# Technical Efficiency Analysis of Pig Production: A Sustainable Animal Protein Augmentation for Nigerians

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Abstract—The study assessed the technical efficiency of pig production in Nigeria. Randomized sampling technique was used to select 27,782 respondents from the study area. The data were collected through well structure questionnaire. The analytical tools employed were descriptive statistics and Stochastic Frontier production function. The result showed that the mean age of the respondents was 51.23 years. The enterprise is mostly dominated by male (68.3%). The result of the Stochastic Frontier production function showed that feed and labour had positive significant effects on the production output. Education had negative significant effect on technical inefficiency. The mean efficiency was 0.97, indicating a high level of technical efficiency. The study also revealed that most of the farmers (60.0%) were in association and derived huge benefits. Also the study revealed that the farmers are faced with problems such as lack of access to credit facilities, diseases, and lack of access to extension services. Although the pig farmers are technically efficient, efficiency could be increased through better use of available resources, access to credits facilities, extension service and in depth research in the prevalent diseases in pig production. The resultant effect is the reduction of protein intake deficiencies for Nigerian.

*Index Terms*—pig productivity, animal protein augmentation, Nigeria

### I. INTRODUCTION

Agriculture belongs to the real sector of Nigerian economy and it provides primary means of employment for Nigerians and accounts for more than one-third of the total Gross Domestic Product (GDP) and labour force [1]. The livestock sub-sector is equally vital to the national economy since it is the main supplier of the essential animal protein. It also increases the GDP, expands export frontiers, and provides employment opportunities. The importance of livestock sub-sector is in line with recommendation of [1] that on an average basis, a man's daily protein intake should be between 65-72 grams and 53% (about 35 grams) of this should be animal based. The current livestock population in Nigeria is 7 million pigs, 16 million cattle, 56 million goats, 35 million sheep, and 245 million poultry [2]. We also have one (1) million horses and donkeys as well as a negligible number of

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camels [3]. However, the annual growth rate for cattle, sheep, goat, chicken and pig are 1.94, 4.21, 7.41, 1.97 and 16.49 respectively [4]. According to [3], the livestock sub-sector contributes about 5percent to the nation's Gross Domestic product (GDP) and 15.3 percent of the total agricultural sector. The total meat consumption in Nigeria is 8.7kg/person/year [5]. This translates to about 23.82 grams per capita per day which is about 11.18 grams less that the recommended per capita animal protein consumption. The per capita consumption of pork is 1.4kg, beef is 2.0kg, poultry is 1.7kg, mutton is 2.8kg, and goat is 0.8kg [5]

Animal protein is essential in human nutrition because of its biological significance. In realization of this the various governments in Nigeria have been pursuing programmes at national, state and community levels to boost the mass production of crop and livestock. Some of the programmes include the Farm Settlement Scheme, Agricultural Development Project (ADP), Better Life Programme, and Micro-credit Scheme for livestock parent/foundation stock.

Pig production is an example of such community level livestock programmes. The name pig is broadly applied to all mammals of the family *Suidae* and order *Artiodactyla* but specifically to the domestic animal known scientifically as *Sus scofa* from which domestic pig was developed. One of the major advantages of pigs is the ability to convert different kinds of feed even including kitchen waste to meat [6]. Considering general feed conversion, pig is by far the most efficient among farm animals in the conversion of feed energy to body energy [7].

The high rate of productivity is another major advantage of pigs having large number of piglets per litter. CTA [8] for example identified the average litter size of pig to be 9.3 live piglets per sow. Okoli [9] also identified the litter per sow to be 9.96, though, before weaning, an average of 1.51 died, leaving the average number of piglet weaned per sow to be 8.45. So a sow farrowing twice a year comes up with an average of 16.9 piglets per year, this is a remarkable advantage over ruminants like cattle whose maximum are two calves within such period. Tewe and Adesehinwa [10] revealed that the pig is a more efficient carcass yielder than cattle, sheep or goat, dressing out at about 70% compared to 52.5% for cattle and about 50% for sheep and goat. In addition, pig carcasses have a smaller proportion for bones and higher proportion of edible meat. For a country like Nigeria that has a very low supply of animal protein, pig enterprise may be a viable alternative.

Benue State is one of the largest pig producing States (more than 20% of the total country production). Pig enterprise contributes significantly to the economy of the State. Most of the pigs are owned by small holders. They also play an important role in the social and cultural life of most of the communities in the State, providing cheap meat and contributing to pork supply to traditional marriages and burial rites. In addition, pigs provide a ready and regular source of cash to meet the rural families' needs, such as paying school fees, health expenses and farm inputs, on a day-to-day basis.

The development of pig meat production has been slowed down due to a number of constraints. These constraints may include social factors, religious opposition to pig production and consumption, disease, inadequate technical assistance in the form of extension services, and inaccessibility of pig farmers to credit facilities.

Social factors that could influence pig production are the general preference for ruminant meat, and also the belief that pigs are dirty and constitute a health hazard. This could be untrue for pigs that are produced under modern intensive production techniques, since under suitable modern husbandry, pigs can be very clean animals [11].

Nigeria has a large population of Muslims who constitute the majority of most States of the North-West and North-East zones. Also, with the growth of Islamic fundamentalism, opposition to pig production is very significant and sometimes finds its way into policy decision at State and Federal levels. The solution to this constraint is to educate the public on the need to promote pig production for those who consume it in order to reduce the pressure on other meat sources and in essence, make this available at cheaper rate to pork consumers.

The technical analysis of pig production serves as a useful tool for agricultural planners and researchers. It will also make available to famers the relative importance of the factors of pig production which may assist them in decision making to improve productivity. This could lead to efficiency in pig production system, thus fostering economic growth of the state and the country. It will boost pig meat production and create access to cheap and good meat for Nigerians, thus increasing their protein consumption.

## A. Objective of the Study

The overall objective of this study is to examine the efficiency of pig production in Nigeria. The specific objectives are to:

- Analyse the socio-economic characteristics of the pig producers in the study area
- Determine the technical efficiency of pig production in the study area

- Investigate the organization of pig producers into farmers groups and the benefits derived from membership
- Identify the problems faced in pig production in the study area.

The single hypothesis for the study is stated as follows: Ho: Pig farmers in Nigeria are not technically efficient.

## II. METHODOLOGY

## A. Area of Study

Benue State lies midway between the northern and the southern States of Nigeria. It is situated between longitudes 7° 44′E and 9° 55′E and between latitudes 6° 29′N and 8° 7′N. It has a population of 3.0 million distributed over its 33,706 km<sup>2</sup> land area. The rainy season begins mostly in March and ends in October giving an average of 1377 mm and a temperature range of 10 - 40 °C. The economic activities of the people in the area of study include farming, fishing, trading in goods and services. The farmers grow varieties of crops like yam, cassava, maize, millet, rice and groundnut. Varieties of vegetables, sweet potatoes, sorghum and soybean are the other crops grown in the study area. The rural communities within the study area rear livestock such as goat, sheep, rabbit, pig, poultry, and cattle.

B. Sampling Technique

Benue State is divided into three zones, namely zones A, B and C. From a total of twenty-three Local Government Areas (LGA) a sample of sixteen LGAs was selected applying a simple random technique and a sampling proportion of 70%. For the second stage, a sampling frame of the farm families, who were pig farmers, (owning at least two sows) in the sixteen LGAs was prepared and a sampling proportion of 50% was applied to arrive at 27,782 randomly selected households for the study. The sampling protocol was based on the Village listing conducted by Benue State Agricultural and Rural Development Authority, Makurdi, Benue State [12], with population growth rate of 3.3%.

## C. Variable Measurement and Data Collection

Pig weight in kg, feed intake in kg, labour in man days, drugs and vaccines in monetary values and level of education of the head of household measured in terms of number of year spend in school were some of the variables used for the study.

Primary data were used in the study and they were obtained by the use of structured questionnaires administered to the pig farmers in the study area.

## D. Analytical Technique

The Stochastic Frontier Production function was used to analyse the technical efficiency and its determinants in pig production, in the study area. Descriptive statistics, such as percentages, frequencies and tables was used to analyse data provided by the respondents. Coefficients of the estimated model were tested using t-test statistics. For this study, the production technology of the farmers is assumed to be specified by the Cobb Douglass frontier production function defined as follows:

$$LnYi = Ln\beta_o + \beta_1 LnX_{1i} + \beta_2 LnX_{2i} + \beta_3 LnX_{3i} + V_i - U_i$$

where; Y = Pig weight (Kg);  $X_1 = Feed$  intake (Kg);  $X_2 = Labour$  (manday); and  $X_3 = Cost$  of drugs and vaccines (N)

 $V_i$  = Random error that is assumed to be normally distributed with zero mean and constant variance ( $\sigma^2 v_i$ ).

 $U_i$  = Technical inefficiency effects independent of  $V_i$ , and half normal distribution with zero mean and constant variance ( $\sigma^2 u_i$ ).

The technical inefficiency effects, U<sub>i</sub> is defined by:

$$U_{i} = \delta_{o} + \delta_{1}Z_{1i} + \delta_{2}Z_{2i} + \delta_{3}Z_{3i} + \delta_{4}Z_{4i} + \delta_{5}Z_{5i}$$

where  $Z_1$  = Age of farmer (years);  $Z_2$  = Level of education of farmer (years);  $Z_3$  = Farming experience (years);  $Z_4$  = Household size; and  $Z_5$  = Breed of pig (exotic =1, local =0)

Pig weight is expected to be influenced positively by feed intake, labour, cost of drugs and vaccines.

A priori, level of education, farming experience, household size and the farmer's choice of pig breeds are expected to have negative effects on the technical inefficiency while age of the farmer is expected to have a positive effect. The  $\beta$ s and  $\delta$ s are scalar parameters that will be estimated. The variances of the random errors,  $\sigma_v^2$  and that of the technical inefficiency effects  $\sigma_u^2$  and the overall variance of the model  $\sigma^2$  are related thus:  $\sigma^2 = \sigma_v^2 + \sigma_u^2$  and the ratio  $\gamma = \sigma_u^2 / \sigma^2$ , measures the frontier which can be attributed to technical inefficiency [13]. The estimates for all the parameters of the Stochastic Frontier production function and the inefficiency model would be simultaneously obtained in a single stage maximum likelihood estimation procedure, using the computer software frontier version 4.1 [14].

### III. RESULTS AND DISCUSSION

#### A. Socio-Economic Characteristics of the Respondents

The socio economic characteristics of the pig farmers in the study area are presented in Table I. Over ninetypercent (25,120) turned in useful data Majority of the farmers are males (68.3%), while 31.7% are females. This result suggests that men who are relatively stronger are mostly involved in pig production in the study area. This also suggests that sex may increase technical efficiency as male producers who often is the head of the family, who are energetic to procure and administer production inputs are the majority pig farmers in the study area.

The study also reveals that majority of the pig farmers are married (83.3%) while 10.0% are single and 6.7% are widowed. This high marital status may imply large family size which may translate to the higher use of family labour.

The result also indicates that good number of the pig farmers (50.0%) is between 46-55 years of age while 30.0% are between 56-65 years of age and 20.0% are between 35-45 years of age. The average age of the pig

farmers is 51.23 years. This shows that most of the farmers are young and agile to carry out the production activities. This result suggests that age may increase technical efficiency because young farmers who are very energetic and may have learnt efficient routines and practices constitute majority of pig farmers in the study area.

From the results to the average farming experience of the pig farmers is 11.08 years. Farming experience may increase technical efficiency as experience has positive influence on managerial ability as it tends to improve ability of the farmers to obtain and process information about technology which in turn increases efficiency.

The average number of years spent by the farmers in school as computed from the results is 7.71 years. In all 75.0% of the respondents are literate farmers. The implication of this high level of literacy in the study area is that most of the pig farmers have the ability to obtain and process information about input use. This result suggests that the educational level of farmers probably increases technical efficiency of pig farmers in the study area.

The average household size of the pig farmers as computed based on the frequencies is 7.16. This large household size may translate to higher use of family labour. This implies that the cost of hiring labour is reduced.

## B. Estimate of Stochastic Frontier Production Parameter

The maximum livelihood estimate of the Stochastic Frontier Production function for pig farmers are presented in Table II. There was presence of technical inefficiency effects in pig production as confirmed by a high significant Gamma ( $\gamma = 0.84$ ) for the pig farmers. This implies that about 84 percent variation in the maximum output among farmers in the study area was due to inefficiencies on the part of the farmers rather than random variability.

Further more, the significance of sigma squared ( $\delta^2 = 6.50$ ) at 1 percent for the pig farmers shows that the, Cobb Douglas Stochastic Production Function which is estimated with inefficiency effects fits the data better than the conventional production model.

#### C. Output Elasticity and Return to Scale

The result in Table II shows that the output elasticity of mean value of feed (0.24) is largest, while drug and vaccine (0.02) are least. The result also shows that feed (0.24) has a positive coefficient and is significant at 1% level, labour (0.14) has positive coefficient and is significant at 5% level, while drug and vaccine (0.02) have a positive coefficient but not significant even at 10% level. This therefore means that an increase in feed and labour would result to increase in the weight of pig in the study area. This implies that the use of more production inputs by pig farmers in Nigeria would lead to increase in pig output in terms of weight which in turn increases the profitability of the farmers provided there is no price depression. The sum of elasticities is 0.4 (< 1) which indicates that the pig farmers are producing in the region of diminishing returns to scale. The pig farmers are therefore producing in the region of optimum output.

 
 TABLE I.
 PERCENTAGE DISTRIBUTION OF THE SOCIO-ECONOMIC CHARACTERISTICS OF THE RESPONDENTS

Index	Frequency	Percentage
Sex	1 2	0
Female	7,955	31.7
Male	17,165	68.3
Total	25.120	100.0
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Marital Status		
Single	2,512	10.0
Married	20,934	83.3
Widowed	1,675	6.7
Total	25,120	100.0
Age		
35-45	5,024	20.0
46-55	12,560	50.0
56-65	7,536	30.0
Total	25,120	100.0
Farming experience		
1-10	12,560	50.0
11-20	11,723	46.7
21-25	837	3.3
Total	25,120	100.0
Voors spont in school		
	6 280	25.0
1-6	6 280	25.0
7-12	7 955	31.7
>12	4,605	183
Zotal	25 120	100.0
Total	23,120	100.0
Household size		
2-5	5,443	21.7
6-10	18,421	73.3
11-15	1,256	5.0
Total	25,120	100.0

TABLE II. MAXIMUM LIKELIHOOD ESTIMATE FOR THE PARAMATERS IN THE STOCHASTIC FRONTIER PRODUCTION FUNCTION FOR THE PIG FARMERS IN NIGERIA.

Variable	Parameters	Estimate
		3δ
Stochastic Production Frontier		
Constant	$\beta_0$	1.94(3.21)
Ln Feed	$\beta_{I}$	0.24(3.48**)
Ln Labour	$\beta_2$	0.14(2.93*)
Ln Drug and Vaccine	$\beta_3$	0.02(0.66)
Inefficiency Model	-	
Constant	$\delta_0$	0.43(1.34)
Age	$\delta_{I}$	0.02(1.38)
Education	$\delta_2$	-0.04(-5.26**)
Farming experience	$\delta_{3}$	0.01(1.03)
Household size	$\delta_4$	0.01(1.44)
Breed of pig	$\delta_5$	0.02(1.32)
Variance parameter		
Sigma squared	$\delta^2$	6.50(4.95**)
Gamma	γ	0.84(4.33**)
Log likelihood function		65.12

\*\*t-ratio significant at 1% level, \*t-ratio significant at 5% level

## D. Inefficiency Stochastic Frontier Model of the Production Function

The result in Table II also shows that at 1% level of significance the estimated coefficient of education (-0.04) is negative and significant. This result suggests that technical inefficiency effects in pig production in the

study area declines with increase in education. This means that education has positive effect on technical efficiency in pig production in the study area, suggesting that education is important for achieving effective utilization of inputs in pig production in Nigeria. In other words, farmers who are educated achieved higher levels of technical efficiency in pig production in the study area. The implication is that, policy that would encourage the education of pig farmers would ensure efficient use of resources in pig production in the study area. This would improve the profitability in pig production in Nigeria provided there is no glut in the pig market.

#### E. Respondent Distribution by Technical Efficiency

The result in Table III shows that majority of the respondents (85.0%) operated at a technical efficiency of 0.95 - 0.99, while 15.0% of the respondents operated within the technical efficiency of 0.91-0.95. The mean technical efficiency of pig farmers in Nigeria is 0.97, and the minimum technical efficiency is 0.91, while the maximum technical efficiency is 0.99. This result shows a high level of technical efficiency among pig farmers in the study area. This result suggests that technical efficiency in pig production in the study area could be increased by 3% through better use of available resources given current state of technology. This could be achieve through farmers' specific factors like age, education and farming experience. This also means that if the average farmer in the sample is to achieve the technical efficiency level of his or her most efficient counterpart, the average farmer would be 2% [i.e. 1-(97/99)] more productive. Similarly, the most technically inefficient farmer would be 8% [i.e. 1-(91/99)] more productive in order to achieve more productive level of the most technically efficient farmer.

 
 TABLE III.
 PERCENTAGE DISTRIBUTION OF RESPONDENTS BY TECHNICAL EFFICIENCY ESTIMATES

Technical efficiency	Frequency	Percentage
0.91-0.95	3,768	15.0
0.951-0.99	21,352	85.0
Total	25,120	100.0
Mean efficiency	0.97	
Minimum efficiency	0.91	
Maximum efficiency	0.99	

Though the mean technical efficiency of the pig farmers in Nigeria is high (0.97), however, the pig farmers in Nigeria are only confined largely to the north central zones, while the north east and west zones where the animal is regarded as a taboo contain large proportions of the Nigerian population. The pig farmers' productivity in the north-central geopolitical zone should therefore be scaled up so as to increase the pig output and thus satisfy the animal protein needs of Nigerians in both the north central and the south south, south west and south east geopolitical zones. This will reduce the competition on other animal protein sources for Nigerians, and therefore reduce the overall animal protein deficiency of 11.18 g per capita per day for Nigerians.

# F. Farmers Organization

Table IV shows the organization of pig farmers into farmers group. Majority of the pig farmers (60.0%) are in farmers' organization, while 40.0% are not in any pig farmers group. Given the large number of pig farmers in farmers organization (60%) some benefits could flow from the organization to the members.

Result in Table IV shows the benefits derived from the association. These include, introduction of members to new practices or technologies (60.0%), assistance to farmers in form of loan or capital for investment (23.3%), support of members with cash when in bereavement or celebration (23.3%), and protection of members from excessive taxation or charges (10.0%). This result suggests the importance of belonging to farmers association. This result implies that farmers can obtain relevant information about new practices or technologies which might help them to be more efficient in production. Also support services are being rendered by these associations in terms of assisting the farmers to obtain loan or capital for investment which increases production. The overall effect is the reduction of animal protein intake deficiency for Nigerians.

TABLE IV. PERCENTAGE DISTRIBUTION OF RESPONDENTS ACROSS FARMER ORGANIZATIONS AND BENEFITS DERIVED FROM MEMBERSHIP

Parameter	*Frequency	*Percentage
Farmer Organization		
Belong	15,072	60.0
Do not belong	10,048	40.0
Total	25,120	100.0
Benefits		
Assists with loan or capital	5,861	23.3
Introduction to new technologies	15,072	60.0
Protect members from excessive	2,512	10.0
tax	5,861	23.3
Support members with cash	25,120	100.0
when bereaved or celebrating		
Total		

\*Multiple responses

TABLE V. DISTRIBUTION OF RESPONDENTS BY PIG PRODUCTION PROBLEMS

Problems	*Frequency	*Percentage
Lack of access to credit facilities	7,117	28.3
Diseases	12,560	50.0
Lack of access to extension service	5,443	21.7
Total	25,120	100.0

\*Multiple responses

### G. Problems Faced in Pig Production

The major problems faced in pig production by farmers in the study area are presented in Table V. These include disease (50.0%), lack of access to credit facilities (21.7%), and lack of access to extension services (28.3%). The high percentage of responses concerning disease implies the inadequacy of research to provide solution in terms of drugs and vaccines to meet this disturbing problem. This result suggests that government intervention to provide adequate resources for in-depth research so as to solve the disease problems will improve production and may also improve technical efficiency. The percentage of responses concerning the other

constraints is indicative of the fact that the government policy interventions in the pig industry have not yet adequately addressed these problems.

## IV. CONCLUSION AND RECOMMENDATION

# A. Conclusion

The study has shown the distribution of technical efficiency of pig farmers in Nigeria. Farmers' specific factor like education contributed positively to technical efficiency level of the pig farmer in the study area. Also production inputs like feeds, labour, drug and vaccines, contributed positively to technical efficiency level. Furthermore, 84% of the variations in input use among the pig farmers were due to inefficiency on the part of the farmers rather than random variability.

More so the distribution of efficiency estimates among the pig farmers has shown a high level of technical efficiency. On an average, technical efficiency of the pig farmers could be increased by 3%, using the current production technology.

Although the pig farmers are faced with problems ranging from, diseases, lack of access to credit facilities, and lack of access to extension service, these can be tackled through in depth research to find solution to the prevalent diseases, and through policies that would enhance access of the farmers to credit facilities and relevant information through an effective extension service. This would lead to increase in productivity, profitability and also efficiency gains.

## B. Recommendations

Based on the findings of the study, some recommendations have been made.

- Efficiency in pig production in Nigeria could be increased through better use of available resources, given the current state of technology and through policies that would encourage the education of pig farmers.
- Pig farmers are encouraged to belong to pig farmers' association around them so as to have access to relevant information about new technologies or practices.
- Policies that would guarantee adequate access to credit facilities by the pig farmers are strongly advocated. This will ensure that the farmers have enough resources for expansion.
- Policies that would encourage in depth research by research institutions to profer solutions to prevalent diseases in pig production are advocated. This would reduce the risk in pig production and also increase efficiency.
- An effective extension service should be established to bridge the gap between pig farmers and the research institutions, and also to create awareness about improved technologies in pig production.

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