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COMPARATIVE ANALYSIS OF TECHNICAL EFFICIENCY OF MILK PRODUCTION SYSTEMS IN UASIN GISHU COUNTY OF KENYA

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ABSTRACT

In Uasin Gishu County the rapidly declining household land sizes are a pre-requisite to increased intensification in dairy production. Although the three dairy production pathways are used by farmers in the County, it has not been established which one of them would be comparatively competitive to enhance commercialization process and lead to attractive returns to smallholders investing in milk production. The objective of this paper was to determine the economic efficiency of smallholder milk production under different intensification methods. A sample size of 246 smallholder dairy farmers was selected in Uasin Gishu County using stratified random sampling method. Using both primary and secondary data, economic efficiencies were evaluated utilizing Cobb-Douglas stochastic frontier production function. The result of the analysis indicate that presence of technical inefficiencies had effects in milk production as depicted by the significant estimated gamma coefficient of each model, the generalized likelihood ratio test and the predicted economic efficiencies within the dairy farms. Technical efficiency increased with the level of intensification of milk production with open grazing, semi-zero grazing and zero grazing recording a mean score of 0.54, 0.57 and 0.81 respectively. The maximum likelihood estimates for technical efficiency was an increasing function of cost of feeds and equipment in the three production systems with statistical significance of 5%. Market access condition the technical efficiency of milk production especially for this highly perishable product. Educational opportunities for farmers lead to initiative, innovation and improvements. There is need to increase the level of intensification in milk production to enhance technical efficiency.

Keywords: Milk, Frontier production function, Technical efficiency, Maximum likelihood estimates, Intensification.

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Contribution/ Originality:

This study contributes in the existing literature on competitiveness. It uses new estimation methodology for estimating technical efficiency. It is one of very few studies which have investigated livestock performance. The paper contributes the first logical analysis of efficiency and this increased with intensification. This study documents milk production efficiency.

1. INTRODUCTION

Analysis of intensification of smallholder milk production in Kenya has suggested that an evolution process of intensification pathways occurs, mainly involving feeding and breeding strategies. It would appear that intensification pathways in smallholder milk production are diverse and involve investment in external input use. Further analysis of intensification of milk production by Baltenweck *et al.* (2000) concluded that there was no clear-cut relationship between the intensification level and the level of competitiveness at the farm level. A similar analysis of intensification in Uganda by Nanyeenya *et al.* (2008) concluded that all smallholder milk production systems were profitable and remunerated labour above the opportunity cost. The contrasting results on competitiveness of smallholder milk production suggest the need for further analysis of intensification pathways because optimal resource use differs between the pathways. Dairy production in Uasin Gishu County is experiencing structural changes towards intensification. Previous studies have shown that competitiveness of smallholder milk production varies with intensification approach from free grazing, semi-zero grazing or zero grazing. This is true for Uasin Gishu County where rapidly declining household land size is contributing to increased intensification in dairy production. However, how intensification influences farm efficiency and profitability still requires empirical evidence. Inefficiency of milk production leads to the sub-sector being uncompetitive in the market due to relatively high cost of milk production and low output. In addition, low levels of profit leads to poor living standards for smallholder dairy farmers. The sub-sector thus becomes unattractive to investment, limiting its potential to provide employment and food security. Researchers have suggested that improvement in efficiency is one of the key factors for the survival of dairy farms (Tauer and Belbase, 1987; Alvarez *et al.*, 2008). Consequently, the aim of this study was to gain insight into the intensification pathways influencing competitiveness in smallholder milk production in Uasin Gishu County with a view to identifying more efficient pathways for further development.

2. LITERATURE REVIEW

Galanopoulos *et al.* (2006) defined technical efficiency as the ability of Decision Making Units (DMUs) to produce maximum outputs given a set of inputs and technology (output-oriented) or, alternatively, to achieve maximum feasible reductions in input quantities given input prices and output (input-oriented). Economic efficiency is consistent with the principles of profit maximization. According to Kumbhakar and Lovell (2000) profit maximization requires a firm to have both technical and allocative efficiency. Previous relevant literature on technical efficiency has focused on estimating the level of technical efficiency among samples of dairy farms. To do so, these studies have used either a non-parametric method such as Data Envelopment Analysis (Tauer, 1998; Alemdar *et al.*, 2010) or an econometric approach such as stochastic

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(production, cost or profit) frontier models (Cuesta, 2000; Bravo-Ureta *et al.*, 2008). These two methodologies have also been used to analyze the potential sources of inefficiencies (Tauer and Mishra, 2006; Murova and Chidmi, 2009). However, Kumbhakar and Lovell (2000) argue that stochastic frontier models have the advantage of dealing with stochastic noise and allowing for a single step estimation of the inefficiency effects. But these models have the disadvantage of making assumptions about underlying data generating process for instance Ordinary Least Squares (OLS), Three Stage Least Squares (3SLS) and Generalized Method of Moments (GMM). The advantage of GMM over the other estimators, like 3SLS, is that GMM does not require strong assumptions about the underlying data generating process and has the ability to generate standard errors that are robust with respect to heteroscedasticity and autocorrelation (Ooms, 2007).

This paper used a stochastic frontier model and chose the Cobb-Douglas stochastic frontier production function. Once the production function is known, the first-order conditions for profit maximization were derived. From these first-order conditions functions for output supply, variable input demands and shadow prices of quasi-fixed inputs were derived, assuming price-taking behavior in input and output markets. Thus, the farm is assumed to be in static equilibrium with respect to outputs and variable inputs, conditional on the level of quasi-fixed inputs and prices of outputs and variable inputs.Therefore, it is worth an attempt to incorporate a novel methodology, such as HMS, into the state of the art of workforce sizing. This paper also analyses the determinants of technical efficiency. The efficiency estimates are regressed on a set of contextual factors usually considered in the literature, such as human capital and other household and market characteristics. In contrast to the inputs and outputs considered in the estimation of technical efficiency, these factors are intended to capture differences in managerial abilities and access to input and output markets that affect household decision making (Lovo, 2013).

3. METHODOLOGY

3.1. The Study Area and Data Collection

Uasin Gishu County was chosen for this study because it was leading in milk production, had the highest population of dairy cows in Kenya and the three dairy production pathways. First, the population was stratified according to a poverty level of at least 46% and milk production potential of 60,000 – 90,000 liters/Km^2/year. Second, a probability proportional to size technique was used to obtain the number of farmers per stratum. Finally, random sampling was used within the strata to select 246 individual households. Collection of data involved administration of pre-tested structured questionnaires, observations, focused group discussions and use of key informants. The study combined primary and secondary data. The data included the quantities and prices of all inputs and outputs of milk production. Outputs included milk while inputs were feeds, breeding costs, herd health management costs, investment in housing and equipments and labour costs.

3.2. Data Analysis

Data analysis was sub-divided into estimation of technical efficiency and its determinants.

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3.2.1. Estimation of Technical Efficiency

The Cobb-Douglas stochastic frontier production function was used to estimate the technical and economic efficiency of smallholder milk production. Following Coelli (1996) the model is expressed as:

$Y_i = x_i\beta + (V_i - U_i)$, $i = 1,\ldots, N$ (1)

Where

Y_i = logarithm of the milk production of the i-th farm;

X_i = a *kx1* vector of the logarithm of the input quantities of the i-th farm;

β = a vector of unknown parameters;

V_i = random variables which are assumed to be N $(0,\sigma_V^2)$, and independent of the U_i;

U_i = non-negative random variables which are assumed to account for technical inefficiency in production, and are assumed to be $|N(0,\sigma_U^2)|$.

The computer program FRONTIER version 4.1 was used to estimate model 1 and obtain maximum likelihood estimates of the stochastic frontier production function. The production function has farm effects which are assumed to be distributed as truncated normal random variables.

Calculation of the maximum likelihood estimates (Coelli, 1996) requires that:

$$\sigma^2 = \sigma_V^2 + \sigma_U^2 \quad (2)$$

and $$\gamma = \frac{\sigma_U^2}{\sigma_V^2 + \sigma_U^2} \quad (3)$$

The parameter, γ, must lie between 0 and 1 and thus this range was searched to provide a good starting value for use in an iterative maximization process of Davidson-Fletcher-Powell (DFP) algorithm. A model selection procedure was conducted by testing the significance of the γ parameter. If the null hypothesis that $\gamma = 0$ is accepted, this would indicate that σ_U^2 is zero and hence the U_i term should be removed from the model, leaving a specification with parameters that can be consistently estimated using ordinary least squares. The selected model then provided the technical efficiency of the smallholder dairy farms.

3.1.2. Determinants of Technical Efficiency

A censored regression model in (4) and (5) with a dependent variable, y, that is left-censored and right censored, was used to measure the determinants of technical and economic efficiency (Henningsen, 2012):

$$Y_i^* = x_i\beta_i + \varepsilon_i \quad (4)$$

$$y_i = \begin{cases} 0 \text{ if } y_i^* = \leq 0 \\ y_i^* \quad \text{if } y_i^* > 0 \end{cases} \quad (5)$$

Where

Y_i^* = Unobserved (latent) variable;

i = the *i*-th household,(i =1,2,…,246);

y_i = the natural logarithm of the technical efficiency indices;

x_i = a vector of explanatory variables;

β = a vector of unknown parameters;

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ε_i = a disturbance term.

The model in (4) and (5) was then estimated by the Maximum Likelihood (ML) method. Assuming that the disturbance term, ε, follows a normal distribution with mean 0 and variance σ^2, the log-likelihood function was given by Henningsen (2012):

$$\text{Log L} = \sum_{i=1}^{N} \left[I_i^a \log\Phi\left(\frac{a - x_i'\beta}{\sigma}\right) + I_i^b \log\Phi\left(x_i'\beta \frac{x_i - b}{\sigma}\right) + (1 - I_i^a - I_i^b)\left(\log\phi\left(\frac{y_i - x_i'\beta}{\sigma}\right) - \log\sigma\right) \right] \quad (6)$$

where $\phi(.)$ *and* $\Phi(.)$denote the probability density function and the cumulative distribution function, respectively, of the standard normal distribution. I_i^a and I_i^b are indicator functions with Henningsen (2012):

$$I_i^a = \begin{cases} 1 \text{ if } y_i = a \\ 0 \text{ if } y_i > a \end{cases} \quad 7$$

$$I_i^b = \begin{cases} 1 \text{ if } y_i = b \\ 0 \text{ if } y_i = b \end{cases}$$

Here, a is the lower limit of the dependent variable that will take the value of 0 and b is the upper limit of the dependent variable that will take the value 1 because efficiency measures range between zero and one. The censored regression model was chosen for this study because the dependent variable can be either left-censored, right-censored, or both left-censored and right-censored, where the lower and/or upper limit of the dependent variable can be any number. This model is a generalization of the standard Tobit model. The log-likelihood function of the censored regression model in (6) is then maximized with respect to $(\beta_i, \sigma)'$ using standard non-linear optimization algorithms.

4. RESULTS AND DISCUSSION

This section includes the technical efficiency and its determinants.

4.1. Technical Efficiency

Table 1 shows that the overall significance of the Cobb Douglas Stochastic Frontier Production model given by the estimated sigma squared (δ^2) of 0.06 for zero grazing, 0.76 for semi zero grazing and 0.65 for open grazing were significantly different from zero at 5% level. This indicates a good fit and the correctness of the specified distributional assumption of the composite error term. The variance ratio, gamma (γ), explains the total variations in output from the frontier level of output attributed to technical inefficiencies. The value of γ was 1.00 for zero grazing, 0.95 for semi zero grazing and 0.99 for open grazing (Table 1) and this implies that 100% , 95% and 99% respectively of variation in milk output is due to inefficiency. This means that the technical inefficiency effects are significant at 5% level in the stochastic frontier production function.

These results are consistent with the findings of Manoharan *et al.* (2004) that 80% of the differences between observed and the maximum production frontier output were due to difference in dairy farmer's level of technical efficiency in Pondicherry, India. Similarly, Alemdar *et al.* (2010) found a highly significant gamma statistic that indicated the presence of a high systematic inefficiency and implied that 95% of the variations in milk production could be attributed to inefficiencies.

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Table-1. The maximum likelihood estimates (MLE) for technical efficiency of the stochastic frontier production function

Parameter		zero grazing	semi-zero grazing	open grazing
		MLE estimates	MLE estimates	MLE estimates
		coefficient (t-ratio)	coefficient (t-ratio)	coefficient (t-ratio)
Constant	β_0	5.68	3.55	8.20
		(6.09)	(2.625)	(16.04)
Feeds	β_1	0.16**	0.23**	0.07**
		(3.91)	(2.47)	(5.31)
Herd replacement	β_2	-0.0208	-0.0929	0.1164**
		(-0.34)	(-0.817)	(2.38)
Health management	β_3	-0.14**	0.24**	-0.06
		(-5.41)	(2.79)	(-0.41)
Housing	β_4	-0.22**	-0.18**	-0.16
		(-7.29)	(-2.10)	(-1.60)
Equipment	β_5	0.17**	0.81**	0.70**
		(2.38)	(5.57)	(8.10)
Labour	β_6	0.38**	0.08**	-0.07**
		(8.30)	(0.88)	(-2.03)
Sigma-Squared	δ^2	0.06**	0.76**	0.65**
		(5.04)	(3.88)	90.99)
Gamma	Υ	1.00**	0.95**	0.99**
		(11.49)	(14.61)	(182.99)
Log (Likelihood)	Θ	17.56	-66.25	-66.25
LR Test Statistic		7.92	6.33	8.02
Mean Efficiency		0.81	0.57	0.54

** = significant at 5% level.

Mean technical efficiency increased with the level of intensification of milk production with open grazing, semi-zero grazing and zero grazing recording a mean score of 0.54, 0.57 and 0.81 respectively (Table 1). Therefore, the scopes for technical efficiency improvement are 19% for zero-grazing, 43% for semi-zero grazing and 46% for open grazing systems. The parameters of the production frontier are feeds, herd replacement, health management, housing, equipment and labour. The maximum likelihood estimates (MLE) for technical efficiency was an increasing function of feeds and equipment in the three production systems with statistical significance of 5%. Therefore, increasing the quantity of feed and equipment will lead to higher milk output. Labour significantly and positively influenced milk output in both the zero grazing and semi-zero grazing systems and negatively in the open grazing system. The labour requirements increase with intensification. Herd replacement was a significant maximum-likelihood estimate of the production frontier in the open grazing system only while health management was significant in both zero grazing (-0.14) and semi-zero grazing (0.24).The elasticities of frontier output with respect to housing were negative in all the systems but significant in the zero grazing (-0.22) and semi zero grazing (-0.18). The elasticity of mean value of milk output in the zero grazing system is an increasing function of feeds, equipment and labour while in the semi zero system it is an increasing function of feeds, health management and labour. The results in Table 1 show that for open grazing system the elasticity of mean value of milk output is estimated to be an increasing function of feeds, herd replacement and equipment. For instance, a 1 percent increase in herd replacement, and holding other things constant would increase milk output by 0.12 percent. These results are consistent with the findings of Baltenweck *et al.* (2000) that the longer term competitiveness of dairy production systems depends on labour, land and infrastructure over time. At farm level, housing and equipment provide the appropriate infrastructure to support milk production and improve

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technical efficiency. With a finding of 78% mean efficiency, Alemdar *et al.* (2010) recommended that the scope to increase efficiency of milk producers mainly depended on structural enhancements in the long run such as introducing high yield breeds. The results of the current study demonstrate that zero grazing has a greater technical efficiency than semi-zero grazing while open grazing has the lowest level of technical efficiency. Baltenweck *et al.* (2000) reported similar results that intensive dairying offers the highest returns to a household unit. The distribution of the estimated input-oriented technical efficiency scores is presented in Table 2.The results show that the technical efficiencies vary from one milk production system to another. In Uasin Gishu, the computed technical efficiency for the zero-grazing system varied between 0.66 and 0.97 in the 1st and 4th quartile respectively, with a mean value of 0.82. The semi-zero grazing system had computed technical efficiency of 0.28 in the 1st quartile and 0.83 in the 4th quartile with a mean value of 0.58 and standard deviation of 0.21 (Table 2). The technical efficiency for open grazing system varied between 0.28 and 0.86 in the 1st and 4th quartile respectively, with a mean of 0.57 and standard deviation of 0.22 (Table 2). In comparison, these results show that the zero grazing system had higher mean technical efficiency than open grazing and semi-zero systems. Therefore the dairy producers need to put more effort in utilization of the inputs that increase milk yield (such as feeds, equipment and labour) in Uasin Gishu County so as to minimize inefficiency. In addition, technical efficiency increases with intensification.The technical efficiency scores are compatible with the findings of Manoharan *et al.* (2004) that revealed a technical efficiency of 0.82 for milk production in India. The concept of technical efficiency is based on the identification of a production frontier representing the maximal combination of outputs attainable given the available set of inputs. Technical efficiency expresses the ability to derive maximum output from a given set of inputs. Households operating on the frontier are considered technically efficient, while those located below the frontier are considered inefficient. The assumption of homogeneous inputs and outputs is necessary when input quality is not observed (Lovo, 2013). This assumption is important as quality attributes of both inputs and milk are variable in Uasin Gishu County.

The technical efficiency results in the three milk production systems show the presence of inefficiency. Many studies have shown that inefficiency is the rule rather than the exception (Battese, 1992). This finding is important because the main consequence of technical inefficiency is to raise production costs, making farms less competitive. Michalickova *et al.* (2013) analyzed the technical efficiency of milk production in dairy cattle farms in Slovakia for the period 2006 to 2010.

Table-2. Input-oriented technical efficiency scores of the stochastic frontier production function

	zero grazing		**semi-zero grazing**		**open grazing**	
frequency	**n**	**efficiency scores**	**n**	**efficiency scores**	**n**	**efficiency scores**
1st quartile	8	0.66	22	0.28	31	0.28
2nd quartile	8	0.79	22	0.52	31	0.53
3rd quartile	8	0.87	22	0.67	32	0.61
4th quartile	7	0.97	23	0.83	32	0.86
Total	31		89		126	
Min		0.44		0.11		0.19
Max		0.99		0.92		0.99
Mean		0.82		0.58		0.57
Std. Dev		0.12		0.21		0.22

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Table-3. Coefficients and corresponding standard errors of the determinants of technical efficiency for the estimated censored regression model

technical efficiency	zero grazing			semi-zero grazing			open grazing		
	coefficient	t	p>|t|	coefficient	t	p>|t|	coefficient	t	p>|t|
Gender	0.0881	1.33	0.186	-0.1182	-0.93	0.356	-0.0447	-0.69	0.497
	(0.0662)			(0.1273)			(0.0646)		
Age	-0.0080	-2.86	0.005***	-0.0071	-1.38	0.173	0.0003	0.14	0.888
	(0.0028)			(0.0052)			(0.0020)		
Education	0.0015	0.10	0.920	0.0094	0.25	0.806	0.0071	0.19	0.852
	(0.0149)			(0.0381)			(0.0374)		
Household size	0.0274	2.42	0.017**	-0.0155	-0.92	0.359	0.0181	1.59	0.126
	(0.0113)			(0.0168)			(0.0114)		
Experience	0.0032	1.20	0.231	0.0094	2.12	0.037**	0.0112	1.33	0.197
	(0.0027)			(0.0044)			(0.0084)		
Land size	-0.0023	-0.34	0.734	0.0109	0.6	0.551	-0.0010	-0.07	0.946
	(0.0067)			(0.0182)			(0.0146)		
Social capital	0.0533	1.12	0.266	0.0698	0.62	0.537	0.0093	0.65	0.523
	(0.0477)			(0.1126)			(0.0144)		
Market distance	-0.0255	-2.22	0.028 **	0.0126	1.12	0.266	-0.0531	-1.05	0.308
	(0.0115)			(0.0113)			(0.0508)		
Credit access	0.0218	0.49	0.628	0.0450	0.55	0.583	0.0690	1.2	0.243
	(0.0450)			(0.0817)			(0.0574)		
No. of cattle	0.0041	0.74	0.459	0.0112	0.73	0.467	-0.1177	-1.06	0.300
	(0.0056)			(0.0154)			(0.11090)		
constant	0.6449	4.47	0.000***	0.8178			0.3951	1.16	0.259
	(0.1443)			(0.4542)	1.8	0.076*	(0.3407)		
sigma	0.2131			0.1996			0.1117		
	(0.0135)			(0.0151)			(0.0146)		
Prob > chi^2	0.6671			0.1690			0.1268		
Pseudo R^2	-0.2127			-0.8305			-1.0801		
Log likelihood	21.6877			15.5255			14.5839		

The evaluated herds reached 96% of technical efficiency in milk production on average and the value was statistically significantly influenced by the feed costs only. The negative influence of this factor indicates inefficient utilization of feeds (balance of feeding ration, losses of storage, reciprocal substitution of feeds) or inefficient utilization of its production potential in relation to the given output level. Farmers need to examine the best practices of efficient peer farms to increase their overall technical efficiency. Qushim *et al.* (2013) assessed the scale and technical efficiencies of southeastern U.S. cow-calf farms using stochastic production frontier techniques to estimate input-oriented technical efficiency scores. They found an average efficiency of 0.86, implying a technical inefficiency level that is 14% on average, or that the average southeastern cow calf farm could reduce about 14% in inputs to produce the same output as an efficient southeastern farm on the frontier. The results also show that approximately 80% of the farmers achieved technical efficiency levels of 80% or higher. These results are higher than those found in the current study.

4.2. Determinants of Technical Efficiency

The coefficients and corresponding standard errors of the determinants of technical efficiency for the estimated censored regression model are presented in Table 3. The positive coefficient implies that any increase in the value of the variable would lead to an increase in the level of technical efficiency and vice versa.

The determinants of technical efficiency considered in this paper are gender, age, education, household size, experience, land size and social capital. Others include distance to the market, credit access and number of cattle owned by the smallholder dairy farmers. The results show that in the zero grazing milk production system, age affects milk production negatively and significantly. It affects output in semi-zero grazing negatively but not significantly different from zero while in open grazing it has a value of approximately

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zero and it is not significant. This result is consistent with Nganga *et al*. (2010) and Igbekele (2003) who reported that those who are aged tend to be less efficient. Younger operators of dairy enterprises tend to have a higher level of technical efficiency as they are likely to be more agile and aggressive in their business drive than the old operators. There was a negative but insignificant relationship between technical efficiency and the gender of the household head for both semi zero grazing and zero grazing production systems (see Table 3).

Education, social capital and access to credit were all positive in the three milk production systems although they were not significant. Those farmers who have a higher level of education tend to be more efficient (Nganga *et al*., 2010). Educational opportunities for farmers lead to initiative, innovation and improvements. Social capital provides farmers' organizations with the ability to generate and utilize resources more effectively through the development of infrastructure and service provision including credit access. Local organizations allow the structuring and channeling of information flow for farmers and they can complement, facilitate and at times replace the functions performed by primary executing and supporting agencies of development.

Access to credit coefficient carried the expected sign but was not found to be a significant determinant of technical efficiency. This suggests that the contribution of access to credit variable to the probability of increased technical efficiency is due to its risk mitigating effect, increased investment and improved cash flow. Experience of the dairy farmers had the expected positive sign. It was significant at 95% level in semi zero grazing system (Table 3). Farm household size in zero grazing milk production systems had a coefficient of 0.0274 that was statistically significant at 95% level (see Table 3). This variable was not significant in the other production systems. Zero grazing is more labour intensive compared to the other two systems. Therefore large household size provides the necessary family labour. Alemdar *et al*. (2010) found that use of family labor may have positive and negative effects on efficiencies depending on the situation and that it is a source of stronger incentives for efficiency in small scale family farming. The policy implication in dairy milk production of these finding is that inefficiency can be reduced significantly by increasing intensification and therefore achieving increased employment in the rural areas. The results showed that experience, measured in years, has a significant effect on the technical efficiency in semi-zero grazing systems. Similar results were reported by Ajibefun and Daramola (2003) who found that individuals with more experience tend to exhibit higher levels of profit efficiency. Land size and number of cattle were not significant determinants of technical efficiency in any of the three milk production systems. Nevertheless, a negative relationship in open grazing system indicates the possibilities to improve technical efficiency through greater utilization of small land sizes. The distance to the market had a negative and significant coefficient of - 0.025 mean technical efficiency in the case of zero grazing milk production system. This was also negative for open grazing system. This result indicates that access to markets is useful in improving technical efficiency especially in zero grazing systems that is associated with higher input use. Market access condition the technical efficiency of milk production especially for a highly perishable product like milk. Market oriented small scale dairying has the potential to reduce losses and transaction costs.

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5. CONCLUSION

The results of the analysis indicate that presence of technical inefficiencies significantly affected milk production. Technical efficiency increased with the level of intensification of milk production. The elasticity of milk production was an increasing function of cost of feeds and equipment in the three production systems with statistical significance of 5%. Labour significantly influenced milk output in zero and semi-zero grazing system while it negatively did so in the open grazing system. There is need to increase the level of intensification in milk production to enhance technical efficiency. Suggested future work is needed in improvement on feed production and utilization technologies in order to increase technical efficiency. Educational opportunities for farmers lead to initiative, innovation and improvements while social capital provides farmers' organizations with the ability to generate and utilize resources more effectively through the development of infrastructure and service provision including credit access. Family labor had a positive effect on mean technical efficiency of the zero grazing production system being a source of stronger incentives in small scale intensive dairy farming. Finally, younger operators of dairy enterprises tend to have a higher level of technical efficiency as they are likely to be more agile and aggressive in their business drive than the old ones.

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