

Technical and Allocative Efficiency of Smallholder Dairy Farmers in Swaziland

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Abstract
The objectives of the study were to describe the socioeconomic characteristics of smallholder dairy farmers; estimate the technical and allocative efficiency of smallholder dairy farmers in Swaziland, and to identify factors affecting the technical and allocative efficiency of smallholder dairy farmers. This study used a descriptive quantitative survey to analyse data from a sample of 111 smallholder dairy farmers. Purposive and random sampling techniques were used to select the farmers. Data were analysed using descriptive statistics and econometric analysis (Stochastic Production and Cost Frontier Functions). The average levels of TE and AE for the farmers were 66% and 78% respectively. The availability of water for irrigating pastures, pasture size, soil fertility of pastures, the dairy farming experience, training on dairy farming, distance to the market, farmer's age, credit access, household size and herd size contribute to the explanation of variations in the TE and AE of the dairy farmers. The study concludes that smallholder dairy farmers were relatively technically and allocatively efficient, however, there is still a 34% and 22% potential to improve the TE and AE levels respectively. The study recommends that soil testing should be done by farmers in order to improve efficiency. There is a need for financial institutions to consider advancing credit to dairy farmers. The SDB should strengthen their technical training through the extension officers in order to encourage efficient use of input resources.
Keywords: Allocative efficiency, dairy farmers, technical efficiency,

1. Introduction

Swaziland has a dual land tenure system consisting of Swazi Nation Land (SNL) and Title Deed Land (TDL). The dairy industry in Swaziland is developed and regulated by the Swaziland Dairy Board (SDB). According to T. Mnisi (personal communication, November 14th, 2013) dairy farmers in Swaziland are divided into three categories namely; smallholder farmers (herd size ranges from 1 – 10 cows), medium-scale farmers (herd size ranges from 11 – 40 cows), and large-scale dairy farmers (herd size is more than 40 cows). There is a high demand for milk and its products in Swaziland. In 2008, the annual demand for milk products was documented to be 56 million litres per year, whereas milk production from the national dairy herd was 8.4 million litres, leaving a shortage of 47.6 million litres (CBS, 2009). In 2009, dairy imports amounted to 44.3 million litres of liquid milk equivalents (LME) (CBS, 2010). During the 2009/2010 financial year, the demand for dairy products became 52 million litres per annum in liquid milk equivalents (LME), while milk production from the national dairy herd was 7.52 million litres per annum. The shortage on the same year was 44.48 million litres. This shortage was covered by imports of dairy products and milk from South Africa. Swaziland imports over E800 million worth of dairy products, consisting of cheese, cream, yoghurt and others, annually (Thompson, 2012). In the year 2010, the demand for milk and milk products rose to 53.53 million litres per year, whereas the raw milk production from the national dairy herd was 7.71 million litres per year (SDB, 2011).

The SDB has signed a memorandum of understanding with Swaziland Government to allow dairy farmers to source dairy cattle locally through the rehabilitation of the Gege ranch into a breeding station. Even though such a provision has been made, there are still numerous challenges in milk production in the country. These include high feed costs, livestock disease prevention and control costs. Milk production costs are higher compared to the revenue generated per litre of milk in Swaziland, which negatively affects the farmers' profit margins. Even though the market for milk is available in Swaziland, but the milk production rate is low, and that is attributed to the high production costs (Makhubu, 2012).

In spite of the efforts made by the Swaziland Government and Swaziland Dairy Board (SDB) in improving milk production in the country, smallholder dairy farmers still face high input costs in milk production coupled with the low milk price offered in the market, which together reduce their profit margins (Makhubu, 2012). This could be due to inefficiencies in the dairy industry. Dlamini (2012) found that smallholder dairy farmers in Swaziland are technically inefficient; however, there was need to investigate the technical and allocative efficiency of the smallholder dairy farmers.

The main purpose of this study was to estimate the technical and allocative efficiency of smallholder dairy farmers in Swaziland. The specific objectives were to: describe the socioeconomic characteristics of smallholder dairy farmers; estimate the technical and allocative efficiency of smallholder dairy farmers; and to identify factors affecting the technical and allocative efficiency of smallholder dairy farmers. The study tested the following hypotheses:

1. H_0 = Smallholder dairy farmers are technically and allocatively inefficient
2. H_0 = Institutional factors, socioeconomic and farm characteristics have no significant effect on the technical and allocative efficiency of smallholder dairy farmers

The poor performance and the under development of the dairy sector can be attributed to inefficiency of the local smallholder dairy farmers, who constitute a larger percentage of the dairy sector. Therefore, there was need to assess the technical and allocative efficiency of smallholder dairy farmers. Hence, the results of this study are important because they reveal some information to help smallholder dairy farmers and all stakeholders (such as, the Ministry of Agriculture, SDB and the milk processing plants) in the dairy industry to try to eliminate factors that cause technical and allocative inefficiencies.

2. Theoretical framework

Efficiency is considered as one of the most important issues in agricultural production economics. It is measured by comparing the actually attained value of the objective function against what is attainable at the production frontier. The analysis of production and resource use in the smallholder dairy sector has more significance in agricultural policy frameworks that seek to increase local milk production by encouraging optimal resource utilization. Improving technical and allocative efficiency is an important factor of productivity growth in a developing country like Swaziland. Hassanpour (2012) stated that the analysis of technical and allocative efficiencies under the current technological change in agriculture helps policy makers to formulate adequate and appropriate extension services, pricing, marketing, credit, input distribution and land allocation policies.

2.1 Technical Efficiency

In economic theory, a production function is described in terms of maximum output that can be produced from a specified set of inputs, given the existing technology available to the farm (Battese et al., 1995). When the farm produces at the best production frontier, it is considered efficient. The most common assumption is that the goal of the producers is profit maximization; however, it is believed that the objectives and goals of the producer are intertwined with farmers' psychological makeup. TE is achieved when a high level of output is realized given a similar level of inputs. It is therefore concerned with the efficiency of the input to output transformation. The reason for TE research is to understand factors that shift production function upwards (Battese et al., 1995).

2.2 Allocative Efficiency

Allocative efficiency (AE) is the ability of the firm to allocate an input bundle or produce a given level of output in the cost minimizing way (Chukwuji et al., 2006). Thus, the allocatively efficient level of production is where the farm operates at the least-cost combination of inputs. AE can also be defined as the ratio between total costs of producing a unit of output using actual factor proportions in a technically efficient manner, and total costs of producing a unit of output using optimal factor proportions in a technically efficient manner. Thus for the farm to maximize profit, under perfectly competitive markets, it is required that the extra revenue (Marginal Value Product) generated from the employment of an extra unit of a resource must be equal to its unit cost (Marginal Cost = unit price of input) (Chukwuji et al., 2006).

2.3 Profit maximization theory

The profit maximizing theory assumes that smallholder farmers are profit maximizing economic agents and are thus efficient producers. On the other hand, the risk-averse smallholder farmers' theory argues that poor smallholder farmers are risk-averse and they attempt to increase family security rather than maximizing profit (Mumba, 2012; Snyder & Nicholson, 2008). In many industries**,** profit maximization is not simply a potential goal; it is the only feasible goal, given the desire of other business people to drive their competitors out of business (Skaggs, 2010).

A firm can increase its output so long as the marginal revenue earned from additional units of production is greater than the marginal cost of those units. Marginal revenue is the additional revenue earned by selling one more unit of a product. Marginal cost is the additional cost incurred in producing one more unit of output. As long as MR > MC, profit grows. However, when MR < MC, profit shrinks. So firms expand output only to the point at which MR = MC, which is the point that maximizes profit. The profit-maximization rule applies both to firms that are able to sell their product at a constant price and to firms that find they must reduce the price of their product to increase sales. In the real world, firms have to engage in trial-and-error discovery processes, searching for the profit-maximization point. The process can be clearly described by the marginal revenue-marginal cost rule (Skaggs, 2010; Snyder & Nicholson, 2008).

3. Methodology

3.1 Study Area

Swaziland is comprised of four administrative regions, which are; Hhohho, Manzini, Lubombo and Shiselweni. This study was conducted in all the regions of the country.

3.2 Research Design

The study used a descriptive and quantitative research design on the Technical and Allocative Efficiency of smallholder dairy farming in Swaziland.

3.3 Sampling Technique

The target population was all smallholder dairy farmers registered with SDB in Swaziland. The sample frame of 444 farmers was obtained from SDB. Purposive and random sampling techniques were used to select 111 respondent farmers (Barlett, Kotrlik, and Higgins, 2001) Table 1 shows the population and sample sizes from the different regions.

Table 1. Smallholder dairy farmers' sample size per region

Region	Population (N)	Sample (n)
Manzini	205	50
Hhohho	103	26
Shiselweni	82	21
Lubombo	54	14
Total	444	111

3.4 Instrument and data collection

The research questionnaire was divided into three parts, which were according to the specific objectives. Part 1 was based on the factors affecting efficiency (farm characteristics, socio-economic characteristics and institutional factors); part 2 was based on the technical factors (general milk production) and part 3 was based on the costs and returns for the smallholder dairy enterprise. Closed-ended and open-ended questions were used in the questionnaire because of the nature of the data that were collected from the farmers. The instrument was reviewed for content validity by a panel of experts consisting of officers at the SDB, Ministry of Agriculture and experts from the Department of Agricultural Economics and Management (AEM) of the Faculty of Agriculture. This was to ensure that the instrument measured what it intended to measure, items were clearly worded, and statements were not ambiguously stated. A pre-test was conducted with eight smallholder dairy farmers, in order to establish the reliability of the instrument.

3.5 Data Collection

Cross-sectional data were collected from sampled dairy farmers using face to face interviews. Data consisted of socio-economic characteristics, dairy production, input and output levels, farm management practices as well as income received from the dairy farming through the use of a structured questionnaire.

3.6 Data Analysis

Data were analysed using descriptive statistics such as means and frequencies, and Cobb-Douglas regression analysis in the form of a production and cost functions were used to determine TE and AE respectively, while Tobit regression was used to identify factors affecting TE and AE.

3.7 Analytical Framework

3.7.1 Estimation of Technical Efficiency

Technical efficiency TE) was estimated using a Cobb Douglas Stochastic Production Function. The two stage approach of analyzing TE based on Stochastic Production Frontier is as follows;

1. Estimate the stochastic production function, from which efficiency scores were derived.
2. Efficiency scores were regressed on explanatory variables using Tobit regression.

This study assumed that the milk yield per cow was dependent on herd size, grazing pasture size, monthly quantity of concentrate feed and the monthly quantity of fertiliser. The model used in this study was expressed in general form as:

$$Y \quad f(X_1, X_2, X_3, X_4) \qquad (1)$$

The empirical form of the model was expressed as:

$$Y = f\,(X_{herd\ size}, X_{pasturesize}, X_{feed}, X_{fertiliser}) \qquad (2)$$

The Cobb-Douglas stochastic production function was specified as follows:

$Y = \beta_0 X_1^{\beta 1} X_2^{\beta 2} X_3^{\beta 3} X_4^{\beta 4} e^{v-u}$ (3)

Taking the natural logarithms of both sides, the log linear form of the production function becomes:

$lnY = \beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + (v_i - u_i)$ (4)

Where:

lnY = natural logarithm of the monthly milk yield per cow (litres)

lnX_1 = natural logarithm of the herd size (total number of cows per farm)

lnX_2 = natural logarithm of grazing pasture size (ha)

lnX_3 = natural logarithm of monthly concentrate feed (kg)

lnX_4 = natural logarithm of monthly fertiliser amount (kg)

$\beta_0, \beta_1, \beta_2, \beta_3$ and β_4 = are unknown parameters to be estimated

$(v_i - u_i)$ = e = random error term

Where v is a two-sided $(-\infty < v < \infty)$ normally distributed random error $[V \approx N(0,\sigma_v^2)]$ that captures the stochastic effects outside the farmer's control (e.g., weather, natural disasters, and luck), measurement errors, and other statistical noise. The term u is a one-sided $(u \geq 0)$ efficiency component that captures the economic inefficiency of the farmer. It measures the shortfall in output (Y) from its maximum value given by the stochastic frontier $f(X_i; \beta_i) + v$. It was assumed that u has an exponential distribution $[U \approx N(0,\sigma_u^2)]$. The two components v and u are also assumed to be independent of each other. The parameters were estimated by the maximum likelihood method following Bravo-Ureta and Pinheiro (1993). Following Jondrow et al. (1982), the technical efficiency estimation is given by the mean of the conditional distribution of inefficiency term U_i given ε_i; and thus defined by $E(U_i | \varepsilon_i)$ (6)

3.7.2 Estimation of Allocative Efficiency

Allocative efficiency (AE) was estimated using a Cobb Douglas Stochastic Cost Function. This study assumed that the total costs were dependent on costs of concentrate feed, labour costs, chemical costs and milk yield per cow. The model used in this study was expressed in general form as:

$C \quad f(X_1, X_2, X_3, X_4)$ (7)

The empirical form of the model was expressed as:

$C = f(X_{feed\ costs}, X_{labour\ costs}, X_{chemicals\ costs}, X_{milkyield\ per\ cow})$ (8)

The Cobb-Douglas stochastic cost function was specified as follows:

$C = \beta_0 X_1^{\beta 1} X_2^{\beta 2} X_3^{\beta 3} X_4^{\beta 4} e^{v-u}$ (9)

Taking the natural logarithms of both sides, the log linear form of the cost function used becomes:

$lnC = \beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + (v_i - u_i)$ (10)

Where:

lnC = natural logarithm of the total milk production costs (Emalangeni)

lnX_1 = natural logarithm of the total cost of concentrate feed used in each farm (Emalangeni)

lnX_2 = natural logarithm of total labour costs (Emalangeni)

lnX_3 = natural logarithm of total costs of chemicals (Emalangeni)

lnX_4 = natural logarithm of milk yield per cow (Litres)

$\beta_0, \beta_1, \beta_2, \beta_3$ and β_4 = are unknown parameters to be estimated

$(v_i - u_i)$ = e = random error term

3.7.3 Estimation of factors affecting technical and allocative efficiencies

To estimate the factors affecting TE and AE, a Tobit regression model was used. The Tobit model was used because the efficiency scores lie within a double bounded range of 0 to 1. The Tobit regression model coefficients do not directly give the marginal effects of the associated independent variables on the dependent variable. But their signs show the direction of change in the dependent variable as the respective explanatory variables change (Goodwin, 1992; Mussa, 2011). The Tobit regression model was estimated as;

$$Y_i^* = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + \beta_{13} X_{13} \quad (12)$$

Where Y^* = level of TE and AE; X_i is a vector of explanatory variables that include age (in years), gender (1 = male; 0 = female), education level (in years of study), household size (number), years of experience for the

household head (in years), farm location (1 = SNL; 0 = TDL), water availability (1 = yes; 0 = no), pasture size (hectares), soil fertility (1 = good; 0 = poor), membership to dairy farmers association (1 = yes; 0 = no), training on dairy farming (1 = yes; 0 = no) and distance travelled to the market (in kilometres), herd size (total number).
Table 3 indicates that the older the farmer the more efficient he should be, the bigger the household size, and the more experienced the farmer, the more efficient he is. However, for the other variables, their impact could take any

Table 3: Two – limit Tobit Regression Model Variables

Explanatory Variables	Description of Variables	Unit of Measurement	Hypothesized Sign
Age	Age	Years	+
Gender	Gender	1 = male; 0 = female	-/+
Ed. level	Educational level	Years	+
Hsholdsz	Household size	Number	+
Exper	Farmer's experience	Years	+
Fmloc	Farm location	1 = SNL; 0 = TDL	-/+
Wtav	Water availability	1 = yes; 0 = no	-/+
Pastsize	Pasture size	Hectares	+
Soilfert	Soil fertility	1 = good; 0 = poor	-/+
Mdfa	Membership to a dairy farmers' association	1 = yes; 0 = no	-/+
Train.	Training 2 years ago	1 = yes; 0 = no	-/+
Dist.	Distance to market	Kilometres	-
Hdsze	Herd size	Total number	+

4. Results and discussion

4.1 Characteristics of the respondents

Table 4 presents the socioeconomic characteristics of smallholder dairy farmers. The results of the study indicated that 33% of the sampled smallholder dairy farmers were females, while 67% were males. This was an indication that the dairy farming was dominated by male farmers in Swaziland. The age of the sampled smallholder dairy farmers ranged from 31 to 75 years old. The majority (32%) of the farmers had their age ranging from 51 to 60 years. The mean age was 55 years. The results also indicated that 78% of the sampled smallholder dairy farmers attained tertiary education is important because it enlightens the farmers about risks and uncertainty involved in the dairy business, and it also sharpens their problem solving abilities. It was also revealed that 89% of the sampled smallholder dairy farmers were married. The findings of the study also indicated that 68% of the farmers had household sizes ranging from 4 to 8 members.
The results further showed that 37% of the farmers had a dairy farming experience ranging from 11 to 15 years. The average experience of farmers in dairy farming was 11.14 years. The results also revealed that 98% of the dairy farmers had an off-farm income. This implied that very few farmers were solely depending on dairy farming for their livelihoods and most farmers had other sources of income.
The results further showed that 29% of the dairy farmers had pastures with sizes ranging from 2 to 2.9 hectares. However, the mean pasture size was 6 hectares. The results also showed that 76% of the dairy farmers tested their pasture soils, hence they have knowledge of the conditions of their soils, and they were able to maintain good soil fertility. A majority (96%) of the smallholder dairy farms were located on the Swazi Nation Land, while the remaining 4% were located on the Title Deed Land. The findings also revealed that 76% of the smallholder dairy farms had available water for the irrigation of the pastures, while the remaining 24% had no water available for pasture irrigation. It was expected for dairy farmers with available water for pasture irrigation to be technically efficient.

Table 4: Farm and socioeconomic characteristics for smallholder dairy farmers

Variable		Frequency	Percentage	Mean	SD
Gender					
	Female	37	33.3		
	Male	74	66.7		
	Total	111	100.00		
Farmer's age					
	31 - 40	7	6.31		
	41 - 50	33	29.73		
	51 - 60	35	31.53		
	61 – 70	32	28.83		
	71 – 75	4	3.60		
	Total	111	100.00	54.802	9.449
Level of education					
	None	1	0.90		
	Primary	5	4.50		
	Junior	10	9.01		
	High school	8	7.21		
	Tertiary	87	78.38		
	Total	111	100.00		
Marital Status					
	Single	1	0.90		
	Married	99	89.19		
	Widowed	8	7.21		
	Separated	3	2.70		
	Total	111	100.00		
Household size					
	1 – 3	11	9.9		
	4 – 8	75	67.57		
	9 – 13	20	18.02		
	14 – 35	5	4.50		
	Total	111	100.00	6.847	4.185
Dairy farming experience					
	1 – 5	14	12.61		
	6 – 10	37	33.33		
	11 – 15	41	36.94		
	16 - 20	15	13.51		
	21 – 36	4	3.60		
	Total	111	100.00	11.144	5.164

Table 4 continues

Variable		Frequency	Percentage	Mean	SD
Off-farm income					
	No	2	1.80		
	Yes	109	98.20		
	Total	111	100.00		
Pasture size (Ha)					
	0.1 – 0.9	13	11.7		
	1.0 – 1.9	18	16.2		
	2.0 – 2.9	32	28.8		
	3.0 – 3.9	17	15.3		
	4.0 – 4.9	11	9.9		
	5.0 – 6.9	11	9.9		
	7.0 – 200	9	8.2		
	Total	111	100	5.777	20.02

4.2 Factors affecting milk production and production costs

With reference to Table 5, all the coefficients of the explanatory variables for monthly milk output per cow had positive signs. This implied that 1% increase in herd size, pasture size, monthly amount of concentrate feed and monthly amount of fertiliser would increase average monthly milk output per cow by 1.79%, 0.83%, 1.36% and 1.08% respectively. Athe estimates of the cost function indicate that a 1% increase in cost of concentrate feed, labour costs, and chemicals costs would increase the total monthly milk production costs by 0.81%, 0.09% and

0.79% respectively, whereas a 1% increase in milk yield per cow would reduce milk production costs by 0.08%. Two technical factors (herd size and monthly amount of concentrate feed) were significant at 5% level of significance, while the pasture size and monthly amount of fertiliser were significant at 10% level of significance. The allocative factors (feed costs and milk yield per cow) were significant at 1% level of significance, while labour costs and chemical costs were significant at 5% and 10% level of significance respectively. The minimum TE was 32%, while the maximum TE was 81%, and the average TE was 66%. The minimum AE was 21%, the maximum AE was 94%, and the average AE was 78%.

Table 5: Factors affecting milk yield per cow and milk production costs

Production Factors	Coefficient	t-vaue	p-value	Costs Factors	Coefficient	t-value	p-value
Herd size	1.79**	1.41	0.04	Feed cost	0.81***	33.2	0.00
Pasture size	0.83*	1.09	0.07	Labour cost	0.09**	2.66	0.01
Concentrate feed	1.36**	0.85	0.02	Chemical cost	0.08*	1.80	0.07
Fertiliser	1.08*	0.64	0.09	Milk per cow	-0.08***	-4.89	0.00
Constant	4.57***	2.45	0.00	Constant	0.93***	4.45	0.00
Lambda	1.24			Lambda	0.019		
Regional TE:				**Regional AE**:			
Manzini = 63%				Manzini = 67%			
Shiselweni = 74%				Shiselweni = 89%			
Hhohho = 68%				Hhohho = 83%			
Lubombo = 60%				Lubombo = 72%			
Minimum = 32%				Minimum = 21%			
Maximum = 81%				Maximum = 94%			
Average = 66%				Average = 78%			

4.4 Factors affecting technical and allocative efficiencies

Table 6 presents the results of the factors affecting the levels of TE and AE for smallholder dairy farmers in Swaziland. The results indicated that technical efficiency was affected by soil fertility, dairy farming experience, access to credit, and training at 5% level of significance, while it was affected by available irrigation water, pasture size, distance to market, and hard size at 10% significance level. All the variables had positive relationship with TE except distance to market.

Similarly, allocative efficiency was affected by age of the farmer, household size, distance to market, and herd size at 1% significance level. It was also affected by availability of irrigation water, credit access and membership to an association (p <05), while pasture size was significant at 10% level. All the variables had a positive relationship with allocative efficiency with the exception of household size and distance to market.

Table 6: Factors Affecting Technical and Allocative Efficiency

Efficiency Factors	TE			AE		
	Coefficient	t-value	p-value	Coefficient	t-value	p-value
Location	0.53	0.52	0.50	1.24	0.75	0.55
Water for irrigation	0.73*	1.64	0.08	6.44**	2.05	0.04
Pasture size	0.18*	1.42	0.09	0.62*	1.67	0.05
Soil fertility	0.47**	2.03	0.02	1.48	1.73	0.14
Gender	0.15	1.66	0.11	2.56	2.56	0.48
Age	0.06	1.03	0.31	5.93***	3.43	0.00
Level of education	0.01	0.14	0.89	9.52	0.58	0.67
Household size	0.05	0.19	0.85	-4.73***	4.72	0.00
Dairy experience	0.01**	1.23	0.04	1.74	0.89	0.38
Credit access	1.26**	2.40	0.01	4.65**	1.68	0.02
Assoc. membership	0.01	0.1	0.92	5.72**	2.11	0.04
Training	0.36**	2.36	0.03	5.14	1.69	0.10
Distance to market	-0.01*	2.00	0.06	-1.13***	6.18	0.00
Herd size	0.004*	1.81	0.07	3.79***	5.64	0.00
Constant	0.72	1.43	0.17	0.99***	7.20	0.00

Note: * (p<01%), ** (p<05%), and * p<10%**

5. Conclusion and recommendations

5.1 Conclusion

The results of the study indicated an average TE and AE of 66% and 78% respectively. Therefore, there is 34% and 22% potential for smallholder dairy farmers to improve their TE and AE respectively. Hence, the null hypothesis (H_0 = smallholder dairy farmers are technically and allocatively inefficient) was rejected and the alternative hypothesis (H_1 = smallholder dairy farmers are technically and allocatively efficient) was accepted. The variables: availability of water irrigation of pastures, pasture size, pasture's soil fertility, the dairy farming experience, credit access, training on dairy farming, distance to the market and herd size contribute to the explanation of variations in the TE of dairy farmers; whereas, the variables: pasture size, availability of water for pasture's irrigation, credit access, farmer's age, household size and herd size contribute to the explanation of variations in the AE of dairy farmers. Therefore, the null hypothesis (H_0 = institutional factors, socioeconomic and farm characteristics have insignificant effects on the level of TE and AE) was rejected in favour of the alternative hypothesis (H_1 = institutional factors, socioeconomic and farm characteristics have significant effects on the level of TE and AE).

5.2 Recommendations

Based on the results, the study recommends that since the herd size, grazing pasture size, monthly amount of concentrate feed, monthly amount of fertiliser, feed costs, labour costs, chemical costs had significant positive effects on TE and AE, therefore, it can be recommended that smallholder dairy farmers increase these inputs to improve efficiency. The pasture's soil fertility had a positive significant effect on TE, therefore, it is recommended that dairy farmers must regularly test their soils and improve the fertility, so that eventually, they can improve TE. Credit access had a positive significant effect on TE and AE, hence, it is recommended that financial institutions should expand credit access to smallholder dairy farmers so that they can improve their levels of TE and AE.

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