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Analysis of Resource Use Efficiency and Elasticity of Production among Smallholder Broiler Producers in Ikwuano Local Government Area of Abia State, Nigeria

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Abstract

Resource use efficiency is the extent at which a firm or production unit makes proficient decisions by utilizing limited resources to maximize profit. Elasticity of production is a measure of a firm's success in producing maximum output from a set of input. This research analyzed resource use efficiency and elasticity of production among smallholder broiler producers in Ikwuano LGA of Abia State, Nigeria. Specific analytical techniques employed was the production function analysis involving the four functional forms of linear, double log (Cobb Douglas), semi-log and exponential. This was used to obtain the parameters for the measurement of resource use efficiency among the broiler producers. The results of the analysis shows that resource use efficiency (r) was 1.064, 0.018, –0.046 and 0.049 for quantity of broiler produced (stock size), labour expenses, cost of medicines/drugs and feed expenditure respectively. Stock size and feed expenses had the highest efficiency index of 1.064 and 0.049. The least efficiency index was recorded for medicines/drugs with a negative value of –0.046 which implied that the resource use efficiency for medicines/drugs was grossly inefficient. The resource use efficiency for stock size/quantity of day-old-chicks shows that the resource was completely over used. The resource use efficiency with which poultry feeds were utilized shows that the quantity of feeds was over utilized. The elasticity of production of the smallholder broiler producers was 1.016 ($\Sigma Ep>1$). This shows that, if all resources were to increase by 100%, output would increase by 101.6%. This implies that fixed resources (land, depreciated equipment) were abundant relative to variable resources (feed, day-old-chicks, medication and labour); yet, these fixed resources were not efficiently utilized due to lack of sufficient quantity of variable resources. There is a paramount need to increase variable resources in order to maximize profit.

Keywords: Resource Use Efficiency, Elasticity of Production, Production Function, Smallholder Broiler Producers, Abia State Nigeria

Introduction

The development and improvement of the poultry industry has been a major focus of Nigeria's Federal Government initiative; because, apart from the fact that poultry meat contribute tremendously to the protein intake of individuals, it also serves as a ready source of income to smallholder farmers (Afolabi, 2002). Poultry offer short-term investment opportunities and thus helps to increase meat and egg availability, thereby improving the health and standard of living of the people (Onyenweaku, Igwe and Mbanasor, 2004). Broilers are birds (male or female) reared for meat. They attain a market weight of between 1.5 kilogram and 2.5 kilogram in about 7 – 10 weeks (Ramrao *et al.,* 2008*)*.

Economic efficiency is the capacity of a firm or a production unit to maximize profit (Onyenweaku, Igwe and Mbanasor, 2004). Economic efficiency is tantamount to resource use

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efficiency. The extent to which small scale broiler farmers make efficient decisions by utilizing their low inputs (limited resources) up to the level at which their marginal contribution to the value of production is equal to the factor costs is a measure of her resource use efficiency.

Elasticity of production is the degree of responsiveness of output to changes in a variable input. It is the percentage change in output as a ratio of a percentage change in input. It is a measure of a firm's success in producing maximum output from a set of input (Farrel, 1957).

Efficiency in the use of farm resources is concerned with the relative performance of the processes used in transforming given inputs into outputs. There are basically three major types of efficiency, *viz*., technical, allocative and economic efficiency. Technical efficiency refers to the ability of firms to employ the best practices in the production processes so that not more than the necessary amount of a given set of inputs is employed in producing the "best" level of output (Carlson, 1989). Allocative efficiency denotes the choice of optimum combination of inputs consistent with the relative factor prices *(*Nwaru, 1993*)*. Economic efficiency on the other hand is the ability of a firm to fully maximize profits. Farrel (1957) and Iheke (2006) emphasized that technical efficiency tenders on the ability of production units to produce maximum outputs from a given set of inputs. Efficiency of resource use is acquiescent to technical research, thereby leading to the identification of opportunities for increased performance through appropriate adjustment in the pattern of resource use. (Mbanasor and Chidebelu, 2001).

Attainment of efficiency in small scale broiler production is a very important factor for its productivity and growth; most especially in developing agrarian economies such as Nigeria where resources are meager and opportunities for developing commercial poultry enterprise are capital intensive, which doesn't provide a measurable level of employment to greater percentage of the populace.

With over 65 percent of the population in Sub Saharan Africa suffering chronic food insecurity, the need for efficient resource utilization cannot be over emphasized. Efficient resource use remains a major challenge for proficient policy measures targeted at improving livelihoods of small scale broiler farmers (Kuriuki, Ritho and Muneik, 2008).

This research analyzed resource use efficiency and elasticity of production among smallholder broiler producers in Ikwuano Local Government Area of Abia State, Nigeria. The project recommends proficient policy measures that enables smallholder broiler farmers increase her efficiency.

Methodology

Study Area

The study was conducted in Ikwuano Local Government Area of Abia State, which is located in Umuahia Agricultural Zone of Abia State. Ikwuano Local Government is made up of four clans which comprises several autonomous communities and villages. These clans include: Ariam, Ibere, Oboro and Oloko. The Local Government area is situated in the south-eastern part of Abia State. Ikwuano has a population of 52,214 people, with male having 28,840 and females 23,374 (Federal Government of Nigeria - FGN, 2009). Ikwuano is found between latitudes 5^0 24' – 5^0 30' North and longitudes at 7^0 32'- 7^0 37'East. The people are mostly farmers which constitute about 70% of the rural population. The predominant soil of the area is sandy loam while the natural vegetation is the tropical rainforest (Iheke, 2006) and is characterized by two distinct seasons; dry and wet seasons. The dry season lasts from November to March while the wet season lasts from April to October. The settlement pattern is rural and farming is the predominant occupation of the inhabitants. Most families are involved in one farming activity or the other as a primary or secondary occupation. Livestock are also kept especially on a smallholder basis (Nwaru, 2005).

Sampling Procedure / Sampling Technique

Multi stage random sampling technique was employed in selecting the respondent. In the first stage, one (1) clan was randomly selected from the four clans that make up Ikwuano Local Government area of Abia State. In the second stage, four (4) autonomous communities were randomly selected from the clan. In stage three, one (1) village was randomly selected from each of the four (4) autonomous communities; making a total of four (4) villages. In the fifth stage, 21 smallholder broiler producers were randomly selected from each of the four (4) villages; making a total of 84 smallholder broiler producers for a comprehensive study.

From the four villages, each village was allocated 21 questionnaires which were randomly administered to the different smallholder broiler producers (21 x 4 = 84). However, only 80 copies of the questionnaires which were satisfactorily and appropriately filled were used for the analysis.

Method of Data Collection

Data was collected from primary source. The data collected include cost of broiler production, return from the sales of broiler produce (culled birds, droppings), labour employed, quantity of broiler output, price of output, amount spent on inputs, total revenue realized, etc. Well-structured questionnaires were employed in soliciting information from the randomly selected broiler farmers.

Analytical Techniques and Model Specification

Estimation of Resource Use Efficiency among Smallholder Broiler Producers

The analytical procedure employed was production function analysis. This was used to obtain the parameters for the measurement of resource use efficiency among the smallholder broiler farmers.

A multiple regression analysis was used to estimate the production function and violation of assumptions of Ordinary Least Squares (OLS) were checked before interpreting the results. The model used was illustrated as follows:

$Q = f(X_1, X_2, X_3, X_4, X_5, \mu)$ --------1

Where:

Q = Quantity of broiler produced (Kilogram)

X_1 = Number of birds housed (Farm size)
X_2 = Labour expended (man days)
X_3 = Cost of veterinary services and Medicine/drugs (Naira)
X_4 = Cost of feed (Naira)
X_5 = Years of experience in broiler production
μ = Stochastic error term

The linear, double log (Cobb Douglas), semi-log and exponential functions were employed to determine which of the functional forms would best fit the relationship between the quantity of broiler produced (dependent variable) and the exogenous variables. The final choice of the functional form was based on:

(I) highest value of adjusted R^2,
(ii) Significance of regression coefficients, and
(iii) High value of F-value.

Whichever model that has the highest adjusted R^2 and shows many statistical significant were adopted following (Koutsoyiannis, 1977 and Adinya *et al*., 2008).

The functional forms fitted were specified below:

(a) Linear production function: ------2

$$Q = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + \mu$$

(b) Cobb-Douglas Function (double log)

$$\ln Q = a + b_1\ln X_1 + b_2\ln X_2 + b_3\ln X_3 + b_4\ln X_4 + b_5\ln X_5 + \mu$$

(c) Semi-Log Production Function:

$$Q = a + b_1\ln X_1 + b_2\ln X_2 + b_3\ln X_3 + b_4\ln X_4 + b_5\ln X_5 + \mu$$

(d) Exponential Production Function:

$$\ln Q = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + \mu$$

Where:

X_1-X_5 = are defined in the implicit form
b_1-b_5 = Regression coefficients of variables X_1-X_5
a = Constant term
μ = Error term
ln = Natural Logarithm

The resource use efficiency was obtained from the estimated equation by comparing the Marginal Value Product (MVP) of a particular input with the Marginal Factor Cost (MFC) of that input.

The following ratio i.e. r = MVP/MFC, was used to estimate the relative efficiency of resource use.

Where:

MVP = Value added to broiler output due to the use of an additional unit of input, calculated by multiplying the MPP (Marginal Physical Product) by the price of mature broiler, i.e., {MPP x P_Q = bi x P_Q}

MPP x Price of broiler = Marginal Value Product (MVP). Where MPP = bi (slopes of the coefficients of resource input).

MFC = Cost of one unit of a particular resource: The marginal factor cost (MFC) of an input is the addition to cost as a result of using additional unit of the input; which for a firm operating in purely competitive industry is the market unit price.

In this study, the smallholder broiler farmers were assumed to operate in a purely competitive input market, thus, the market unit price of input was taken as the marginal factor cost.

As of the time of the analysis, the marginal factor cost of farm land was the tribute paid to the tenant farmer which was ₦2,650 on the average for the building per production cycle (one batch). That of labour was ₦950 per manday, that is, the average market rate of hired labour.

In order to evaluate the resource use efficiency of smallholder broiler farmers, the study adopted the method used by Oladeebo and Ezekiel (2006) thus: MVP = MPP.Xi x P_Q. Depending on the functional form selected as lead equation for regression, the MPP and the corresponding values of MVP was obtained as follows:

Linear: MPP = dQ /dX = bi; MVP = bi x P_Q
Double log: MPP = bi x Q/Xi; MVP = bi x Q/Xi x P_Q
Exponential: MPP = bi x Q; MVP = bi x Q x P_Q
Semi log: MPP = bi / Xi; MVP = bi /Xi x P_Q
Therefore, Resource Use Efficiency (r) = MVP / MFC --3

Decision Rule for Resource Use Efficiency

If r = 1; it shows that resources is efficiently used, that is optimum utilization of resources, hence the point of profit maximization.

If r < 1; resources is excessively used or over utilized, hence decreasing the utilization of that resource increases profits.

If r > 1; resources is under used or underutilized, hence increasing its rate of use will increase the profit level.

Economic optimum takes place where MVP = MFC.

Thus, When Resource Use Efficiency (r) =1, resources are optimally utilized. When r<1, resources are over utilized. When r > 1, resources are underutilized

Where:

bi = regression coefficients, i=1,2,3,……
Q = mean output of broiler produce,
Xi = mean value of resource,
Pxi = price of resource per unit
P_Q = price of output per unit
MFC = marginal factor cost
Xi = of particular resource input.

Analysis of Elasticity of Production among Smallholder Broiler Farmers

Elasticity of production (Ep) is the percentage change in output as a ratio of a percentage change in input. The elasticity of various inputs was determined by this formula:

Ep = dQ / dXi x Q / Xi or Ep = MPP / APP ----- 4
APP = Q / Xi and MPP = dQ / dXi

Where:

Q is the broiler output in Kg
Xi's are the various input used in production,
X and Q are the averages of input and output respectively.
MPP = Marginal Physical Product and APP = Average Physical Product
ΣEP = Summation of Elasticity of Responds.

Since the Cobb-Douglas production function gave the best fit, the regression coefficient will still be the elasticities; and used to measure the rate of return; which is a measure of a firm's success in producing maximum output from a set of input. [$\Sigma EP = b_1+b_2+b_3+b_4+b_5$]

Criteria for return to scale estimation

ΣEP =1: constant return to scale

ΣEP <1: decreasing return to scale

ΣEP >1: increasing return to scale

Results and Discussion

Analysis of Resource Use Efficiency among Smallholder Broiler Producers

The analytical procedure employed was the production function analysis. This was used to obtain the parameters for the measurement of resource use efficiency among the smallholder broiler farmers.

Table 1. Production Function of Smallholder broiler farmers in Ikwuano LGA, Abia State, Nigeria

Variables	Linear	Semi log	Double log^{++}	Exponential
(a) Constant	53.017	–3735.816	3.085	5.305
	(2.527)**	(-0.402)	(1.715)*	(7.050)***
(X_1) Number of Birds	1.628	273.161	0.949	0.005
	(46.781)***	(18.498)***	(31.138)***	(19.029)***
(X_2) Expenditure on Labour	0.153	48.769	0.014	–0.002
	(0.802)	(2.628)**	(2.542)**	(-1.818)*
(X_3) Cost of Medicines/drugs	–0.005	73.645	–0.074	–7.422E-5
	(–0.672)	(1.781)*	(–2.003)*	(–0.919)
(X_4) Cost of Feed	0.003	162.582	0.108	–3.387E-6
	(–2.647)**	(0.683)	(5.320)***	(-0.397)
(X_5) Years of Experience	1.181	7.387	0.019	0.003
	(1.726)*	(1.824)*	(0.961)	(0.600)
R^2	0.949	0.829	0.969	0.835
R^2 Adjusted	0.938	0.818	0.967	0.824
F – ratio	381.176***	71.785***	475.177***	75.034***

Source: Field Survey Data, 2012; ( ) = t values computed, $^{++}$ = lead equation

***, **, * = Significant at 1 percent, 5 percent and 10 percent, respectively

Linear, semi – log, double log and exponential function of the production function were estimated. All models were significant (P < 0.05) with F – values of 381.176, 71.785, 475.177 and 75.034 respectively, with R^2 of 0.949, 0.829, 0.969 and 0.835 for linear, semi – log, double log and the exponential, in that order. The regression coefficients had the *a priori* expected signs. The Double log production function was chosen as the lead equation for the analysis based on conformity with *a priori* expectations of signs and magnitude of the coefficients, overall significance of the functional form (F-ratio) as well as the explanatory power of the variables (adjusted R^2). The F-value was statistically significant at 1.0%, which shows that the regression model gave a good fit, signifying that the exogenous variables (X_1, X_2, X_3, X_4 and X_5) included in the model best explain the dependent variable (Q).

In Table 1, the lead equation (double log) shows that R^2 is 0.969, which infers that about 96.9% of the variation in broiler output was explained by the variables (number of broilers, amount of labour, cost of medicine, cost of feed and years of experience), while the remaining 3.1% was the unexplained variation.

The estimated production function for the smallholder broiler producers in Ikwuano Local Government Area of Abia State is $Q = 3.085^* + 0.949^{***}X_1 + 0.014^{**}X_2 – 0.074^*X_3 + 0.108^{***}X_4 + 0.019X_5$. The equation showed that all other statistically significant variables will increase the output of broiler to the tune of 308.5kg. The stock size (number of birds), amount of labour and cost of feed were positive and statistically significant at 1.0%, 5.0% and 1.0% respectively. The implication of these positive signs is that an increase in each of these variables would lead to an increase in the level of broiler output produced, while the negative sign denote a decrease in the level of broiler output.

This result agrees with *a priori* expectation, suggesting that, as the quantity of consumed feed increases, output of broiler is likely to increase. This is true because broiler birds have a high feed intake to be able to justify their genetically endowed fast growing ability. Also, the more the stock size, the higher the profitability of an enterprise. This agrees with the findings of Ghadoliya (2000) who reported that larger flocks sizes (>20,000 birds) yielded higher returns per bird compared to smaller flocks.

The inverse relationship between cost of medicines/drugs and broiler output is consistent with *a priori* expectation, that is, as the cost of medicines/veterinary services decreases, output increases, and vice versa. The cost of labour was positively directly related to the output of broiler at 5.0% level of significant. This implied that the higher the labourers employed, the more specialized the enterprise becomes. As specialization increases, output also increases; due to an

efficient use of scarce productive resources. Years of experience was found to be insignificant in the study, denoting that it never affected the output of broiler production.

Table 2. Resource Use Efficiency Indicators among Smallholder Broiler Producers in the study area

Resources	MPP	MVP	MFC	MVP/MFC = r
(X_1) Number of Birds	1.064	2500.40	₦2350.0/bird	1.064
(X_2) Expenditure on Labour	0.018	9.55	₦530.53/manday	0.018
(X_3) Cost of Medicines/drugs	–0.046	–1.68	₦36.38/unit/bird	–0.046
(X_4) Expenditure on Feed	0.049	23.93	₦488.42/Kg of bird	0.049

Source: Field Survey Data, 2012

Given the level of technology and prices of both inputs and outputs, efficiency of resource use was ascertained by equating the Marginal Value Product (MVP) to the productive Marginal Factor Costs (MFC) of resources. A resource is said to be optimally allocated if there is no significant differences between the MVP and MFC *i.e.* if the ratio of MVP to MFC = 1 (unit). The Resource Use Efficiency (r) was 1.064, 0.018, – 0.046 and 0.049 for stock size, labour expenses, cost of medicines/drugs and feed expenses respectively. These results indicate that stock size and feed expenses had the highest efficiency index of 1.064 and 0.049. The least efficiency index was recorded for medicines/drugs, with a negative value of about – 0.046, which implied that resource use efficiency index of medicines/drugs was grossly inefficient.

With the ratio of MVP/MFC for stock size (number of broilers) being greater than unity, the broiler farmers appear to be underutilizing their resources. This is evident from the fact that the scales of their holding are small. These call for the expansion of their broiler scale of production and improved medication/drugs.

The resource use efficiency, with which feeds are utilized (0.049), shows that the amounts of feeds are over utilized. These results was supported by similar findings by earlier researchers (Salasya *et al*., 1986; and Nandwa *et al*., 1997) who identified input costs such as feeds as a key determinant to enterprise improvement. In order words, economic efficiency and productivity could be achieved if a farmer uses poultry feeds more efficiently.

In summary, the ratios of the MVP to the MFC were greater than unity (1) for stock size except labour, cost of medicines/drugs and feed expenses. This implies that within the limits of statistical error, none of the inputs was efficiently allocated by the broiler farmers.

Table 3. Elasticity of Production among Smallholder Broiler Farmers in the Study Area

Productive Inputs	Elasticity
(X_1) Quantity of Birds	0.949
(X_2) Expenditure on Labour	0.014
(X_3) Cost of Medicines/drugs	–0.074
(X_4) Cost of Feed	0.108
(X_5) Level of Experience (Years)	0.019
Returns to scale	1.016

Source: Field Survey Data, 2012

Table 3 shows the elasticity and returns to scale of the smallholder broiler farmers. The regression coefficients constituted the respective elasticities of production in the chosen lead equation (Cobb- Douglas production function). The summation of all the partial elasticities of production with respect to every input is 1.016 ($\Sigma Ep>1$), representing the total output elasticity/function coefficient; also referred to as returns to scale. If all factors are varied by the same proportion, the function coefficient indicates the percentage by which output would increase. In this case, it means, if all of the variables were to increase by 100%, output would increase by 101.6% representing increasing return to scale.

This implied that each additional unit of input adds more to total product than the preceding unit. In this stage, fixed resources (land, depreciated equipment) are abundant relative to variable resources (feed cost. cost of day-old-chicks, medication cost, labour cost, etc.), and these fixed resources were not efficiently utilized due to lack of sufficient quantity of variable resources.

This finding conform to similar study by Ramrao *et al*., (2008), who reported that farmers who maintained a flock size of 10,000 broilers were able to recover their fixed invested capital from production in about two years compared to those who keep smaller flock sizes.

Conclusion and Recommendations

Given the level of technology and prices of both inputs and outputs, efficiency of resource use was ascertained by equating the Marginal Value Product (MVP) to the productive Marginal Factor Costs (MFC) of resources. The Resource Use Efficiency (r) was 1.064, 0.0018, - 0.046 and 0.049 for stock size, labour expenses, cost of medicines/drugs and feed expenses respectively. The ratios of the MVP to the MFC were greater than unity for stock size, except labour, cost of medicines/drugs and feed expenses; which implies that within the limits of statistical error, none of the inputs was efficiently allocated by the broiler farmers.

The resource use efficiency with which poultry feeds were utilized shows that the quantities of feeds were over utilized. The efficiency analysis indicates underutilization of land and overuse of labour resources. The returns to scale of the smallholder broiler producers are 1.016. The implication of this in general is that, the broiler farmers in the study area are not yet operating at optimum scale of production. Hence, there is need for improvement such as better equipment and using more variable inputs to boost production.

It is therefore recommended that credit facilities be made available to the broiler farmers. There is a paramount need to increase variable resources in order to maximize profit. Livestock research centers and State Agricultural Developing Programmes (ADP) should develop genetically improved breeds of poultry which efficiently convert feed. Effectively harnessing the potentials in alternative but cheaper sources of poultry feed ingredients away from the conventional ones will lower the cost of production leading to more profits per broiler sold.

Compliance with Ethical Standards

Conflict of interest

The authors declare that for this article they have no actual, potential or perceived the conflict of interests.

Author contribution

The contribution of the authors is equal. All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before.

Ethical approval

Experimental procedures were approved by Michaek Okpara University of Agriculture, Umudike, Abia State, Nigeria (July, 23, 2020).

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Data availability

Not applicable.

Consent for publication

Not applicable.

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