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Investigation of Factors Influencing the Technical Efficiencies of Swine Farmers in Nigeria

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ABSTRACT This study presents analyses of cross-sectional data on Swine production in Oyo State of Nigeria. Given the specifications of a Cobb Douglas Stochastic frontier production function, in which the technical inefficiency effects are specified to be functions of three explanatory variables, the inefficiency effects of the swine farmers were significant. The estimated technical efficiencies of the sample farmers varied widely ranging from about 51 percent to 95 percent with mean value of about 82 percent. The results indicate decreasing return to scale technology among the swine farmers.

PROBLEM STATEMENT

The problem of calorie malnutrition have been repeatedly highlighted as a major contribution factor to the prolific health hazard in developing countries. This is substantiated by the growing evidence on mortality rate, low working efficiency and productivity of the human population, which has inevitably resulted in the slow rate of progress (Enemare 1990)

Despite the considerable efforts made in the mid 70's to increase the productivity and output of livestock industry, in order to provide a higher per capital consumption of animal protein, the fact still remains that the average Nigerian consume less than 10g of animal protein / day compared to the 50g, 70g and 80g consume/man /day in Europe, America and oceanic countries respectively (FAO 1985). And going by the Food Agriculture Organization (FAO) recommendation, diets in developing countries will only be said to have reached a minimum satisfactory level when the average intake of animal protein reaches 20g/man/day. In an attempt to improve the quality of the average diet and at the same time bridge the gap between supply of and demand for animal protein source, Nigerian government has allowed the importation of frozen beef and chickens. However, this policy was later reversed, as the foreign earning capacity of the country experienced a downward shock in the early 80's.

This has led to research on animals that can serve as protein sources apart from the traditional cattle, sheep and goat meat. It is then not surprising that swine, hitherto had not played a significant role in meat supply in the country, due to religions, cultural and social constraints, is now been consumed by an increasing number of people (Tewe 1988). But attempts by individuals and business groups to increase commercial swine production in Nigeria has been met with several problems such as lack of adequate supply of genetically sound breeders, high cost of feed, poor infastructural facilities, the fear of inadequate market for piggery products and the absence of pig product processing industry in Nigeria.

All these related problems directly affect the swine farmer through increase production costs coupled with limited revenue. They also indirectly affect the low income group that constitutes majority of Nigeria's population, through inability to afford meat and its products at the prevailing high market price.

In view of the foregoing, the study seeks to estimate the technical efficiency of the swine farmers because efficiency of production is directly related to the overall productivity of the agricultural sector, given the current level of technology. It also seeks to investigate the influence which some basic farmer specific and input variables have on technical inefficiency of production of the swine farmers.

Models for Inefficiency Effects in Stochastic Frontiers

Previous studies on efficiency of farms can be classified broadly into the following three categories, namely, deterministic parametric estimation, non-parametric mathematical paragramming and the stochastic parametric estimation. But according to the model chosen to estimate the frontier production function, two groups of literatures are identified, namely mathematical programming and econometrics estimation.

Econometrics modelling of stochastic frontier methodology of Aigner et al. (1977) associated with the estimation of efficiency has been an important area of research in recent years. Basically, the studies are mostly based on Cobb Douglas function and transcendental logarithmic functions that could be specified either as production function or cost function. Panel data, time variant data and cross sectional data are mostly used. The first application of stochastic frontier model to farm level agricultural data was by Battese and Cora (1977). But technical efficiency of farms was not directly addressed in the work. Kalirajan (1981) estimated a stochastic frontier Cobb-Douglas production function using cross-sectional data and found the variance of farm effects to be a highly significant component in describing the variability of rice yield. Bagi (1984) used the stochastic frontier Cobb Douglas production function model to investigate whether there were any significant differences in the mean technical efficiencies of part-time and full time farmers. The result showed no apparent significance, irrespective of whether the part-time and full-time farmers were engaged in mixed farming or crop only farming.

In recent times, a lot of studies on efficiency of production in Nigeria agriculture have been conducted. Ajibefun and Daramola (1999) estimated shochastic frontier Cobb Douglas production function and the technical inefficiency effects are assumed to be a function of some farms specific variables and farmers specific variables. Results of the analysis indicate that the level of technical efficiencies varies widely across farms, ranging between 49 percent and 85 percent, with a mean technical efficiency of 68 percent. The analysis also indicates that variables such as age of birds and years of experience of the primary decision maker of the poultry egg production business have significant influence on the level of technical efficiency. Amaza and Olayemi (1999) investigates farmers' production efficiency in food crop enterprises in Gombe State of Nigeria using a stochastic frontier production function and by maximum likelihood estimation, (MLE) the parameters were estimated. The MLE revealed that land, family labour, hired labour and fertilizer are the major factors that influence the output of food crops

Ajibefun et al. (1996) analysed a cross-sectional data on food crop production in Oyo State of Nigeria giving a translog stochastic frontier production function, in which the technical efficiencies of the sample farmers varied widely, ranging from about 19 percent to 95 percent, with mean value of about 82 percent. The result indicates increasing returns to scale technology among the smallholder croppers.

Frontier Model for Nigeria Swine Farmers

This study is based on sixty swine farmers in Oyo State of Nigeria. Oyo State is one of the 36 States in Nigeria. It lies in the western part of the country, and is well suited for the rearing of swine.

The sample farmers were randomly selected from the swine farmers in the study area. This involved a two stage selection method. In the first stage, the towns in the state were divided into five strata and one town was selected from each stratum. The second stage involved random selection of sample farmers from the list of swine farmers made available at the pig farmers association of Nigeria. From each of the selected towns, a total of 12 swine farmers were interviewed, making a total of 60 sample farmers.

DATA ANALYSIS

The stochastic efficiency frontier independently posed by Aigner et al. (1977) and Meusen and Broeck (1977) was used for the data analysis. The approach has the advantage that it accounts for the presence of measurement error in the specification and estimation of the frontier production function. The stochastic frontier function differs from the traditional production function in that the former consists of two error terms. The first error term accounts for the existence of technical efficiency and the second accounts for factors such as measurement error in the output variable, weather and the combined effects of unobserved inputs on production.

For our empirical analysis, a Cobb-Douglas stochastic frontier production function to be estimated is defined by:

$$\text{Ln } Y = \beta_0 + \beta_1 \text{Inx}_1 + \beta_2 \text{Inx}_2 + \beta_3 \text{Inx}_3 + \beta_4 \text{Inx}_4 + \beta_5 \text{Inx}_5 + vi - ui \quad (1)$$

where

In represents the natural logarith;

Y = represents total output in kg

x_1 = represents quantity of feed in kg

x_2 = represents family labour in mandays

x_3 = represents cost of Hired labour in Naira

x_4 = represents cost of drugs, disinfectant and vaccine, in Naira

x_5 = represents total machinary cost which include depreciation on equipment and cost of repairs. The Vis are assumed to be independent and identically distributed normal random errors having Zero mean and unknown variance, σ^2;

The U_{is} are non-negative random variables, called technical inefficiency effects, which are associated with technical inefficiency of production of the swine farmers which are assumed to be independent of the Vis such that Ui is the non-negative truncation (at zero) of the normal distribution with mean ui, and variance, ^{2} where ui is defined by

$$Ui = \delta_0 + \delta_1 Z_1 + \delta_2 D_1 + \delta_3 Z_3 \quad (2)$$

Where

Z_1 = represents the age of the farmers

D_1 = dummy variable for education, where one denotes educated and zero other wise

Z_2 = denotes years of experience of the farmers and β_i and δ_i are unknown scalar parameters.

The variables age, education and years of experience are included in the model for the technical inefficiency effects to indicate possible effects of farmer characteristics on the efficiency of production. The inefficiency model of equation (2) implies that the stochastic frontier model is a non-neutral frontier model, which is a special case of Huang and Lui (1994) model.

The technical efficiency of the ith farmer, given the specifications of the model, is defined by

$$TEi = \exp(ui) \quad (3)$$

Various tests of hypotheses for the parameters of the frontier model are conducted using the generalized likelihood ratio statistic, defined by

$$= -2 \text{ In } [L(H_0)/L(H_1)] \quad (4)$$

where L (H_0) is the value of the likelihood function for the frontier model, in which parameter restrictions specified by the null hypothesis, H_0, are imposed; and L(H1) is the value of the likelihood function for the general frontier model. If the null hypothesis is true, then has approximately a Chi-square (or mixed square) distribution with degrees of freedom equal to the difference between the parameters estimated under H_1 and H_0 respectively.

EMPIRICAL RESULTS

Table 1 presents summary statistics of the variables of interest in the analysis. They include the sample mean value, standard deviation, minimum and maximum values for each of the variables. Labour is highly used in the area, with a mean value of 529.5 mandays and N56,086.46 for family labour and hired labour respectively. The average quantity of feed consumed in Kg was 22117.63 with a standard deviation of 13815.27. The cost of drugs, disinfectant and vaccine was N12088. Machinery costs, which involve depreciation on equipment and repairs, form an important component of swine production costs with a mean of N6580.32k. The average age of the sample farmers was 47.5 years and the mean value of years of education was 4.7 years. The mean value of farming experience was 8.53 years.

Table 1: Summary statistics of variable for swine farmers in Oyo State of Nigeria

Variable	*Sample mean*	*Standard deviation*	*Minimum*	*Maximum*
Total output (kg)	12603.60	12370.30	1558.6	34676.5
Quality of feed (kg)	22117.63	13815.27	3333.33	57282.0
Family labour (mandays)	529.5	331.83	80.0	1560.0
Hired labour (Naira)	56,086.46	45,046.07	14,400.0	279,00.0
Cost of drugs, disfectent and vaccine (Naira)	12088.0	7622.5	600.0	035000.0
Total machinery cost (Naira)	6580.32	6616.24	769.23	19,000.0
Age os farmers (yrs)	47.5	9.8	26.0	67.0
Education of farmers (yrs)	4.7	5.2	0.0	16.0
Experience of farmers	8.53	4.75	1.0	21.0

Source: Field Survey, 2002

The maximum likelihood estimates of the parameters of the stochastic frontier model are obtained using the program, FRONTIER 4.1, which estimates the variance parameters in terms of $\sigma^2_s = \sigma^2 + \sigma^2_v$, $\sigma^2 = \sigma^2_v + \sigma^2_u$ and $\lambda = \sigma_u / \sigma_v$. These estimates of the parameters are presented in Table 2. The estimates of the first order coefficients of the variable in the Cobb Douglas function can be directly interpreted as elasticities. All the coefficients in the model have the expected apriori signs that are mostly significant.

Table 2: Maximum likelihood estimates of the parameters of the stochastic frontier production function

Variable	*Parameter*	*Coefficient*	*Standard error*
Constant	0	1.7634	1.0581
Feed (x_1)	1	0.1553**	0.0778
Family labour (x_2)	2	-0.4081**	0.1802
Hired labour (x_3)	3	0.2578**	0.0928
Drug (x_4)	4	0.1880*	0.1019
Total Machinery cost (x_5)	*5*	0.2262	0.4519
Inefficiency Factors			
Contant	0	0.1326	0.945
Age (z1)	1	0.0602	0.1813
Education (D1)	2	0.3264*	0.1879
Experience (Z2)	*3*	-0.2118	0.7586
Diagnostic Statistics			
Sigma - square (σ^2)		0.1745**	0.0715
Gamma (γ)		0.9324***	0.5650
log likelihood	- 46.76		

*** significant at the 0.01 level
** significant at the 0.05 level
* significant at the 0.10 level

The positive and highly significant coefficient of feed confirms the expected positive relationship between quantity of feed and total output.

The elasticity of output with respect to family labour is negative at 0.41 and it is statistically significant at the 5 present level. This implies that family labour is a significant but negative factor that influences changes in the output of swines.

The production elasticity with respect to hired labour is positive as expected and it is statistically significant at the 5 percent level. The magnitude of the coefficient of hired labour which is 0.26 indicates that output of swine is inelastic to changes in the amount of hired labour used. The 0.26 elasticity of hired labour suggests that a 1 percent increase in hired would cause an increase of 0.26 percent in total output, and vice versa.

The estimated coefficient for cost of drugs, disinfectant and vaccine is positive and highly significant at 10 percent level while that for machinery cost is also positive but not significant.

The estimated coefficients in the explanatory variables in the model for the technical inefficiency effect are of interest and have important implications . The positive coefficient for the age variable implies that the older farmers are more technically inefficient than the younger farmers. The positive coefficient for the level of education implies that the more the level of formal education, the more is the level of technical inefficiency. The negative coefficient for farming experience implies that farmers with more experience tend to be less inefficient.

It is evident from Table 2 that the estimate of σ^2_s(0.1745) is statistically significant and different from zero at (=0.05). This indicates a good fit and the correctness of the specified distributio-nal assumption of the composite error term. Moreso, the variance ratio, is estimated to be as high as 93.24 percent, suggesting that systema-tic influences that are unexplained by the pro-duction function are the dominant sources of random errors. In other words, the presence of technical inefficiency among the sample farmers explain about 93 percent variation in the output level of the swine.

The results of testing various null hypothesis of interest are presented in Table 3. The first null hypothesis, H_0: μ=0, which specifies that the inefficiency effects are absent from the model, is strongly rejected, indicating that the traditional mean response function is not an adequate representation of the data. The second null hypothesis which states that the inefficiency effects are not stochastic is also rejected. The third null hypothesis considered in Table 3, H_0: $\delta_1 = \delta_2 = \delta_3 = 0$ specifies that the inefficiency effects are not a linear function of age, educational level and years of experience of the swine farmers.

Table 3: Test of hypothesis for parameters of the inefficiency frontier model for swine farmers

Null hypothesis	*Loglikehood*		*Critical value*	*Decision*
Ho : μ = 0	-53.736	22.978	12.59	Reject
Ho : g = 0	-51.343	16.44	9.49	Reject
Ho : $\delta_1 = \delta_2 = \delta_3 = 0$	-43.671	39.179	7.82	Reject

Source: Field survey, 2002

This is also rejected at the 5% level of significance. This implies that the three explanatory variables in the inefficiency model make a significant contribution in the explanation of the inefficiency effects associated with the values of output for the farmers involved.

TECHNICAL EFFICIENCIES

The individual technical efficiencies obtained using the estimated stochastic frontier model(1) (2) are presented in Table 4. The predicted technical efficiencies differ substantially among the farmers, ranging between 0.505 and 0.953, with the mean technical efficiency estimated to be 0.823. The frequencies of occurrence of the predicted technical efficiencies in decile range (Fig.1) indicate that the highest number of farmers have technical efficiencies between 0.80 and 0.89. The sample frequency distribution indicates that there is a wide distribution of technical efficiencies among the swine farmers. There appears to be considerable room for effecting improvements in the technical efficiencies of the farmers in the region.

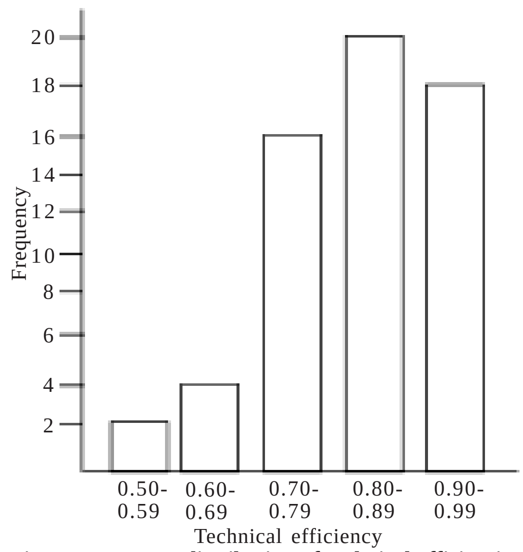

Fig. 1. Frequency distribution of technical efficiencies in the deciles ranges

Table 4: Estimated average technical efficiencies of swine farmers in Oyo State in Nigeria

Farmer	*Technical efficiency*	*Farmer*	*Technical efficiency*
1	0.779	31	0.877
2	0.908	32	0.953
3	0.577	33	0.937
4	0.721	34	0.889
5	0.701	35	0.790
6	0.807	36	0.938
7	0.881	37	0.915
8	0.878	38	0.898
9	0.879	39	0.661
10	0.826	40	0.783
11	0.863	41	0.714
12	0.714	42	0.705
13	0.810	43	0.852
14	0.748	44	0.907
15	0.737	45	0.780
16	0.715	46	0.921
17	0.505	47	0.890
18	0.725	48	0.897
19	0.815	49	0.793
20	0.892	50	0.936
21	0.688	51	0.835
22	0.948	52	0.951
23	0.911	53	0.741
24	0.903	54	0.875
25	0.948	55	0.721
26	0.842	56	0.629
27	0.932	57	0.659
28	0.909	58	0.884
29	0.923	59	0.818
30	0.885	60	0.870
Mean		0.823	

Source: Field Survey, 2002

The returns to scale parameter is estimated to be 0.42, (Table 5) which is significantly less than unity. This indicates that there are dec-reasing returns to scale at the mean values of the variable for the swine farmers in the region. This suggests that the farmers are engaged in produc-tion of swine on an optimal scale of operation.

Table 5: Elasticities of production and return to scale for swine farmers in Oyo State of Nigeria.

Variable	*Elasticity*
Feed	0.1553
Family labour	-0.4081
Hired labour	0.2578
Drug	0.1880
Total machinery cost	0.2262
Return to scale	0.4192

Source: Field Survey, 2002

CONCLUSION

A Cobb Douglas production function, in which the technical inefficiency effects are specified in terms of age, level of education and farming experience of the farmers is estimated for swine farmers in Oyo State of Nigeria. The stochastic frontier production function involves feed, family and hired labour, drug and total machinery cost.

The MLE results reveals that feed, family labour, hired labour and drugs are the major factors that are associated with changes in output of swines.

Given the specification of the Cobb Douglas stochastic frontier function the results indicate that the technical inefficiencies of production of swine farmer are specificantly related to age, level of education, and farming experience.

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