International Journal of Veterinary Science and Agriculture Research
Volume 1 Issue 2, July-August 2019
Available at www.ijvsar.com

Analysis of Technical Efficiency and its Determinants among Cattle Fattening Enterprises in Kebbi State, Nigeria

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Abstract: Livestock fattening means feeding the animals in order to obtain fast live weight gains in relatively short time (Alawa *et al*., 2008). Efficiency is the ratio or relationship between inputs and output. The study examined the technical efficiency and its determinants among cattle fattening enterprises in Kebbi state, Nigeria. Data were collected from a sample of 160 fatteners using the multistage sampling technique. A translog stochastic frontier production function model was employed for the analysis in which technical efficiency effects are specified to be a function of socioeconomic variables estimated using the maximum likelihood method. The results of the analysis revealed that medication, feeds, fattening animals, depreciation, water and transportation are the dominant variables that influenced the level of technical efficiency in cattle fattening with coefficient values of (0.053, 0.452, 6.804, 1.058, 0.986 and 0.197), respectively. Technical efficiency indices varied from 0.74 to 0.98%, with a mean of 0.90%, indicating that there was no wide gap between the efficiency of best technical efficient fatteners and that of the average fattener. It also revealed that the fatteners were not operating at the optimal efficiency level thus, the need to increase the scope. The result also showed that fattening experience and herd size influenced the level of technical efficiency with coefficients of (-0.011 and -1.260) at 1% while household size with coefficients of 0.009 at 10%. This implies that fattening experience and herd size increases the technical efficiency of fattening while household size decreases the technical efficiency of cattle fattening. It is recommended that for cattle fatteners to increase their technical efficiency, they will need to increase their herd size so as to gain from economies of scale.

Keywords: Efficiency, Determinants, Cattle, Fattening Enterprises

I. Introduction

The problems of food insecurity and hunger have continued in recent years to attract the attention of experts and governments worldwide (Babatunde *et al.*, 2002). Animal protein especially meat is expensive, in short supply and is out of the reach of the majority of the population (Tanko and Jiya, 2010). The traditional method of domestic meat animal production results in low productivity due to the fact that animals receive the bulk of their nutrition from overgrazed ranges which are poor in quality (Iwuanyanwu, 2001). Furthermore, the size of such ranges is declining due to their use for industries including agricultural development projects devoted to especially crop production. The traditional system of meat animal production cannot thus be expected to meet the future demand for meat in particular and animal protein in general.

As a panacea, to bridge the demand- Supply gap for animal protein in terms of meat in Nigeria, there is the need to adopt other sustainable means of production. Thus, livestock fattening appears to be an alternative to meeting the increasing demand for meat in the nation. According to Oni (2006), the economic viability of cattle fattening enterprise is not in doubt, because raw materials needed for the venture can be sourced at ease, production technology is simple and the manpower requirement can be met with family labour.As an economic way of feeding animals whereby the yield of edible carcass is increased during a short period, fattening offers rapid means for enhancing productivity. Fattening has a role to play in a situation where range cattle are so under nourished that a short period on high level of nutrition is necessary to increase their productivity and to prepare them for market.It also has the tendency to forestall some of the problems leading to frequent clashes between herders and crop farmers in Nigeria. In an effort to develop other sustainable livestock production technologies so as to enhance meat availability within the shortest possible time and in view of the various agricultural programs and policies implemented over the years to raise farmers' efficiency and productivity, it becomes imperative to quantitatively measure the current level of technical efficiency and its determinants among cattle fatteners, given the fact that efficiency of production is directly related to the overall productivity of the agricultural sector (Ajibefun, 2002).

The measurement of efficiency remains an important area of research both in developing and developed economies. The measurement of efficiency goes a long way to determine profitability of an enterprise and agricultural growth is linked to profit. The relationships between efficiency, market indicators and household characteristics have not been well studied in livestock fattening enterprises. The dearth of empirical studies manifests in near absence of studies that determined the technical efficiency of cattle fattening enterprises using stochastic frontier production function approach. This study therefore used the translog stochastic frontier production function approach to provide estimates of technical efficiency and its determinants among cattle fattening enterprises in Kebbi State, Nigeria.

Animal Fattening is the feeding method of particular interest in order to increase the weight of the animals and quantity of meat in a relatively short time (Alawa *etal*., 2008; Osuhor, 2008; Umar *et al.*, 2014). The primary objective of smallholder livestock fatteners/farmers is to increase the live weight of the animal and quantity of meat in a relatively short time.

Theoretical Framework

A stochastic frontier analysis which requires a parametric representation of the production technology was employed in this research. In addition, it incorporates stochastic output variability by means of a two part error term. This approach was pioneered independently by Aigner et al (1977) and Meeusen & Van den Broeck (1977). The general notation of the model is as follows:

$$\gamma_i = h(x_i;\ \alpha) \exp(\varepsilon_i) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .. (1)$$

Where: γi is output of producer I (bounded above by the stochastic component $h(x_i;\ \alpha)\ \exp(\varepsilon_i)$, x_i is vector of inputs used by producer I, α is a vector of unknown technology parameters, $h(x_i;\ \alpha)$ is production frontier. The composed error, term is $\varepsilon_i = v_i - u_i$. Where V_i captures the effect of pure noise in the data attributed to measurement error extreme weather conditions etc. and $u_i$is one-sided error that captures the inefficiency effects. The symmetric element v_i account for random variation in output quantity attributed to factors outside farmer's control e.g. disease and weather while u_i account for random variation in output quantity attributed to factors under farmer's control. A one-sided component $u_i \leq 0$ reflects technical inefficiency relative to stochastic frontier. Thus $u_i = 0$ for farm output that lie on the frontier (100% technical efficiency in resource use) and $u_i = 0$ for farm output below the frontier as Nδ_u^2, v.

Conceptual framework

The conceptual framework for the study is based on the concept of the technical efficiency of resource utilization and the concept of production by Coelli *et al.* (1998). Technical efficiency shows the success of a firm enterprise, as it indicates ability of a firm to produce maximum output from a set of input mix (Farrell, 1957; Ali and Flinn 1989; Moses, 2017). Figure 1.1 illustrates the concept of a feasible production set which is the set of all inputs-output combination that are feasible. This set consists of all point between the production frontier, 0F and X-axis. The points along the production frontier define the efficient subset of this feasible production set. Point A represents an inefficient point whereas points B and C represent efficient points. A firm operating at point A is inefficient because technically it could increase output to the level associated with the point B without requiring more input.

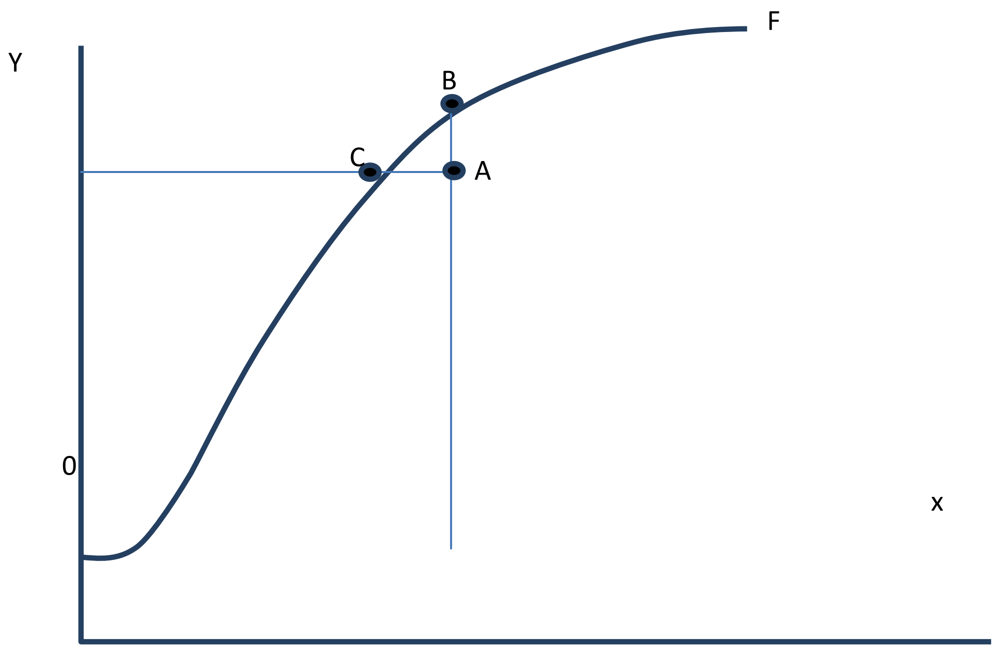

Figure 1.1 Production Frontiers and Technical Efficiency

Source: Coelli *et al*., 1998

Model specification

To any empirical research, the decision to select a functional form is very important because the selected functional form can significantly affect the parameter estimates (Kebede, 2001). The two common functional forms of stochastic frontier model generally used are: Cobb-Douglas and Trans-log functional forms. Cobb-Douglas functional form is very easy to adopt but it imposes a severe restriction on production elasticity to be constant and the elasticity of input substitution to be unitary. On the other hand, Trans-log functional form is known to be less restrictive, permitting for the combination of square and cross product terms of the exogenous variables with the view of having goodness of fit of the model.

Mean Production Function Specification

This research employed the trans-log stochastic production function model specified as follows:

$$Iny_j = \alpha_0 + \sum_{i=1}^{n} \alpha_i Inx_i + \frac{1}{2}\sum_{i=1}^{n} \alpha_{ii} Inx_i^2 + \sum_{i=1}^{n}\sum_{k=1}^{k} \alpha_{ik} Inx_k + \varepsilon_j$$

Where: γ_i is output of producer j, x_i is vector of inputs used by producer j, α_0, α_i, α_{ii} *and* α_{ik}

are vectors of unknown technology parameters, j is j-th farmer where j- 1,2,3, …, n and i is i-th input where i – 1,2,…, n. The composed error term is $\varepsilon_j = v_i - u_i$. Where v_i captures the effect of pure noise in the data attributed to measurement error, extreme weather conditions etc and u_i is one-sided error that captures the inefficiency effects.

Inefficiency model specification

Following the specification in equation above, the linear technical inefficiency model is specified as follows:

$$u_i = \delta_o + \sum_{r=1}^{15} \delta_r W_{rj}$$

Where $u_i^{'}s$ are inefficiency effects, δ_o and δ_r's are estimated coefficients of technical inefficiency model and W_r's are vectors of I producer technological/socioeconomic variables that consists of age, level of education, fattening experience, household size, herd size and credit access.

II. Methodology

Study Area

The study was conducted in Kebbi State, Nigeria. This was purposively selected due to its importance in livestock fattening.

Sampling Technique and Sample Size

The sampling method used was the multi-stage sampling technique. The State was divided in to four according to Kebbi State Agricultural Development Project (ADP) zones, namely Argungu, Bunza, Yauri and Zuru Zones. In the first stage, two Local Government Areas (LGAs) were randomly selected in each zone through lottery method (drawing lots), making a total of eight LGAs in the study. These include Argungu and Dandi LGAs in Argungu zone, Jega and Bunza LGAs in Bunza zone, Yauri and Ngaski LGAs in Yauri zone and Danko-Wasagu and Zuru LGAs in Zuru zone. Secondly, from each of the LGAs, two leading villages noted for cattle fattening were purposively selected giving a total of sixteen villages and from each village ten livestock fatteners were randomly selected through snow ball technique, giving a total of 160 fatteners that were interviewed for the study.

III. Data Analysis and the model

Data were collected at fortnight intervals so as to get comprehensive data using the cost route approach. Information on primary data collected includes input – output data on fattening enterprises. The weights of cattle fattened were obtained using a weigh band. The weigh band is set at the circumference of the body of the animal at a point immediately behind the fore- legs, perpendicular to the body axis. The weight in kilogram was then recorded. The difference between the initial body weight and the final body weight gives the weight gain.

Empirical model

$Ln\ y = \beta_o + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 Ln\ X_3 + \beta_4 Ln\ X_4 + \beta_5 LnX_5 + \beta_6 Ln\ X_6 + \beta_7 LnX_7 + ½\ \beta_{11} Ln\ X_1^2 + ½\ \beta_{22} LnX_2^2 + ½\ \beta_{33} LnX_3^2 + ½\ \beta_{44} Ln\ X_4^2 + ½\ \beta_{55} Ln\ X_5^2 + ½\ \beta_{66} Ln\ X_6^2 + ½\ \beta_{77} LnX_7^2 + \beta_{12} LnX_1 LnX_2 + \beta_{13} LnX_1 In\ X_3 + B_{14} LnX_1 LnX_4 + \beta_{15} LnX_1 LnX_5 + \beta_{16} LnX_1 LnX_6 + \beta_{17} LnX_1 LnX_7 + \beta_{23} LnX_2 LnX_3 + \beta_{24} LnX_2 LnX_4 + \beta_{25} LnX_2 LnX_5 + \beta_{26} LnX_2 LnX_6 + \beta_{27} LnX_2 LnX_7 + \beta_{34} LnX_3 LnX_4 \beta_{35} LnX_3 LnX_5 + \beta_{36} LnX_3 LnX_6 + \beta_{37} LnX_3 LnX_7 + \beta_{45} LnX_4 nX_5 + \beta_{46} LnX_4 LnX_6 + \beta_{47} LnX_4 LnX_7 + \beta_{56} LnX_5 LnX_6 + \beta_{57} LnX_5 LnX_7 + \beta_{67} LnX_6 LnX_{7+} Vi – Ui$

Where:

β_o	=	Constant term
β_1- β_{67}	=	Parameters to be estimated
Ln	=	Logarithm to base e.
Y	=	Output (Weight gain in Kg)
X_1	=	Labour in Man-days
X_2	=	Expenses on medication and veterinary services (₦)
X_3	=	Expenses on feeds and feed supplements (₦)
X_4	=	Expenses on fattening animals purchased (₦)
X_5	=	Depreciation on livestock fattening facilities such as housing, drinkers, ropes, rake, watering basin etc. (₦)
X_6	=	Quantity of water utilized in (liters)
X_7	=	Cost of transportation (₦)
Vi	=	Normal random errors which are assumed to be independently and identically distributed having zero mean and constant variance.
Ui	=	Non – negative random variables associated with the technical inefficiency of the enterprise(s) involved.
Ui	=	$\delta_o + \delta_1 z_1 i + \delta_2 z_2 i + \delta_3 z_3 i + \delta_4 z_4 i + \delta_5 z_5 i + \delta_6 z_6 i$
Z_1	=	Age of the livestock fattener in years
Z_2	=	Level of education in number of years spent in school
Z_3	=	Fattening experience in years
Z_4	=	Household size
Z_5	=	Herd size
Z_6	=	Dummy variable for credit access (1 for access to credit, 0 otherwise).
δ - δ_6	=	Unknown parameters estimated

IV. Results and Discussion

Parameter estimates for technical efficiency in cattle fattening enterprises are presented in Table 1. Result from Table 1 shows the sigma squared value of 0.018, is statistically significant at 1% level. This parameter estimate ascertains the goodness-of-fit and the correctness of the specified distributional assumptions of the composite error term. The estimate of the variance ratio/the gamma was 0.912 indicating that 91.2% of the disturbance in the system is due to inefficiency, one sided error and therefore 8.80% is due to stochastic disturbance with two–sided error, supported by the high t-value. Ohajianya (2005) and Moses (2017) in their various investigations obtained similar results.

Table1: Translog parameter estimates for technical efficiency in cattle fattening enterprise, Kebbi State, Nigeria

Production factor	Parameter	Coefficient	Standard error	t-ratio
Constant term/intercept	β_0	13.255	0.493	26.895***
Labour	β_1	-0.172	0.145	-1.183
Medication	β_2	0.053	0.027	1.988*
Feeds	β_3	0.452	0.241	1.875*
Fattening Animals	β_4	6.804	0.331	20.586***
Depreciation	β_5	1.058	0.257	4.113***
Water	β_6	0.986	0.284	3.473***
Transportation	β_7	0.197	0.096	2.054**
Squared terms				
Labour x Labour	β_{11}	0.023	0.032	0.712
Medication x Medication	β_{12}	0.008	0.005	1.689*
Feeds x Feeds	β_{33}	0.105	0.030	3.492***
Fattening Animals x Fattening Animals	β_{44}	0.653	0.050	12.948***
Depreciation x Depreciation	β_{55}	0.288	0.058	4.989***
Water x Water	β_{66}	0.145	0.045	3.212***
Transportation x Transportation	β_{77}	0.039	0.017	2.334**
Interaction among inputs				
Labour x Medication	β_{12}	0.006	0.013	0.504
Labour x Feeds	β_{13}	1.048	0.111	9.467***
Labour x Fattening Animals	β_{14}	-0.609	0.155	-3.927***
Labour x Depreciation	β_{15}	-0.732	0.129	-5.683***
Labour x Water	β_{16}	0.412	0.130	3.176***
Labour x Transportation	β_{17}	-0.058	0.043	-1.325
Medication /Feeds	β_{23}	-0.081	0.301	-0.269
Medication x Fattening Animals	β_{24}	-0.123	0.675	-0.183
Medication x Depreciation	β_{25}	-2.444	0.449	-5.438***
Medication x Fattening Animals	β_{26}	1.964	0.515	3.814***
Medication x Water	β_{27}	0.130	0.166	0.784
Medication x Transportation	β_{34}	3.489	0.543	6.420***
Feeds x Fattening Animals	β_{35}	2.557	0.796	3.213***
Feeds x Depreciation	β_{36}	-3.225	1.138	-2.834***
Feeds x Water		-3.038	1.437	-2.114**
Feeds x Transportation	β_{37}	-9.801	0.884	11.088***
Fattening Animals x Depreciation	β_{45}	-2.599	0.963	-2.698***
Fattening Animals x Water	β_{46}	8.210	0.810	10.135***
Fattening Animals x Transportation	β_{47}	12.692	1.491	8.512***
Depreciation x Water	β_{56}	-4.833	0.934	-5.176***
Depreciation x Transportation	β_{57}	-2.425	1.094	-2.217**
Water x Transportation	β_{67}			
Diagnostic statistics				
Log likelihood function		169.151		
Sigma square (δ°)		0.018	0.039	4.693***
Gamma		0.912	0.074	12.355***
LR test		8.682		

Source: Computer printout of Frontier 4.1

Asterisks ***, ** and * implying significant at 1, 5 and 10% levels respectively

Result from Table 1 indicates that the coefficients of the variables medication (0.053), feeds (0.452), fattening animals (6.804), depreciation (1.058), water (0.986) and transportation (0.197) carried positive signs. They were statistically significant at 1% level except for medication and feeds that were significant at 10% level. Output elasticity for fattening animals, depreciation and water utilized indicated that an increase by 1% of these variables will lead to 6.804, 1.058 and 0.986% increase in the output (weight gain) of livestock fattening, respectively. The result depicts that fattening animals and depreciation are the dominant production variables that influenced the technical efficiency in cattle fattening enterprise. The sum of output elasticity indicates that increasing returns to scale prevailed. Increasing returns indicates that an additional unit of input results in a larger increase in production than the preceding unit. In this scenario, resource use efficiency had not been attained and resources are misallocated. This finding disagrees with that of Nganga *et al* (2010) who found that feeds are the dominant variable that influenced profit efficiency among milk producers.

Most of the interaction terms (2^{nd} order coefficients) were statistically significant at the conventional significance levels (1, 5 and 10%), implying the suitability of the translog function (Okoye and Onyenweaku, 2007). Among the squared terms, the coefficients of feeds, fattening animals, depreciation and water are positive and highly significant at 1% level of probability, showing a direct relationship with weight gain (output). Coefficient of squared term for medication and transportation are significant at 10 and 5%, probability levels respectively. Coefficient of interaction between feeds x transportation and water x transportation are significant at 5% level of probability and have a direct relationship with weight gain in livestock fattening while interaction between labour x feeds, labour x fattening animals x depreciation, labour x water, medication x depreciation, medication x water, feeds x fattening animals, feeds x depreciation, fattening animals x water, fattening animals x depreciation, fattening animals x water, fattening animals x transportation, depreciation x water and depreciation x transportation shows direct relationship with weight gain and are highly significant at 10% level of probability.

The negative signs recorded against the slope coefficients of the variables for the interaction terms such as labour x fattening animals, labour x depreciation, medication x depreciation, feeds x water, feeds x transportation, fattening animals x depreciation, fattening animals x water, depreciation x transportation and water x transportation indicated that as more inputs were incurred on the farm, after reaching its thresh hold, the contribution of these items reduce the level of output or weight gain of the fattening enterprises. This is a sign that these resources were not being efficiently allocated or the farm is experiencing diminishing returns with respect to the variables. The finding is in agreement with that of Onoja and Emodi (2011) who found that the contribution of these interaction terms beyond the optimal level will decrease the level of efficiency.

Estimates of technical efficiency among cattle fatteners are presented in Table 2. The results of technical efficiency estimates of cattle fattening enterprises in Table 2 indicate that technical efficiencies range from 0.74 to 0.98. The mean technical efficiency was 0.90, indicating that there was no wide gap between the efficiency of best technical efficient fatteners and that of the average fatteners. The estimates reveal that for the average cattle fattener to attain the level of the most technically efficient fattener in the sample, he/she would require a cost savings of 8.16 percent that is (1-0.90/0.98%). The least technically efficient farmer will however, experience efficiency gain of about 24.49 percent that is (1-0.74/0.98%) to be able to attain the level of the most technically efficient cattle fattener.

Table 2: Distribution of cattle fatteners according to technical efficiency indices, Kebbi State, Nigeria

Technical Efficiency index	Frequency	Percentage
0.71-0.80	20	12.50
0.81-0.90	58	36.30
0.91-1.00	82	51.20
Total	160	100.00
Mean Technical efficiency	0.90	
Standard deviation	0.06	
Minimum Technical efficiency	0.74	
Maximum Technical efficiency	0.98	

Source: Computer printout of Frontier 4.1

Results from Table 2, indicate that about 51.20 percent of cattle fatteners attained between 0.91 and 0.98 technical efficiency levels. None of the cattle fatteners had an efficiency level below 60 percent. The high level of technical efficiency in cattle fattening is suggestive of the fact that only 10% is attributable to inefficiency. The efficiency distribution disagrees with that obtained by Moses (2017) who obtained efficiency level of less than 79 per cent. Although cattle fatteners in the study were inefficient in production technically, results revealed that the fatteners tended towards technical efficiency.

Results of the determinants of technical efficiency among cattle fattening enterprises are depicted in Table 3. The result in Table 3 with respect to technical efficiency determinants show that fattening years of experience (-0.011) and herd size (-1.260) have negative coefficients and are statistically significant at 1% probability levels. Negative coefficients of these variables connotes that the variables reduces technical inefficiency (increases technical efficiency). This is likely because, more experienced fatteners are likely to have extension contacts and therefore, more willing to adopt improved technology that would enhance their technical efficiency. This result is in consonance with that of Umar *et al*. (2014) who found out in their studies that fattening experience and herd size had negative coefficients while it disagrees with that of Moses (2017) who found out that herd size had positive coefficient. A negative and significant coefficient of herd size implies that herd size increases technical efficiency (decreases technical inefficiency among cattle fatteners). This result corroborates with those of Umar *et al*., (2014) who found similar outcome.

Table 3: Maximum likelihood estimates of the determinants of technical efficiency in cattle fattening enterprise, Kebbi State, Nigeria.

Variable	Parameter	Coefficient	Standard error	t-ratio
Intercept	Z_0	4.651	0.194	23.993***
Age	Z_1	0.001	0.003	0.061
Level of education	Z_2	0.009	0.007	1.301
Fattening experience	Z_3	-0.011	0.003	-3.493***
Household size	Z_4	0.009	0.005	1.840*
Herd size	Z_5	-1.260	0.043	-29.451***
Credit access	Z_6	-0.029	0.025	-1.174

Source: Computer printout of Frontier 4.1
***, **, * are significant levels at 1, 5 and 10% respectively.

V. Conclusion

Based on the findings of the study it can be concluded that technical efficiency indices varied from 0.74 to 0.98%, with a mean of 0.90%, revealing that there was still room for improving the technical efficiency of the average farmer to be able to attain the optimal technical efficient level. The results also revealed that fattening experience and herd size enhances the technical efficiency of the farmers. It is recommended that for Cattle fatteners to increase their level of technical efficiency, there is need to increase their herd size in order to gain from economies of scale.

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