Determinants of Technical Efficiency of Smallholders Dairy Farmers in Njombe District, Tanzania

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Abstract

This paper is based on a study conducted in nine dairy cattle keeping villages of Njombe district in Tanzania with the overall objective of estimating Technical Efficiency (TE) and analyzing factors influencing Technical Inefficiency (TI) of smallholder dairy farmers. Cobb-Douglas stochastic frontier production function in which the parameters for the production frontier and for the inefficiency model were estimated jointly using the maximum likelihood technique on cross section data of 81 smallholder dairy farmers. Findings reveal that majority of respondents (61.7%) had TE below 50%. The implication of these findings is that majority of the respondents were technically inefficient and that the value of dairy production could be increased by 54.54% through better allocation and use of available resources. The inefficiency model showed that age, gender, education level, experience of the farmer and selling to processor are major factors having a significant and positive influence on the farmers' technical inefficiency while marital status and use of hired labor are the major factors having a significant and negative influence on the farmers' technical inefficiency.

Key words: Technical efficiency; Technical inefficiency; stochastic frontier production function; maximum likelihood estimates; Returns to scale

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1.0 Introduction

Smallholder dairy farming is one of the fast growing enterprises in the livestock industry in Tanzania. Smallholder dairy production though limited in size, has been receiving more emphasis in investment and improvement because of four main reasons namely: improvement of nutritional status of the society through increased milk consumption, increased cash income for dairy farmers, saving in terms of reduced dairy import and contribution to market oriented economy (National Livestock Policy, 2006).

Despite government and donor efforts to improve milk production, production of milk and other dairy products has not kept pace with population and urbanization growth, (Sumberg 1997). Total milk production from indigenous cattle and improved cattle is currently estimated at 1.6 billion liters (Budget Speech, 2009). The overall per capita milk availability is low (42 liters/annum) compared with Kenya (80 liters/annum), the average for Africa (35 liters/annum) and the world average (105 liters/annum) Kurwijila, (1995).

According to the MoAC/SUA/ILRI (1998) milk demand projections to the year 2010 (based on consumption level of 22 litres per-capita per annum, urbanization level of 5% per annum, a population growth rate of 2.3% per annum, an overall income elasticity of dairy products of 0.8 and modest real GDP growth of 1% per annum) demand is estimated to increase by 60% annually or per-capita consumption of 44 and 30 litres per annum respectively in urban and peri-urban areas. On the other hand, milk production (under assumptions that: no change in cattle herd productivity and structure, an increase in indigenous cattle population of 1.7% per annum and dairy herd expansion of 46% per annum) would increase by 43% resulting in a short fall of some 17%. These observations suggest that without substantial effort to improve the performance of dairy sector, Tanzania will face severe shortage of milk and dairy products.

Inadequate production of milk and dairy products may potentially be explained by the fact that most smallholder farmers practice subsistence farming with low and varied productivity. This may be attributed to both high technical and allocative inefficiencies. Although some of the factors that lead to low productivity have been identified, socio-economic and institutional factors that are expected to have significant influence on technical efficiency of smallholder dairy farmers are still not well empirically established. This paper focuses on estimating technical efficiency and factors influencing technical inefficiency of smallholder dairy farmers in Njombe district, Tanzania.

The Cobb-Douglas stochastic frontier production function in which the parameters for the production frontier and for the inefficiency model were estimated jointly using the maximum likelihood technique on cross section data of 81 smallholder dairy farmers. Findings reveal that majority of respondents (61.7%) had TE below 50%. The implication of these findings is that majority of the respondents were technically inefficient and that the value of dairy production could be increased by 54.54% through better allocation and use of available resources. The inefficiency model showed that age, gender, education level, experience of the farmer and selling to processor are major factors having a significant and positive influence on the farmers' technical inefficiency while marital status and use of hired labor are the major factors having a significant and negative influence on the farmers' technical inefficiency.

The remainder of this study is organized as follows. Section two provides the methodology. Section three reports the estimated coefficients and discusses the results. Section four gives conclusions and policy implications.

2.0 Methodology

2.1. Data collection methods

A sample of 81 smallholder dairy farmers was selected from the population of the smallholder dairy farmers in the nine selected villages of Njombe District. Sample representatives were selected from each village using random sampling technique. Data was collected using a semi structured questionnaire containing both closed and open ended questions in a face to face interview. Secondary data was collected through documentary review.

2.2. Analytical Framework and model specification

The stochastic frontier production function analysis was used to estimate the coefficients of the parameters of the production function and also to predict the technical efficiencies of the dairy farms. The production technology of the farmer was assumed to be specified by the Cobb Douglas frontier production function which is specified as follows:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + V_i - U_i \quad (1)$$

Where *i* and *Ln* are the *i*th farmer and the logarithm to base *e*, respectively; *Y* denotes the value of dairy outputs in Tanzania Shillings, X_1 is veterinary costs, X_2 is concentrate feed costs in Tanzania Shillings, X_3 other costs in, X_4 lactating in numbers; X_5 daily hours spent on dairy Activities in hours; Vi is random errors which covers random effects on production outside the control of the decision unit and U_i is technical inefficiency effect which is the result of behavior of factors which could be controlled by an efficient management (Xu and Jeffrey, 1998). V's are random errors which are assumed to be independent and identically distributed having zero means and unknown variance N. (U, σ_u^2). U's are technical inefficiency effects, which are assumed to be independent of V's. Where Ui is defined by:

$$\begin{aligned} U_i = {} & \delta_0 + \delta_1(\text{Age}) + \delta_2(\text{gender}) + \delta_3(\text{Marital status}) + \delta_4(\text{Education level}) + \delta_5(\text{Experience}) + \\ & \delta_6(\text{Household size}) + \delta_7(\text{Group Membership}) + \delta_8(\text{Off farm income}) + \delta_9(\text{Herd size}) + \\ & \delta_{10}(\text{Dairy training}) + \delta_{11}(\text{contact with extension agent}) + \delta_{12}(\text{Hired labour}) + \delta_{13}(\text{sale on credit}) + \\ & \delta_{14}(\text{Selling to processor}) + W_i \end{aligned} \quad (2)$$

Where w_i is a (*iid*) random error term, which is defined by the truncation of the normal distribution with zero mean and variance, σ^2_u. Socio -economic characteristics were included in the model to indicate their possible influence on the Technical efficiencies of the dairy farms. The method of the maximum likelihood was used for estimating the parameters of the stochastic frontier equation. The parameters estimated involved β and variance parameters such as $\sigma^2 = \sigma^2_v + \sigma^2_u$ and $\gamma = \sigma^2 / \sigma^2_u$ (Battese and Corra, 1977).Where, σ^2 is the sum of the error variance, while γ measures the total variation of output from the frontier attributed to the existence of random noise or inefficiency.

It should be noted that both the frontier model (Equation 1) and the inefficiency model (Equation 2) may include intercept parameters if the inefficiency effects are stochastic and have particular distributional properties (Coelli and Battese, 1996). Hence it was necessary to test the following null hypothesis:

i) H_0: $\gamma = \delta_0 = \delta_1 = \delta_2 .... = \delta_{14} = 0$ which specifies inefficiency is absent from the model.
ii) H_0 :$\gamma = 0$, which specifies that the inefficiency effects are not stochastic,
iii) H_0: $\delta_0 = \delta_1 = \delta_2 .... = \delta_{14} = 0$ which stipulates that, the coefficients of the explanatory variables in the inefficiency models are simultaneously zero,
iv) H0: $\delta_1 = \ldots = \delta_{14} = 0$, which state, that the coefficients of the variables in the model for inefficiency effects are zero.

The tests of these hypotheses for the parameters of the frontier were conducted using the generalized likelihood ratio statistics (Coelli and Battese, 1996), defined as;

$$LR = -2\{\ln[L(H0)] - \ln[L(HI)]\} \quad (3)$$

Where ln{*L(Ho)*} and ln{*L(H1)*} are the values of the log-likelihood function under the null *(Ho)* and alternative *(H1)* hypotheses, respectively. The restrictions form the basis of the null hypothesis, while the unrestricted model being the alternative hypothesis. LR has a Chi-squared (χ 2) distribution with the number of degrees of freedom provided by the number of restrictions imposed except cases where the null hypothesis also involves the restrictions of γ = 0. In such cases, the asymptotic distribution of the likelihood ratio test statistic is a mixed-χ 2 distribution and therefore the appropriate critical values are drawn from Kodde and Palm (1986) at q + 1 degrees of freedom, where q is the number of parameters to be estimated.

Based on the model estimations, the output for each farmer could be compared with the frontier level of output that is known as the best output given the level of inputs employed, and this deviation indicates the level of inefficiency of the firm. Therefore, the technical efficiency score for the *i*th farmer in the sample (TE_i) under equations (1) and (2) that would be defined as the ratio of observed output to the corresponding best output is given by (Coelli *et al*., 2005):

$$TE_i = q_i / \exp(\ln \beta x + v_i) = \exp(\ln \beta x + v_i - u_i) / \exp(\ln \beta x + v_i) = \exp(-u_i) / (-z_i \delta - w_i) \quad (4)$$

where TE_i is relative technical efficiency of the firm ($0<TE<1$). Note that, when $u_i = 0$ then the *i*th farmer lies on the stochastic frontier and known as technically efficiency. If $u_i > 0$, the farm *i* lies below the frontier, which means that the farm is inefficient.

3.0. Results and Discussion

3.1. Hypothesis Testing

Tests of various null hypotheses associated with the models were carried out using likelihood-ratio (LR) statistics which have approximately χ^2 distribution , except cases where the null hypothesis also involves the restrictions of $\gamma = 0$. In such cases, the asymptotic distribution of the likelihood ratio test statistic is a mixed- χ^2 distribution and therefore the appropriate critical values were drawn from Kodde and Palm (1986). Table 1 presents the results of the hypothesis tested with generalized likelihood ratio tests.

Table 1: Generalized Likelihood Ratio Hypothesis Tests

Null Hypothesis	Test Statistic	Calculated Value	Critical Value	Degree of freedom	Decision at α = 1%
$H_0: \gamma = \delta_0 = \delta_1 = \delta_2 .... = \delta_{14} = 0$	χ2-test	105.097	31.353	16	Rejected
$H_0 : \gamma = 0$	χ2-test	42.970	39.664	22	Rejected
$H_0 : \delta_0 = \delta_1 = \delta_2 .... = \delta_{14} = 0$	χ2-test	62.127	30.578	15	Rejected
$H_0 : = \delta_1 = \delta_2 .... = \delta_{14} = 0$	χ2-test	38.314	29.141	14	Rejected

Source: survey data 2012

The first null hypothesis test that technical inefficiency effects are not present in the model i.e. smallholder dairy farmers are efficient and have no room for efficiency growth. $H_0: \gamma = \delta_0 = \delta_1 = \delta_2 .... = \delta_{14} = 0$, The LR test statistic is asymptotically distributed as a mixture of chi-square distributions. This test statistic exceeds the 1% critical value $X^2_{0.99}$ (16) 105.097χ =, which is taken from Table 1 in Kodde and Palm (1986), so the LR test leads to reject the null hypothesis and concluded that technical inefficiency are present. This implies that, the traditional average (OLS) function is not suitable for this study. The second null hypothesis, $H_0 : \gamma = 0$, which specifies that the inefficiency effects are not stochastic, is again strongly rejected at 1% significant level and concluded that systematic influences that are unexplained by the production function are the dominant sources of random error.

The third null hypothesis considered in the model, $H_0: \delta_0 = \delta_1 = \delta_2 .... = \delta_{14} = 0$ which stipulates that, the coefficients of the explanatory variables in the inefficiency models are simultaneously zero, is also rejected. It indicates that the combined effects of factors involved in the technical inefficiency model are responsible for explaining the level and variations in Technical Efficiency of smallholder dairy farmers although individual effects of some variables may not be statistically significant. The last null hypothesis considered, H0: $\delta_1 = \ldots = \delta_{14} = 0$, which state, that the coefficients of the variables in the inefficiency model effects are zero, is also rejected. It reflects that all the coefficients of the explanatory model are significantly influenced by the hypothesized socio-economic, institutional and marketing variables in the inefficiency model.

3.2. Partial Elasticities

Because all input variables are measured in logarithmic form, the estimated coefficient values represent the partial output elasticities. The production elasticity measures the proportional change in output resulting from proportional change in i-th input level, with all other input level held constant. Presented in Table 2 are elasticity estimates and return to scale value.

Table 2: Elasticity of Smallholder Dairy Farmers

Inputs	Elasticity
Veterinary Cost (TSHS)	-0.1939
Purchased Feed Costs (TSH)	0.4923
Other Costs (TSHs)	0.2269
Number of lactating cows	0.4692
Daily hours Spent on Dairy Activities (HOURS)	0.4434
Return to Scale (RTS)	1.4379

Source: Analyzed survey data 2012

All elasticities are positive and statistically significant at 1% level with the exception of veterinary cost which is negative and statistically significant at 5% level. This implies that the use and allocation of these variables are still underutilized and as such a unit increase in these inputs will eventually results in an increase in the value of dairy outputs of the producers. Of all input variable, purchased feed (concentrates) cost has the highest impact on dairy production with elasticity equal to 0.4923 that is 100% increase in concentrate feed purchased results in an estimated increase in dairy output of 49.23%. The next highest elasticity is for number of lactating cows in the herd (0.4692) followed by daily hours spent on dairy activities (0.4434) and other costs (0.2269). The negative sign of veterinary cost variable indicates an out of optimal usage of this input. The Return to Scale coefficient is 1.4379. This suggest that smallholder dairy farmers in Njombe district exhibit increasing return to scale and they are operating in the irrational zone of production (Stage 1) function with the implication that the resources are not efficiently allocated and used on their dairy farms.

3.3 Technical Efficiency Analysis

The maximum likelihood (ML) estimates of the parameters of the stochastic production frontier are presented in Table 3 below. The sigma squared (σ^2) with value of 0.0964 is statistically significant and different from zero at $\alpha = 0.01$. This indicates a good fit and the correctness of the distributional form assumed for the composite error term. The estimated gamma parameter (γ) of frontier model is 0.9989 and significant ($P < 0.01$). This indicates that systematic influences that are unexplained by the production function are the dominant sources of random error meaning that 99.89% of the variation in output among the smallholder dairy farmers was due to disparities in technical efficiency.

Table 3: Maximum Likelihood Estimate (MLE) of the Stochastic Frontier Production Function

Variables	Parameter	OLS Model			MLE Frontier Model		
		Coefficients	Standard-error	t-ratio	Coefficients	Standard-error	t-ratio
Intercept	$ß_0$	7.703***	1.2749	6.0419	7.6252***	0.7881	9.6758
Veterinary Cost (TSHS)	$ß_1$	0.2776***	0.0756	3.6702	-0.1939**	0.0855	-2.2680
Purchased Feed Costs (TSH)	$ß_2$	0.2630***	0.0846	3.1087	0.4923***	0.0564	8.7205
Other Costs (TSHs)	$ß_3$	0.0209	0.0393	0.5306	0.2269***	0.0749	3.0318
Lactating cows (Number)	$ß_4$	0.1858*	0.1194	1.5551	0.4692***	0.1615	2.9053
Daily hours Spent on Dairy Activities (HOURS)	$ß_5$	-0.0669	0.1204	-0.5556	0.4434***	0.1438	3.0839
Variance Parameters and Diagnostic							
Sigma Square	$\sigma 2$	0.1362			0.0964***	0.0227	4.2502
Gamma	γ	0.4600			0.9989***	0.0031	323.353
log likelihood function	λ	-31.0633			-9.5783		
LR test of the one-sided error		42.9700					

* Significant at 10% level, ** Significant at 5% level and *** Significant at 1%

Source: Survey Data

Table 4 shows that the predicted farm specific technical efficiencies ranged from 13% to 99% with a mean of 45.46% and standard deviation of 24.113%. The table further shows that majority of respondents (61.7%) had technical efficiency below 50%, indicating that more than half of the respondent farmers were relatively inefficient. The implication of the average TE of 45.46% from the analysis is that dairy production could be increased by 54.54% through better allocation and use of available resources.

Table 4: Frequency Distribution of Technical Efficiency Score (N = 81)

Efficiency Scores	Frequency	Percentage
10 - 19	8	9.9
20 - 29	21	25.9
30 - 39	13	16.0
40 - 49	8	9.9
50 - 59	7	8.6
60 - 69	8	9.9
70 - 79	8	9.9
80 - 89	3	3.7
90+	5	6.2
Mean	45.46	
Minimum	13	
Maximum	99	
Standard deviation	24.113	

Source: survey data 2012

3.4. Determinants of Technical Inefficiency of Smallholder Dairy Producers

Sources of inefficiency were examined by using the estimated δ-coefficients of the variables in inefficient model. The coefficients have either positive or negative signs. A positive sign indicates that the variable has an increasing effect on inefficiency while a negative sign indicates a reducing effect on inefficiency. The results of the inefficiency model are given in Table 5.

Results in Table 5 indicate that the coefficients of age, gender, marital status, hired labor and selling to processor were statistically significant at 1% level while coefficients of education level and experience were statistically significant at 5% level. On other hand the coefficients of family size, membership in dairy production and marketing group, dairy herd size, off farm income, dairy herd size, dairy training, contact with extension agent and sale on credit were statistically insignificant. All coefficients had expected sign except the coefficients for membership in dairy production/marketing group and selling to processors.

The estimated coefficient for age variable has a positive sign and statistically significant at 1% level which indicates that older farmers tend to have more inefficiencies than younger ones. This could be explained in terms of adoption of modern technology. As the age increases, the farmers tend to be more risk averse and hesitate to adopt new technologies making the production process inefficient. Ogunniyi and Ajao, (2010) obtained similar findings and concluded that older farmers tend to be more conservative and less receptive to modern technologies. Another reason might be that dairy production is very strenuous giving younger farmers an advantage.

Table 5: Maximum Likelihood Estimates for the Parameters of the Inefficiency Model

Variables	Parameter Estimate	Coefficients	Standard-error	t-ratio
Age	δ_1	0.0190***	0.0061	3.0974
Gender	δ_2	0.0155***	0.0042	3.6712
Marital Status	δ_3	-0.0147***	0.0045	-3.2542
Education Level	δ_4	0.5788**	0.2964	1.9525
Experience	δ_5	0.1464**	0.0696	2.1023
Household Size	δ_6	-0.0034	0.0029	-1.1806
Membership in Dairy Group	δ_7	0.0001	0.0004	0.31534
Off farm Income	δ_8	0.0073	0.0076	0.9519
Dairy Herd Size	δ_9	0.0582	0.1380	0.4217
Dairy Training	δ_{10}	-0.0051	0.0305	-0.1684
Contact with Extension Agent	δ_{11}	-0.0133	0.0261	-0.5102
Hired Labor	δ_{12}	-0.0650***	0.0203	-3.1964
Sale on credit	δ_{13}	-0.0885	0.0764	-1.1589
Selling to Processor	δ_{14}	0.0008***	0.0003	3.1197

* Significant at 10% level, ** Significant at 5% level and *** Significant at 1%

Source: Survey data 2012

The gender coefficient measured as dummy variable with value of one for male and zero for women was found to be positive and highly significant at 1% level. This suggests that men were less technically efficient than women in dairy production. Women are key actors in the business of farming, both in terms of labor supply (Enete *et al*. 2002) and as decision makers (Enete and Amusa 2010). In many cases, farming is disproportionately their responsibility. They may therefore have acquired relatively more technical and managerial expertise on the job than men.

The coefficient for marital status also measured as dummy variable with value of one for married and zero otherwise was negative and statistically significant at 5 percent level. This implies that smallholder dairy farmers who are married are more efficient than those who are either single, divorced, widowed or widowers. This might be due to the fact that marital status in most cases is considered important in household decision making where married people have always succeeded in decision-making (Kibirige, 2008). Also married farmers tend to be more technically efficient, probably reflecting more availability of labor, which is consistent with larger families having more labor at their disposal, thus contributing to higher TE (Oleke and Isinika, 2011). The education coefficient was found to be positive and statistically significant at 5 percent probability level. This implies that there is increased level of technical inefficiency as level of education increases.

These findings might be due to the fact that higher education opens up higher opportunities for livelihoods such as off-farm employment and, hence creates lower incentives to pay much attention to the performance of the dairy farm. Muhammad-Lawal *et al.*, 2009 obtained similar results and concluded that farmers with lower education are more likely to be limited in such opportunities and hence depend more on primary methods for their livelihoods and therefore have acquired relatively more technical and managerial expertise on the job than higher educated ones with alternative livelihood options.

Unexpectedly, the coefficient of dairy production experience was found positive and statistically significant at 5% indicating that farmers with higher experience in dairy production tended to have higher technical inefficiencies. This shows that the experience the farmers had, was not geared towards the competency or skills needed for excellence in handling the available technologies required in smallholder dairy production. This could be due to fact that experience correlates with age, which would always associate with reduced energy and optimism necessary in dairy production. Age in this study was found positively related to inefficiency.

The coefficient of family size is negative but not statistically significant. The negative sign of this inefficiency parameter establishes the fact that inefficiency of smallholder dairy farmers decreases with increase in household size. This may be due to the fact that increased household size means more labour force for dairy production activities. Inability to find a significant relationship could be attributed to fact that average household size of 5.49 people means that household sizes were not large enough to have more equitable labour distribution among farming and dairy production activities. Improved farm labour distribution will lead to concentration on the given task and thus improving technical efficiency (Kibirige, 2008).

Membership in dairy production and marketing group was expected to increase farmer's interactions with fellow farmers, extension agent and other entrepreneurs in his locality. It was hoped that such interactions would help them to receive and synthesize new information on dairy production and marketing activities in his locality and even beyond leading to improved technical efficiency. Contrary to a priori expectation the coefficient for membership in dairy production and marketing group was positive and statistically insignificant implying that membership in dairy production and marketing group has no relationship with technical inefficiency. As majority of the respondents (80.2%) were members of dairy production and marketing groups and were selling milk to dairy processors. This could be accounted to low price paid by processor and delay in effecting payment as farmers complained. As result dairy farmers may regard membership in dairy production and marketing group as a "public good" and not a "social good" where they fraternize not necessarily for production motives.

The coefficient for off farm income variable was positive and not statistically significant. Although not statistically significant, the positive sign of the coefficient indicates that farmers engaged in off-farm income earning activities tend to exhibit higher levels of inefficiency. This was probably due to fact that involvement in non-farm work are accompanied by reallocation of time away from farm related activities, such as adoption of new technologies and gathering of technical information that is essential for enhancing production efficiency. Also due to the lower socioeconomic conditions that prevail in rural areas, smallholder farmers tend to look for a nonagricultural employment in order to complement agricultural income rather than obtain additional resources to be invested in the activity.

The coefficient for dairy herd size variable was positive but not statistically significant. Although not statistically significant the positive sign of the coefficient indicates that technical inefficiency increases as dairy herd size increases. This could be attributed to the fact that resources allocation and management in large herd size are more complex than in small herd size and thus require advance farm management knowledge which could be lacking among smallholder dairy farmers.

Dairy training and contact with an extension officer during the past year were positively related to efficiency but statistically insignificant. These findings are consistent with the findings of Feeder *et al.* (2004); Binam *et al.* (2004); Rahman (2003). Each of these studies involved farmers in developing countries. The inability to find statistical significance has been attributed to bureaucratic inefficiency, poor program design, (Feeder *et al.*, 2004; Binam *et al.*, 2004) and the use of a “top-down” instead of participatory approach (Braun *et al.*, 2002). Tanzanian’s extension program has been characterized by a top down approach. Thus, the lack of a participatory approach may explain the insignificance of Tanzanian’s extension program in terms of its impact on the efficiency of these Tanzanian smallholder dairy farms.

The coefficient of the dummy variable for use of hired labor is negative and statistically significant at the 10 percent level implying that smallholder dairy farms on which hired labor is used to supplement family are less inefficient than those that exclusively use family labor. This finding may reflect the economic use of hired labor resources for farm households that are constrained in terms of family labor.The coefficient of the dummy variable for sale on credit is negative and statistically insignificant. Although statistically insignificant the negative sign of the coefficient shows those smallholder dairy farmers who sell milk on credit and after two weeks or one month receive payments in lump sum are less technically inefficient than farmers who receive daily payments. These findings may be probably due to fact that smallholder milk marketing is associated with sales of small quantity marketable milk surplus which limit the ability of the farmer to afford daily essential dairy production expenses for efficient management. Lump-sum payments may be intrinsically valuable where liquidity flow is required in lumps to match lumpy expenditures (Ngigi et al, 2000). The inability to find significant relationship may be due to delay in payments as complained by majority of farmers who sell on credit to dairy processor. On the other hand the coefficient for selling to dairy processor was positive and statistically significant at 1% level. These results indicate that smallholder dairy farmers who sell to dairy processor are more technically inefficient than those who sell to other outlets. This is contrary to a priori expectation probably because of the low price paid by processor and delay in effecting payment as farmers complained.

4.0. Conclusion and policy implications

This paper has estimated Technical efficiency of smallholder dairy farmers and analyzed factors affecting their technical efficiency in Njombe district using a stochastic production frontier (SPF) methodology under Cobb-Douglas functional form. Findings from the study show that smallholder dairy production in Njombe District Council can still benefit from economies of scale linked to increasing returns to boost production as depicted by return to scale of 1.4379 which indicates stage II of the productivity surface showing an inefficient allocation and utilization of available resources.

The Technical Efficiency (TE) measurement showed that there were technical inefficiency effects in smallholder dairy production. The predicated T E ranged between 13% to 99% with a mean 45.5% and standard deviation of 24.113%. The estimated value of the variance parameter (γ) of 0.9989 for the stochastic frontier production function was not only close to one but also significantly different from zero at probability level1% indicating that 99.89% of the variation in the value dairy output among the smallholder dairy farmers was due to disparities in technical efficiency.

The inefficiency model showed that age, gender, education level, experience of the farmer and selling to processor are major factors having a significant and positive influence on the farmers' technical inefficiency while marital status and use of hired labor are the major factors having a significant and negative influence on the farmers' technical inefficiency. Other factors which were found to have positive influence on technical inefficiency but not statistically significant included membership in dairy production and marketing group, off farm income and dairy herd size. Dairy training, contact with extension agent and selling on credit are factors which were found to have negative impact on technical inefficiency but were also not statistically significant. Some productivity gains linked to improvements in technical efficient can still be realized in the smallholder dairy production sector in Njombe district. Moreover, smallholder dairy producers can still take advantage of scale economies linked to increasing returns to increase value of dairy output.

Technical efficiency can be improved by attracting young and married people to enter or remain into dairy production business. Likewise, improvement of market prices and timely effecting payment may also be paramount. More action may be needed in terms of improving rural roads to facilitate milk collection; creating reliable source of power; review of dairy import policies; and conducting a dairy value chain analysis. Finally, Tanzanian's extension and training programme need to be revamped with the view of making it participatory and client based in nature.

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