study Area: The study was conducted in Akwa Ibom State which lies on the Southern Area of Nigeria. The state is located on the South Eastern part and on the rain forest zone of Nigeria. The state comprises of thirty one (31) Local Government Areas, six (6) Agricultural zones namely Oron, Eket, Uyo, Etinan, Ikot Ekpene and Abak. It lies between latitude 4°33' and 5°33' North and longitude 7°25' and 8°25' East. The ecological condition of the state favours impressive distribution of livestock such as goats, sheep, pig, rabbit, fish, poultry etc. The state has a population of 3392719.602 people (NPC, 2004). Agriculture is the major occupation of the people (Policon,2003).

Sample Selection and Data Collection. A sample frame which denotes the list of egg farmers in the state was obtained from the state Ministry of Agriculture and Natural Resources, Uyo. Resident Agricultural Extension agents of the Agricultural Development Programme (ADP) were contacted and recruited in each zone on the procedure for data collection. Primary data were collected with the aid of a structured questionnaire with emphasis on household egg- production activities and price information during the 2004/2005 production year and complemented with secondary data. The six Agricultural zones of the state were involved and from each zone, at least one Local Government Area (LGA) was purposively chosen based on the type of livestock activities and the preponderance of poultry birds in the area kept intensively. Sixty (60) egg poultry farmers were contacted implying that at least ten (10) egg poultry farmers were chosen from each zone of the state for a detailed study. Information were sought especially on the socio-economic features and other quantitative variables of interest.

The Analytical Techniques:

Descriptive statistical tools such as means, frequency tables, percentages were employed to analyze the socio-economic features of the egg farming households. The stochastic production frontier approach was used in estimating the technical efficiency for egg production enterprises as well as the factors influencing efficiency levels. Given the potential estimation biases of the two-step procedure for estimating technical efficiency scores and analyzing their determinants, a one- stage procedure was employed following Battese and Coelli (1996). The frontier production function model was specified by the Cobb- Douglas production function including all the explanatory variables. It should be noted that the regression coefficients are direct elasticities of the independent variables with which the coefficient was associated.

The Empirical Model:

The specified stochastic production frontier that allows for estimation of individual farm efficiency levels with both time variations is defined as:

$\ln Y = \beta 0 + \beta 1 \ln X1 + \beta 2 \ln X2 + \beta 3 \ln X3 + \beta 4 \ln X4 + \beta 5 \ln X5 + \beta 6 \ln x6 + Vi - Ui$ -------------------- (eqn.2.0)

Where:

Y = Output or Total Value of layers product per farm. Included are the

values of all layers products sold or used on the farm in naira.

X1 = Labour (Mandays)

X2 = Feeds/ feed supplements (Naira)

X3 = Drugs and Medication (Naira)

X4= Expenses on day old chicks purchased (valued in naira)

X5 = Capital inputs (Naira)

X6 = Total number of birds housed.

β = Vector of unknown parameters to be estimated.

Vi = Symmetric error component that accounts for random effects and exogenous shocks.

Ui = One-sided error component that accounts for technical inefficiency. This term is assumed to arise from a normal distribution with μ1 mean and variance $\sigma^2 u$ which is truncated at zero. The study however is related to certain variables as defined explicitly thus:

$Ui = \delta 0 + \delta 1z1 + \delta 2z2 + \delta 3z3 + \delta 4z4 + \delta 5z5 + \delta 6z6 + \delta 7z7 + \delta 8z8 + \delta 9z9$ --(eqn 2.1)

Where:

δ = is the vector of unknown parameters to be estimated.

z1 --------z9 stands for age, education, farming experience, membership to cooperative society, farm size, access to credit, extension contact, gender, household size respectively. The values of the unknown coefficients in equation 2.1 above are jointly estimated by maximizing the likelihood function (Yotopoulous and Lau, 1979, Udoh and Akintola, 2001).

RESULTS AND DISCUSSION.

Socio- economic characteristics of egg farmers in the study area:

The socio- economic data collected and analyzed during the study included the socio – demographic variables. The data was collected from a survey population of sixty (60) egg intensively managed farmers as shown below:

Table 1.1: Distribution of Egg Enterprise ownership by age of farmers.

Age group(years)	No. of farmers	Percentage
20-29	7	11.67
30-39	20	33.33
40-49	24	40.00
50-59	5	8.33
60- and above	4	6.67
Total	60	100
Mean Age (Years)	41.58	

Source : Field Survey ,2005.

Table 1.2: Distributions of Egg Farmers by Educational Attainment.

Educational level	No. of Farmers	Percentage
No formal Education	14	23.33
Primary school	17	28.33
Secondary school	27	45.00
Tertiary level	2	3.33
Total	60	100.00
Mean Year:	12.45	

Source: Field Survey, 2005.

Table 1.3: Distribution of Egg Farmers by years of farming experience.

Years of farming	No. of farmers	Percentage
1-4	11	18.33
5-10	30	50.00
11-15	13	21.67
16-20	3	5.00
21-25	2	3.33
Above 25	1	1.67
Total	60	100.00
Mean Years:	8.67	

Source: Field Survey,2005.

Table 1.4: Distribution of Egg Farmers by Household Size.

Household Size	No. of farmers	Percentage
1-4	20	33.33
5-7	25	41.66
8-10	4	6.67
11-13	6	10.00
14-16	3	5.00
16 and above	2	3.33
Total	60	100.00
Mean Household Size:	4.77	

Source: Field Survey, 2005.

Table 1.5. Distribution of Egg Farmers by Gender.

Gender	No. of Farmers	Percentage
Male	55	91.67
Female	5	8.33
Total	60	100.00

Source: Field Survey,2005.

Table 1.1 depicts the distribution of respondents by age. It shows that the majority of the egg farmers are between the ages of 40 -49 years. This portrays a high proportion of middle – aged farmers in the area. The implication is that they readily accept farm innovations than their aged counterparts. Iwueke (1997) stressed that respondents within the productive age were likely to adopt innovations better because they are still active and dynamic. More so, the mental capacity to cope with the daily challenges decreases with increase in age.

Table 1.2 reveals that between 76.7 and 85.0 percent of the farmers have formal education ranging from primary to tertiary institution. Majority of the farmers have on the average acquired basic and fundamental knowledge and therefore would be willing to adopt and accept innovation to improve their level of productivity in order to enhance the growth of the sector in the study area. Obasi (2005) lending credence to this stressed that the level of education attain by a farmers not only increases his farm productivity but also enhances his/her ability to understand and evaluate new production technologies. Educated farmers are more amenable to taking risks and accepting possible changes than the non-educated farmers. Taiwo (1999) and Nwaru (2001) viewed education and training as being of utmost importance to enhance farmers capabilities to accept and understand technological innovations in economic activities.

Table 1.3 shows the distribution of egg farmers by their years of farming experience. Olomola (1998) however stressed that farmers count more on their experience for increased productivity than on their educational attainment. The table indicates that more than 90.0% of the farmers have been in egg farming business for at least one year. Nwaru (2001) observed that the longer the years of farming experience the more efficient the farmer becomes, because, the number of years a farmer has spent in the farming business may clearly give an indication of the practical knowledge he has acquired. Year of farming is a very important tool in decision making and also in innovation adoption. This type of experience is relevant for enhancing output and income. Freshers in farming business are prone to inefficient utilization of available resources.

Table 1.4 depicts distribution of egg farmers by household size. Iwueke (1997) stressed that relatively large family size is of immense advantage as it enables the household to use family labour especially in the adoption of innovations that require intense labour. Household size ranging between 5 to 7 members had the highest frequency of egg farmers in the distribution. This shows that egg farming in the study area is a labour intensive venture. Ajani (1999) emphasized that more adult in the farmers household implies more work-force and savings in labour cost. Okike and Jabber (2000) stressed that even when members of such large household sizes are available for farming activities, there is high possibility of under-utilization of labour as most of the farmers rear small herds of animals or cultivate small areas of farm land.

Table 4.5 reveals that most of the egg farmers in the study area were males accounting for about 91.67% of producers. Female producers accounted for 8.33%. This indicated that male farmers dominated this line of agriculture in the study area. Uwakah (1982) stressed that many research findings opined that male farmers are better adopters of agricultural technologies possibly due to position as family heads, persons with easy access to relevant farm inputs and extension services. Female participation in these enterprise have been relatively low because they might view it as a male oriented business as majority of their female counterparts engage in other lucrative venture such as trading, weaving etc. It is therefore necessary that livestock policies should take gender related programs and its inherent peculiarities into consideration.

Table 1.6: Maximum Likelihood Estimation Results for Egg Laying Enterprise in Akwa Ibom State, 2005.

Production factors	Parameters	Estimated coefficients	Standard error	t-values
Constant	β0	1.609	0.992	1.621*
Labour (X1)	β1	0.210	0.108	1.954*
Feeds (X2)	β2	0.126	0.059	2.140**
Drugs/ Medication (X3)	β3	0.148	0.055	2.675**
Day old chicks(X4)	β4	0.755	0.122	6.140***
Capital inputs (X5)	β5	-0.161	0.138	-1.166
Farm size(X6)	β6	0.167	0.076	2.192**
Efficiency Factors				
Constant term	δ0	-0.307	1.386	-0.221
Age	δ1	-0.120	0.816	-0.148
Level of Education	δ2	0.072	0.312	0.230
Farming experience	δ3	0.820	0.350	2.342**
Membership of Cooperative society	δ4	0.147	0.516	0.286
Farm size	δ5	0.103	0.251	5.083***
Access to Credit	δ6	-0.048	0.0203	-0.239
Extension contact	δ7	0.123	0.019	6.258***
Gender	δ8	-0.150	0.650	-0.232
Household size	δ9	0.255	1.145	0.223
Diagnostic statistics				
Log-likelihood function		40.293		
Sigma- squared (δ^2)		0.193	0.041	4.674***
Gamma (γ)		0.454	0.112	0.0406
LR Test		3.269		

Note: *,**,*** indicates statistically significant at 10.0%,5.0% and 1.0% respectively.
Source:- Computed from MLE Results/Field survey data,2005.

From the estimated coefficients in Table 1.6, labour is a significant factor that influences changes in the output of egg laying enterprise. This agrees with the findings of Waldman (1994) who reported positive elasticity of labour using stochastic frontier production functions. In most empirical studies, inefficiency of labour in resource use could be explained by the influence of population pressure. Dixon (1992) stressed that in countries where there are rapid population growth the natural tendency was towards excessive utilization of labour on the farms. Surplus supply of labour normally depressed wage rate and thus encouraged farmers to use labour excessively with a resulting inefficiency.

The estimated coefficient of feeds/feed supplements is positive and statistically significant at 0.05 probability level. This implies that the higher the feed intake the more the birds lay eggs or increase output. Poultry feeds are grouped into three according to Okuneye (1989). These include feeds which promote growth, egg laying and more flesh. The quality and quantity of feeds affect the age at first and the number of eggs produced throughout the laying period. The findings of this study is in line with that of Battese and Corra (1997) who reported that egg production and quantity of feed are directly related.

The coefficient for drugs and medication is positive and statistically significant at 0.1 level which conforms with a-priori expectations. Poultry production involved high risks because the birds are susceptible to various diseases and pest attack. To eradicate these problems drugs have to be provided to ensure good health and reduction in mortality rate. Amadi (2002) stressed that certain drugs are required and needed in their ration to improve their growth and performance.

The estimated coefficient for day old chicks is statistically significant and maintained the right a-priori positive sign. This implies that the more these farmers purchased day old chicks the more the chances of increasing their egg output or revenue.

The coefficient of farm size is positive and statistically significant at 0.05 level. This indicates that increase in number of birds housed increases output of eggs. Thus farm size enhances quantity of egg output.

Determinants of Technical Efficiency in Egg Laying Enterprise.

The estimated results of the efficiency model in Table 1.6 indicates that only three variables have significant influence on technical efficiency of farmers. The coefficient of farming experience is positive and statistically significant at 0.05 level. The estimated coefficient is 0.820 indicating that a one percent increase on farming experience of farmers increases the level of technical efficiency by 0.820. Obasi(2005) observed that farmers counted more on their farming experience for improved productivity than on their educational attainment.

The estimated coefficient for farm size followed a-priori expectations. It is positively signed and statistically significant at 0.01 level. This implies that the larger the farm size, the higher the level of output thereby reducing the difference between the frontier output and the observed output.

The estimated results shows extension contact as positive and statistically significant at 0.01 level. This result agrees with that of Ajibefun et al (2000). This probably is because extension agents frequently introduce packages and information which stimulates the productivity of the farmers and promotes their efficiency.

Table 1.7: Frequency Distribution of Technical Efficiency Estimates for Egg Laying Enterprise in Akwa Ibom State, 2005.

Technical Efficiency	Frequency	Percentage Distribution
≤ 0.40	0	0
0.41 – 0.60	2	3.33
0.61 - 0.80	9	15.00
0.81 – 0.90	15	25.00
0.91 – 1.00	34	56.66
Total	60	100.00

Mean of worst 10 = 0.68
Mean of best 10 = 0.99
Maximum Technical Efficiency value = 0.99
Minimum Technical Efficiency value = 0.54
Mean Technical Efficiency = 0.90
Source: Computed from survey data, 2005.

Table 1.7 indicates that the mean technical efficiency is 0.90. This shows low wastage of resource as applied to the enterprise even though there is little room for improvement. From the sampled farmers, more than 81.0 percent have technical efficiency estimates of between 0.80 to 1.00. The maximum technical efficiency value is 0.99 which is very close to the production frontier region while the minimum technical efficiency is 0.54 which is more or less far away from the production frontier region. From this result, the analysis implies that an average farmer from the best 10 group with respect to the enterprise would require (1 – 0.90/0.98) 100 or equals 10.20 percent cost saving to become the most technically efficient farmer in their sampled group while the most technically inefficient farmer in their group needed a cost saving of (1 -0.54/0.98) 100 or 46.94 percent before becoming the most efficient farmer in their sampled group of worst 10.

Table 1.8: Distribution of Elasticity of Production and Returns to Scale for Egg Laying Enterprise in Akwa Ibom State, 2005.

Variables	Estimated Values
Labour	0.21
Feeds/Feed supplements	0.13
Drugs and Medication	0.15
Capital inputs	-0.16
Day old chicks	0.76
Farm size	0.17
Sum of elasticities	1.26

Source: Computed from field survey,2005.

The estimates of production elasticities on Table 1.8 are direct elasticities of Cobb- Douglas production function. The returns to scale which is the summation of production elasticities is 1.26 denoting increasing returns to scale implying that each additional input of production resource results in a larger increase in output than the preceding unit. This is not very common in agriculture. In essence, the enterprise is operating in stage one of the classical production function. This shows that all the inputs are underutilized in the study area.

CONCLUSIONS AND POLICY IMPLICATIONS

The study presented measures of technical efficiency for egg laying enterprise in Akwa Ibom State, Nigeria. The maximum likelihood estimation technique of the stochastic frontier production results for egg laying enterprise revealed that labour, feeds and feed supplements, drugs and medication, day old chicks and farm size were the major factors that were associated with output of the enterprise in the study area. The farmer specific variable such as farming experience, extension contact and farm size were significant in accounting for the observed variation in efficiency among the farmers. Policy options identified for improving the current level of technical efficiency of farmers include education policy that would encourage operators of the enterprise to undergo literacy and training programs, encouraged experienced farmers to remain in farming, the extension service should provide information on better ways of sourcing fixed and variable inputs at lesser and affordable prices, policy to direct more research into the development of feed stuffs that are cheaper and rich in concentrates as well as domestic production of drugs and vaccines to reduce production costs. The farmers would be better off if production is increased as they have increasing returns to input.

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