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Estimating technical efficiency of small scale beef cattle fattening in the lake zone in Tanzania

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This study examines the technical efficiency of small-scale beef cattle fattening in eight districts of Mwanza and Shinyanga regions, the lake zone in Tanzania. Data were collected using a structured questionnaire which was administered to 90 randomly selected cattle fatteners from the eight districts. Data were analyzed using descriptive methods and stochastic frontier production function approach. The estimated stochastic frontier production function showed that the herd size was the critical variable that affected weight gain in beef cattle fattening and hence beef output. The efficiency analysis results show that the estimated farm level technical efficiency ranged between 48 to 98% with a mean of 91%, indicating that the majority of the beef cattle fattening operators in the study area are efficient though not at 100%. The socio-economic determinants of the respondents' technical efficiency were age, education, experience, extension services and ethnicity. These findings can be used by the Ministry of Livestock and Fisheries Development extension agents to promote beef cattle fattening in areas where beef cattle fattening is not practiced in the country.

Key words: Average daily weight gain (ADG), cattle fattening operators, enterprises, technical efficiency, Tanzania shorthorn zebu (TSZ).

INTRODUCTION

The beef sub sector in Tanzania is dominated by indigenous cattle breeds which account for about 94 percent of the national cattle herd kept traditionally under pastoral and agro-pastoral production systems (Ministry of Livestock Development (MLD), 2006). The remaining 6%, fall under improved dairy and beef cattle management systems. Indigenous cattle are made of Tanzania shorthorn zebu (TSZ) and boran and ankole [Ministry of Livestock and Fisheries Development (MLFD), 2011]. The Tanzania short horn zebu (TSZ) and ankole are the dominant indigenous breeds in the country.

These types are well known for their low genetic potential in terms of beef production (MLD, 2006). As a result, the contribution of livestock to the national economy as well as to the household's well-being is low. In 2010, for example the livestock sector contributed only 16 and 3.8% to the agricultural gross domestic product (AGDP) and national gross domestic products (NGDP), respectively and the sector grew by only 3.4% compared to 4.4% for the crop sector (United Republic of Tanzania-URT, 2011). There are two major factors contributing to this situation. First, low average meat production per head especially in the traditional beef production system

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where average cattle productivity is estimated to be 107 kg per head compared to the average of 166 kg per head for other developing countries and 198 kg per head for the world (FAOSTAT, 2005).

Second, the low rate of adoption of improved livestock production technologies such as use of artificial insemination to improve the size of animals and limited use of fattening technologies is another contributing factor (URT, 2011). Low productivity of beef cattle in addition with other factors such as low purchasing power for the most of the population in the country has prevented Tanzania from meeting the World Health Organization (WHO) recommendation of a minimum per capital consumption of meat of 50 kg per year. The per capita consumption of meat in Tanzania is estimated to be 12 kg, compared to the world average of 46.6 kg/year (FAOSTAT, 2005; MLFD, 2012).

In order to improve the contribution of livestock to the national economy and well-being at the household level, the government has formulated the Livestock policy and strategy geared towards improving livestock productivity and commercialization of the livestock in the traditional sector (MLD, 2006, 2010, 2011). In the course of implementing the strategy, efforts have been made to encourage nomadic pastoralists with large cattle herds to reduce their herds and settle in areas where they are allocated land for cattle grazing. Besides encouraging pastoralists to settle, beef cattle fattening has been earmarked as one of the means to improve beef cattle productivity. Beef cattle fattening is a recent undertaking in the country, but it is increasingly gaining importance in some traditional livestock keeping regions of Tanzania. According to MLFD (2012), the number of fattened animals in the country is estimated to be 132,229 heads of cattle. Out of these, the lake zone (Mwanza, Shinyanga and Kagera regions) which is the study area account for 46.6%. Beef cattle fattening has the potential to improve the Tanzanian economy, if well harnessed. However, this depends, to a large extent, on the efficiency of the production system, hence livestock productivity. Efficiency is concerned with relative performance of the processes used in transforming given input into output (Abu and Asember, 2011; Otieno et al., 2012). Efficiency measurement has received significant attention from researchers in different fields of study (Abu and Asember, 2011; Facayode et al., 2011; Dawing et al., 2011). Measuring efficiency is vital because it can guide resource utilization and may lead to considerable resource savings, which have important implication for both policy formulation and farm management (Bravo-Ureta and Rieger, 1991). However, to date there is no study carried out to investigate the technical efficiency of beef cattle fattening enterprises undertaken in the country.

This study investigates the technical efficiency of beef cattle fattening enterprises practiced in Shinyanga and Mwanza regions of Tanzania. The specific objectives of the study are to: (i) estimate the technical efficiency of beef cattle fattening in the study area and (ii) examine the relationship between technical efficiency and socio-characteristics of cattle fattening operators. Subsequent parts of the paper are organized into five main sections which include: the theoretical framework, methodological section, results and discussion, conclusion and recommendations.

Theoretical framework

Economic theory identifies three important efficiency measures (Boris et al., 1997; Effiong and Onyenweaku, 2006). These include; the allocative, economic and technical efficiency. The allocative efficiency (AE) reflects the ability of the farm to use the inputs in optimum proportions given their respective prices and the production technology. Economic efficiency (EE) is defined as the capacity of a firm to produce a predetermined quantity of output at minimum cost for a given level of technology. Technical efficiency (TE) is the measure of the farms success in producing maximum output from a given set of inputs. Alternatively, it is the ability to operate on the production frontier or the isoquant frontier (Effiong and Onyenweaku, 2006). This study examines the TE for beef cattle fattening operators in the study area.

METHODOLOGY

Sampling and data collection

Data for this study were collected from beef cattle fattening enterprises in Mwanza and Shinyanga regions in the lake zone in Tanzania. Geographically, Mwanza and Shinyanga regions lie in the Northern part of the country.

The sampling frame included all beef cattle operators who are engaged in beef cattle fattening in selected districts of Magu, Nyamagana and Sengerema in Mwanza region and Kahama, Kishapu, Meatu, Bariadi and Maswa districts in Shinyanga region as shown in Figure 1. The list of beef cattle fattening entrepreneurs was collected from the respective local government authority offices in the districts, from which 90 respondents were randomly selected. Global positioning system (GPS) devices were used to geo-reference all points where the interview were held.

Data were collected through face to face interviews conducted by the principal researcher during the dry season between July and September, 2011, with the assistance of local experienced interviewers who were adequately trained prior to the surveys. The data were collected during dry season because this is when fattening is practiced. During the wet season animals are able to get enough forage from the rangelands and are normally in good condition hence hardly any fattening was done. Data gathered include information on socio-economic variables of the entrepreneurs such as age, education, household size, location, experience, access to credit and extension services. Information was also collected on the inputs as well as output in terms of weight gain for fattened beef cattle. The inputs data collected included; feeds used, amount of minerals used, and treatment/drugs used while output data collected was the weight of beef cattle after the fattening period.

It was observed during the field survey that beef cattle fattening operators did not weigh their animals before and after fattening.
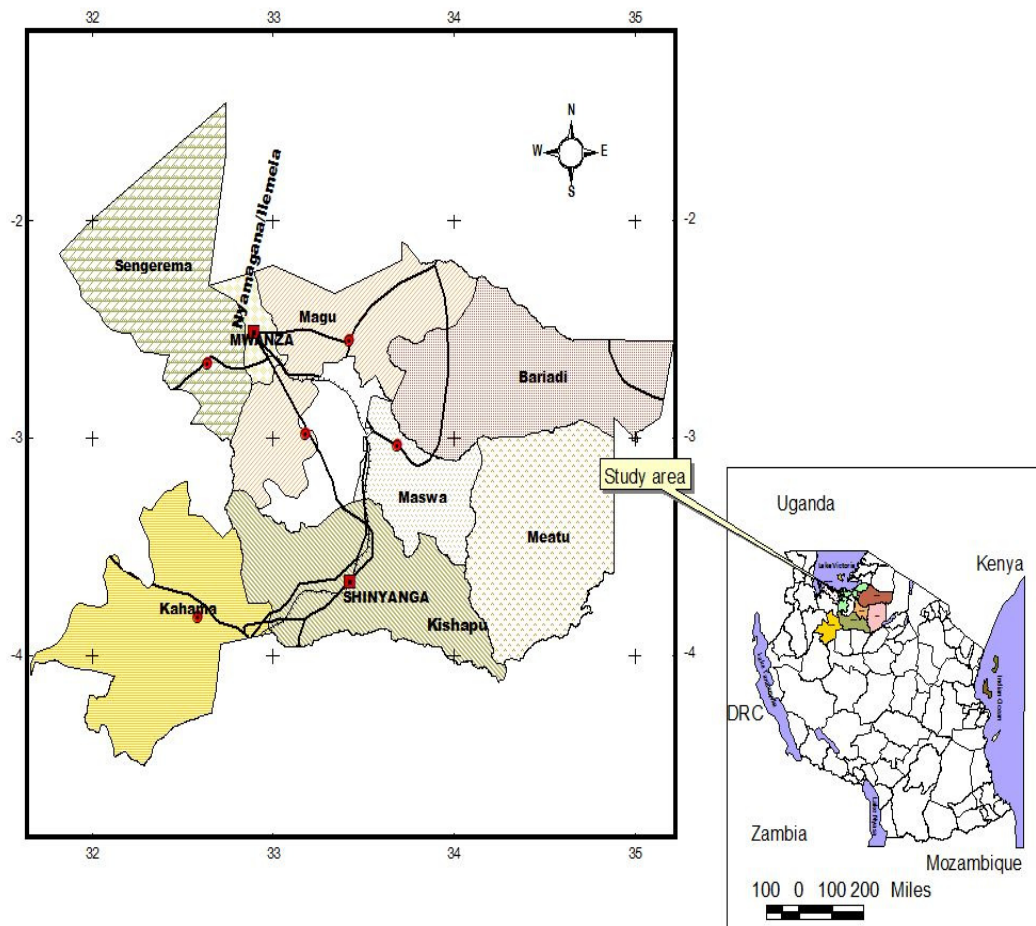
Figure 1. Location of the study area.

Also, they did not keep records of their business. In this regard, a control group of 105 animals were selected from Kahama district and used to determine the Average Daily Gain (ADG) along with 5675 animals (belonging to the respondents) whose weights were tracked during the study period covering 12 to 16 weeks (3 to 4 months). The animals under fattening were of the same breed that is Tanzanian short horn zebu (TSHZ) and same fodder conditions originating within the lake zone. Most of them were mature bulls and few culled cows purchased by the respondents from the livestock markets in the lake zone. A weight band tape, which is designed to take the live weight of animals such as; cattle, pigs, sheep and goats was used to measure the live weight of the study animals from each respondent (Figure 2a and b). The tape measure was used in the field because cattle weighing instruments are costly and heavy to transport and it is a practical field techniques, particularly in less developed countries. The animals' heart girth measurements were taken to predict animal's weights at entry, every two weeks thereafter and at exit.

Analytical framework

Technical efficiency can be estimated using computer software such as LIMDEP econometrics packages (Green, 1993) or the Frontier 4.1 program (Coelli, 1996) to find the maximum likelihood estimates for the parameters of the stochastic frontier production function. The stochastic frontier production function model is

popular because of its flexibility and ability to closely marry economic concepts with modeling the reality (Dawang et al., 2011). Battese and Corra, 1997 applied the technique to the pastoral zone of the Eastern Australia.

Recently, many studies have been done in Africa using the technique which include; Facayode et al. (2011), for Technical efficiency analysis on small scale rabbit production in South to West Nigeria, Dawang et al., 2011 used the technique to estimate the profitability and technical efficiency of artisanal fishermen also in Nigeria, while Oleke and Isinika (2008) used the technique to assess the technical efficiency of commercial egg production in Tanzania.

Stochastic frontier production function analysis (SFA)

Farmers in agricultural production aim at maximizing production, minimizing costs and maximizing profits. However, though every producer may attempt to optimize, not all of them may succeed in their efforts. Given the same inputs and technology, some farmers will produce more efficient than others. Econometrics estimation techniques allow for the fact that deviations of observed choices from optimal ones are due to either failure to optimize (inefficient) or due to random shocks.

The SFA produces efficiency estimates or scores of individual producers, thus identifying those who need interventions and corrective measures. The variations of efficiency scores can be

Figure 2. (a) Weight band tape.   (b) Estimating live weight using weight band tape.

related to producer's characteristics like age, size, ownership, location, education etc. Thus one can identify source of inefficiency. The SFA also provides a powerful tool for examining effects of interventions. A stochastic production frontier model using the FRONTIER 4.1 statistical software developed by Coelli (1996) was used to estimate the technical efficiency of beef cattle fattening in the study area. This analysis has the advantage of separating the impact of weather and other factors that contribute to variations in technical efficiency.

A frontier model with output-oriented technical efficiency according to Battese and Coelli (1995) is specified in Equation 1.

$$Y_i = X_i \beta + (\varepsilon = \nu_i - \mu_i \tag{1}$$

Where; Y_{ij} = is the (logarithm of) output in terms of weight gain obtained by the i-th respondents from the jth animal (for i = 1, 2,3 N; and j = 1,2,3, ...m), X_{ik} = is the corresponding matrix of K inputs, β = is a kx1 vector of unknown parameter to be estimated, ε_i is the disturbance term comprised of two independent components, V_i and U_i, V_i = are random variables which are assumed to be i.i.d. N (0, δ^2_v), and independent of the U_i 's and U_{is} = are non negative random variables which are assumed to account for technical inefficiency in production and are assumed to be independently distributed as truncations at zero of the N (m_i, δ^2_u).

The maximum likelihood estimation of Equation 1 provides the estimators for β_j and variance estimators and other relationships denoted as;

$$\delta^2 = \delta^2_v + \delta^2_\mu \cdot \tag{2}$$

$$\gamma = \delta^2_v / \delta^2 \tag{3}$$

$$\lambda = \delta^2_v / \delta^2_\mu \cdot \tag{4}$$

Where, δ^2, δ^2_v, δ^2_u are the overall variance of the model, variance of the random error, and variance of the technical inefficiencies respectively. According to Battese and Corra (1997), gamma (γ) is the total output made on the frontier function which is attributed to technical efficiency. The parameter gamma (γ) has a value between zero and one. Hence (1- γ) measures the technical inefficiency of the farms. The parameter lambda (λ) is expected to be greater than

one. This condition according to Facayode et al. (2011) indicates a good fit for the model and correctly specified error term (V_i and U_i). From Equation 1, the polynomial of degree 2 technical efficiency equation for beef cattle fattening in the study area was specified as follows;

$$InY_i = \beta_o + \beta_1 InX_1 + \beta_2 InX_2 + \beta_3 InX_3 + \beta_4 InX_4 + \beta_{12} InX_1 InX_2 + \beta_{13} InX_1 InX_3$$
$$+ \beta_{14} InX_1 InX_4 + \beta_{23} InX_2 InX_3 + \beta_{24} InX_2 InX_4 + \beta_{34} InX_3 InX_4$$
$$+ \tfrac{1}{2} (\beta_{11} InX_1^2 + \beta_{22} InX_2^2 + \beta_{33} InX_3^2 + \beta_{44} InX_4^2) + \beta_5 X_5 + \beta_6 X_6$$
$$+ (\nu_i - \mu_i) \tag{5}$$

Where; In = denotes the natural logarithm (base e), Y_i = is the total weight gain over the study period for the jth animal of the ith respondent for I = 1, 2, 3...n and for j = 1, 2, 3...k, X_1 = Herd size in numbers denoted as HERDSIZE, X_2 = Supplementary feeds in kg denoted as FEED, X_3 = Treatment index denoted as TREAT, X_4 = Minerals index denoted as MINERAL, X_5 = Location of farmers denoted as LOC (Dummy), X_6 = Fattening potential according to farmers perception denoted as FATPOT (Dummy) and β_{ij} = A vector of parameters to be estimated

Technical inefficiency model

According to Battese and Coelli (1995) in the efficiency model, the one sided error term is specified as;

$$\mu_i = \delta_0 + \sum \delta_m Z_{mi} + \omega_{it} \cdot \cdot \tag{6}$$

Where; Zs are social economic variables used to explain efficiency differences among beef cattle fatteners, where the parameters δ_m are unknown, to be estimated and ω_{it} are iid random variable with zero mean and variance defined by the truncation of the normal distribution. The specific Z variables in the above model can be specified as follows:

$$U_i = \delta_0 + \sum\sum\delta_{ij}Z_{ij} \tag{7}$$

Where: U_i = the technical inefficiency of the ith respondent for i = 1, 2, 3, ..., N; Z_{ij} = the jth socio-economic variable for the ith respondent for i = 1, 2, 3, ..., N and j = 1, 2, 3, ..., k δ_0 = the intercept, and δ_j = the coefficient for the Kth variable.

Table 1. Average daily weight gain per animal.

Variable	Mean	Min	Max.	Std	Mode
Duration of fattening (days)	92	60	240	21.9	90
Average weight gain per animal over the study period (Kg)	58.6	37.7	151.1	13.6	56.6
Average daily weight gain per animal (Kg)	0.646	0.236	1.259	0.116	0.630

Source: Field survey data, 2011/2012.

The socio-economic variables represented in this study include; 1 = age, 2 = educational level in years, 3 = experience, 4 = housing type, 5 = Ethnic group, 6 = access to credit and 7 = extension services. The technical inefficiency in Equation 7 can be estimated if the technical inefficiency effects, U_i are stochastic and have particular distributional properties (Battese and Corra, 1997). Under the null hypothesis gamma (γ) = 0, the stochastic model reduces to a traditional average response function, thus no technical inefficiency effects exist. The null hypothesis was tested using log likelihood ratio test as follows;

$$\lambda = -2 \, In \, \{ L(H_0) \} - In \, \{ L(H_i) \}. \tag{8}$$

Where; $L(H_o)$ and $L(H_i)$ are values of likelihood function under the null hypothesis and the alternative (H_i) hypothesis, respectively.

RESULTS AND DISCUSSION

Determination of average daily weight gain (ADG)

The ADG was calculated by subtracting the initial weight from the final weight and dividing by the number of fattening days. The computed ADG is as shown in Table 1.

The ADG per animal was 0.646 kg and the mean fattening duration was 92 days. This finding compares well with similar finding by Mwilawa (2012) which revealed that ADG for Boran beef cattle kept under station conditions in Tanzania was 0.889 kg which implies that traditional beef cattle respond to fattening.

Results of technical efficiency analysis

Descriptive statistics of variables used for the production function frontier estimation are presented in Table 3. The mean total animal weight gain per farmer (obtained by multiplying the average daily weight gain per animal (0.646 kg/day) with the number of animals per enterprise and the duration of fattening) was 3607.75 kg with a standard deviation of 4292.2 kg. The large value of standard deviation implies that the beef cattle fattening operators were raising different numbers of animals with a minimum of 4 animals and a maximum of 330 animals.

The mean quantity of supplementary feed used per farmer was 1053.8 kg with a minimum of 0 and maximum of 7800 kg. There was variability in feed usage by cattle fatteners measured by the minimum and maximum amounts, which was confirmed by the large value of the

standard deviation. This may be due to differences in feed ranging from exclusive standing hay to different additional quantities of supplementary feeds. Feed scarcity and the high cost of feeds as it was observed during the survey, making it difficult for most operators to provide adequate feed for speedy weight gain of the animals. This implies that improvement in feed availability in the study area may lead to improvements in animals' weight gain and reduce the duration of beef cattle fattening.

The mean mineral index (calculated as a ratio of feeds) was 0.004 while the mean for the treatment index was 0.32. The location of the respondent (urban = 1 or peri-urban = 0) was included in the model as dummy variable. The fattening potential according to farmers perception of the animals (un-castrated bulls = 1 or castrated bulls and cows = 0) was also included as a dummy variable to test farmers' preferences to fatten un-castrated beef cattle bulls over castrated bulls and cows as observed during the survey. A summary of all the descriptive statistics is presented in Table 2.

Most of the entrepreneurs who were engaged in beef cattle fattening were middle aged being 39.5 years on average age with a standard deviation of 9.2 years. This shows that most farmers were middle aged people. The average year of schooling was 6.8 years with a minimum of 0, a maximum of 16 and a standard deviation of 3 years, hence most of the farmers attended at least primary school. The average experience in beef fattening was 5.4 years with a standard deviation of 4.6 years implying that most of the farmers are relatively new in the beef fattening enterprises, but the most experienced operator had been 26 years in the business. Other variables such as the average housing type, credit provision, extension services and ethnic group were included in the model as dummy values.

Results of stochastic frontier production analysis

Equation 8 was used to test the assumption of the trans-log model specification for the beef cattle fattening. The maximum likelihood estimates of the stochastic frontier production function are presented in Table 3. The findings show that, the value of lambda (λ) was greater than one (17.36) implying goodness fit for the estimated model and also correct specification of the error term

Table 2. Descriptive statistics of variables used in the stochastic frontier analysis.

Variable	Notation	Mean	SD	Min	Max
Total animal weight gain per farmer (kg) for the study period	WGAIN	3607.8	4292	151.1	18699
Number of animals per farmer (N)	HERDSIZE	63.6	76	4	330
Feeds usage (kg)	FEED	1053.8	1214	0	7800
Treatment (Index)	TREAT	0.32	1.8	0	16.7
Mineral Intake (Index)	MINERAL	0.004	0.006	0	0.343
Location	LOC	0.45	0.5	0	1
Fattening Potential	FATPOT	0.4	0.5	0	1
Age (years)	AGE	39.5	9.2	24	69
Education (years)	EDUYRS	6.8	3	0	16
Experience (years)	EXP	5.4	4.6	1	26
Housing type	HOUSE	0.8	0.4	0	1
Credit provision	CREDIT	0.06	0.2	0	1
Extension services	EXT	0.6	0.5	0	1
Ethnic group	ETHNIC	0.8	0.4	0	1

Table 3. Maximum Likelihood estimates of trans-log production function.

Variable	Par.	Expected sign	Coeff.	SE	t-ratio
Constant	β_0		4.874	0.13	37.451
LNHERDSIZE	β_1	-	6.036*	3.232	1.868
LNFEED	β_2	+	1.031	1.214	0.85
LNMINERAL	β_3	-	3.276*	1.895	-1.729
LNTREAT	β_4	+/-	1.758*	1.06	-1.659
LNHERDSIZE^2	β_5	+/-	2.581*	1.617	-1.596
LNFEED^2	β_6	-	-0.613	0.608	-1.009
LNMINERAL^2	β_7	+	1.637*	0.949	1.724
LNTREAT^2	β_8	+	0.915*	0.535	1.71
LN HERDSIZE X FEED	β_9	+	0.093**	0.041	2.284
LN HERDSIZE X MINERAL	β_{10}	+	0.005	0.049	0.097
LN HERDSIZE X TREAT	β_{11}	-	-0.043	0.046	-0.942
LN FEED X MINERAL	β_{12}	+/-	0.025	0.033	0.749
LN FEED X TREAT	β_{13}	+/-	-0.006	0.037	-0.168
LN MINERAL X TREAT	β_{14}	+/-	-0.03	0.053	-0.565
LOCATION	β_{15}	+/-	0.015	0.043	0.344
FATPOT	β_{16}	+/-	0.033	0.038	0.867
Variance parameter					
Sigma-squared	σ^2		0.082***	0.026	3.154
Gamma	Y		0.853***	0.066	13.02
log likelihood (LLF)			46.18		
Lambda	λ		17.36		
Inefficiency effect					
AGE	δ_1	-	-0.044**	0.021	-2.1
AGE^2	δ_2	+/-	0*	0	1.97
EDUC	δ_3	-	0.314***	0.09	3.485
EDUC^2	δ_4	-	-0.02***	0.006	-3.542
EXP	δ_5	-	-0.073*	0.04	-1.814
EXP^2	δ_6	+/-	0.004*	0.002	1.83

Table 3. Contd.

HOUSING	δ_7	+/-	0.085	0.155	0.549
CREDIT	δ_8	-	-0.104	0.14	-0.746
EXTENSION	δ_9	-	-0.366**	0.153	-2.387
ETHNIC	δ_{10}	-	0.531***	0.173	-3.068

Level of Significance; *** α = 0.01; ** α = 0.05; * α = 0.1

distribution. This was also evident from the estimated Gamma (Y) value of 0.853 which measures the level of inefficiency of the production system, this was significant at α = 0.05 and was above the 50 percent of a unity. These results imply that within the study area, about 85.3% of the variation in beef cattle fattening is explained by inefficiency, whereas the remaining 14.7% (that is 1-Y = 0.147) is due to measurement error and specifications bias as well as other factors that are not incorporated in the stochastic frontier and inefficiency effects models. This further confirms that the technical inefficiency effects are significant in the estimated model. The variance parameter (σ^2) was also positive (0.082) and significantly greater than zero at α = 0.05.

The inefficiency model estimates

The inefficiency analysis of the stochastic frontier indicated the coefficients for age, education^2, experience; extension contact and ethnic group were all negative and significantly different from zero, suggesting that increasing these variables will increase technical efficiency. However, ageing (age^2) does not contribute to technical efficiency such that the coefficient for this variable is zero. The estimated coefficient on education is positive and significantly greater than zero indicating increase in production inefficiency. However, as the education level increases (Education^2) the effect on technical efficiency is negative and statistically significant indicating reduction in production inefficiency. In other words, education (years of schooling) had a positive correlation with technical efficiency. These results are consistent with Ogunniyi (2011) and Dawing et al. (2011) who established that for every extra year of schooling that a farmer/fisher got, there was an increase in the chance or probability of being technically efficient.

The estimated coefficient on experience is negative and statistically significantly different from zero, contributing to decrease in technical inefficiency by 7.3% for every year of increase in experience. Credit access showed a negative relationship with technical inefficiency as expected though it was not significant implying that only few farmers had access to credit. Having access to credit reduced the level of inefficiency of respondents by 1.04%. This means policies that will make micro-credit from government and non-governmental agencies accessible to these farmers will go a long way to address

their resource use inefficiency problems. The coefficient for extension service contact was negative and significantly different from zero indicating that if a respondent had contact with extension services they were likely to experience increase in technical efficiency equivalent to about 3.66% average daily weight gain of the fattening animals. The Ethnic group was negative and significant (α < 0.05) indicating that Sukuma group (denoted as 1) were more involved in beef cattle fattening compared to other ethnic groups (denoted by zero).

Technical efficiency score analysis

The frequency distributions of technical efficiency (TE) scores are presented in Table 4. The findings show the beef fattening enterprises achieved on average 91% level of efficiency, ranging from 48 to 98% with a wide range of efficiency variation among the operators (Appendix 1). About 81.6% of beef cattle fattening operators operate at 91% TE or more while 13.8% were able to achieve 81% up to 90% TE levels. The results also suggest that about 98.7% of the respondents were able to achieve above 50% of the technical efficiency. Only 1.1% of the enterprises operated at 50% or less (Appendix 1). These results suggest that the majority of the respondents operate efficiently though not at 100%, there is still room for improving technical efficiency of few beef cattle fattening enterprises in the study area.

CONCLUSION AND RECOMMENDATIONS

This study applied the stochastic frontier model to estimate technical efficiency of beef cattle fattening. Results give efficiency scores that range from 48 to 98%, suggesting that there is room for improving the low performing cattle fattening enterprises. Further, it was found that education, experience, access to credit, extension services and ethnicity of cattle fattening operator contribute negatively to inefficiency that is, positively to efficiency improvement in cattle fattening. On the other hand, location and housing type did not have a positive influence on efficiency in cattle fattening, probably indicating that these variables did not render any technological differences among the cattle fattening entrepreneurs in the study area. All these findings have important implications on improving beef fattening

Table 4. Technical Efficiency scores for the sampled beef cattle operators.

Technical efficiency level (%)	No. of farmers	Percentage
<50	1	1.1
51-60	1	1.1
61-70	1	1.1
71-80	1	1.1
81-90	12	13.8
>91	71	81.6
Total	87	100
Mean	0.91	
Standard Deviation	0.08	
Minimum	0.48	
Maximum	0.98	

efficiency in Tanzania. The positive relationship of education and extension on technical efficiency imply providing appropriate knowledge and skills would facilitate better use of the available cattle fattening technologies by the operators who are currently operating inefficiently. Necessary interventions would include improving fattening operators' knowledge on feeding and disease control methods.

The negative relationship between access to credit and inefficiency implies that policies that will improve access to credit from government and non government agencies would increase the cattle fattening operators' ability to acquire better technologies (better cattle breeds and feeds through acquisition of mini to medium ranches where pastures could be improved and herd size expanded) with the potential of increasing productivity for domestic and export market. The efforts by the government to establish an agricultural bank is likely going to improve access to credit by farmers in Tanzania including cattle fattening operators if the bank conditions for credit will be favorable. These findings can be used by the Ministry of Livestock and Fisheries Development extension agents to promote beef cattle fattening in areas where beef cattle fattening is not practiced in the country.

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Appendix 1. beef cattle fattening operators individual efficiency score

Beef Cattle fattening operators No.	Efficiency score	Percentage
1	0.96214561	96.21
2	0.94622229	94.62
3	0.90990675	90.99
4	0.90836731	90.84
5	0.91718459	91.72
6	0.94651977	94.65
7	0.92162874	92.16
8	0.91154839	91.15
9	0.92729179	92.73
10	0.94453186	94.45
11	0.9178525	91.79
12	0.95143245	95.14
13	0.95393396	95.39
14	0.95476767	95.48
15	0.91568868	91.57
16	0.90804903	90.8
17	0.93534417	93.53
18	0.9089111	90.89
19	0.97801878	97.8
20	0.93575987	93.58
21	0.9321321	93.21
22	0.91532701	91.53
23	0.9009158	90.09
24	0.90640892	90.64
25	0.93834282	93.83
26	0.95582983	95.58
27	0.94903479	94.9
28	0.92827808	92.83
29	0.84726318	84.73
30	0.97484628	97.48
31	0.96947349	96.95
32	0.90510863	90.51
33	0.93306386	93.31
34	0.63422246	63.42
35	0.96445711	96.45
36	0.91327269	91.33
37	0.83504685	83.5
38	0.95367473	95.37
39	0.91304118	91.3
40	0.9195629	91.96
41	0.96544705	96.54
42	0.92534497	92.53
43	0.96375558	96.38
44	0.92175427	92.18
45	0.95109311	95.11
46	0.93799274	93.8
47	0.96986503	96.99
48	0.89269371	89.27
49	0.90672046	90.67
50	0.94312793	94.31
51	0.95021185	95.02

Appendix 1

52	0.91480716	91.48
53	0.87264073	87.26
54	0.9002228	90.02
55	0.96420636	96.42
56	0.94762449	94.76
57	0.96078686	96.08
58	0.95389044	95.39
59	0.9462963	94.63
60	0.91920711	91.92
61	0.93534727	93.53
62	0.94473073	94.47
63	0.92517926	92.52
64	0.9157181	91.57
65	0.89907558	89.91
66	0.95832715	95.83
67	0.90969569	90.97
68	0.90579944	90.58
69	0.92821406	92.82
70	0.85060658	85.06
71	0.95608835	95.61
72	0.94071958	94.07
73	0.88981	88.98
74	0.94438271	94.44
75	0.86631765	86.63
76	0.91320091	91.32
77	0.97630442	97.63
78	0.52971188	52.97
79	0.963581	96.36
80	0.47609183	47.61**
81	0.93853943	93.85
82	0.93368394	93.37
83	0.74611235	74.61
84	0.92489804	92.49
85	0.91071263	91.07
86	0.9428072	94.28
87	0.82394518	82.39

**Below 50%.