Economic Efficiency of Dairy Farmers Participating in Dairy Market Hubs in Tanga and Morogoro Regions, Tanzania

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Abstract

The regular supply of reliable quality milk may call for a hub approach where dairy services are clustered around a milk buyer under some form of contractual agreement. However, empirical evidence on the economic efficiency of hub participating farmers is limited. The objective of this study is to determine the economic efficiency of dairy farmers participating in dairy market hubs (DMHs). The study uses secondary data collected from 384 smallholder dairy farmers in Tanga and Morogoro regions and employs stochastic frontier translog cost model to estimate the level of economic efficiency among smallholder dairy farmers participating in DMHs. Results indicate that economic efficiency index ranged from 0.003-0.999 with a mean of 0.932 points implying that the sampled farmers were close to being fully economically efficient in the allocation of resources for producing a given level of milk output. Key factors indirectly related to cost inefficiency were education level, age, hub membership, and farmer location. These results indicate that new entrants especially the youths need to be encouraged to rear dairy cows. In addition, there is a need to provide farmers with basic information through trainings on profitable dairying, better technology and practices so as to improve their knowledge and skills.

Keywords – Dairy market hub, economic efficiency, smallholder, stochastic frontier

Introduction

Dairy farming is an important livelihood option for many poor rural households in the developing world, providing an important source of nutrients (Chandio *et al.,* 2017; Duncan *et al.,* 2013; Thorpe *et al.* 2000) and contributing to household incomes (Rao *et al.,* 2016). Even though dairying offers promising opportunities to combat poverty, there is a significant risk that dairy development will exclude smallholder poor farmers such as women (Mishkin *et al.,* 2018; Rota, 2009). Developed and emerging nations have intensified milk production in order to reap the benefits of economies of scale while in many developing countries, milk production remains small-scale, scattered and poorly integrated into the market chain (Ngeno, 2018; Bennett *et al.,* 2005). To minimize costs, modern retailers often impose strict standards, which often exclude resource-poor producers (Schipmann and Qaim, 2011). However, restructuring supply chains might also have impacts on economic efficiency and farm productivity; aspects which have not been sufficiently analyzed for less and pre-commercial dairy farmers so far.

Compared to extensive dairying, intensive dairy production often entails more sophisticated planning and use of inputs, which could positively influence cost/economic efficiency (Omore, 2013). Economic efficiency is crucial to production, marketing and trade (Karamagi, 2002). Economic efficiency is a composite product of technical and allocative efficiency (Adesina and Djato, 2008). Hence, economic efficiency is defined as the firm's capacity to produce a given amount of output at the minimum cost for a predetermined level of technology (Mburu *et al.,* 2014). The hypothesis here is that optimal use of inputs is relevant and could contribute to improvements in dairy productivity and efficiency (Maina *et al.,* 2018). If this is the case, intensive dairy farming could contribute to the needed dairy productivity and efficiency gains in Africa, with important positive effects for poverty reduction and rural development (World Bank, 2008).

This can be indicated by a decent standard of living, higher incomes and purchasing power or command over economic resources hence reduced poverty (UNDP and URT, 2015). Whether the rise in farm income will be shared by poor smallholders who need it most is still controversial unless their efficiency is improved. Thus, using stochastic frontier cost function, the economic efficiency of smallholder dairy farmers is examined in this study. This study aims at estimating the level of economic efficiency among smallholder dairy farmers participating in the hubs in Tanga and Morogoro regions.

Methodology

Theoretical framework

The study follows the contemporary production theory which looks at the implications of recent work using duality and translog specifications of the production functions for agricultural research (Debertin, 2002; Nguyen *et al.,* 2008). These theoretical developments have a broad-based applicability to research in production economics and demand analysis for agricultural problems at varying levels of aggregation.

Farm efficiency is the ability of a farm to produce its output without wasting resources. An economically efficient farm is one that operates at the point of tangency between the production isoquant and the isocost line for a given output (Coelli *et al.,* 2005). Given the situation of the Tanzanian dairy sector, dairy farmers are facing decisions of whether or not to intensify their production scale. According to economic principles, only producers who achieve low-cost production by pursuing economies of scale and management efficiency through the appropriate use of production technologies can survive over time in a competitive industry such as the dairy sector (FAO, 2010). Therefore, it is very important to understand differences in household efficiency in utilizing the resources (land, feed and labour) to achieve household objectives.

There are three distinct approaches to measure the firm efficiency based on production, cost and profit functions (Parikh and Ali, 1995; Shaik, 2014). Coelli *et al.,* (2005) distinguish between technical and allocative efficiency as a measure of production efficiency using a production frontier and cost function respectively. The cost function represents the dual approach in that technology is seen as a constant towards the optimizing behaviour of firms (Chambers and Quiggin, 1998). The cost function can be used to simultaneously predict both technical and allocative efficiency of a firm (Coelli, 1994).

This study has adopted a stochastic cost frontier approach following (Coelli *et al.,* 2005). This approach is stochastic and the observations may be off the frontier because they are inefficient or because of random shocks or measurement errors. The cost function approach is preferred over the profit function approach to avoid problems of estimation that may arise in situations where farm households realize zero or negative profits at the prevailing market prices (Gronberg *et al.,* 2005). Dairy farmers use four inputs: purchased feed (F), hired labour (L), dairy cows (C), and other inputs (O) (Katsumata and Tauer, 2008). The other inputs category includes inputs for care and maintenance of the dairy herd such as veterinary drugs, bedding, and operator and family labour. Kumbhakar *et al.* (1991) defined the stochastic cost function as:

$$C_{it} = f(y_{it}, w_{it}) + (v_{it} + u_{it}) \quad (1)$$

Where, v_{it} values are assumed to be independently and identically distributed $N(0,\sigma^2_v)$ two sided random errors, independent of the u_{it}. u_{it} are non-negative unobservable random variables associated with cost inefficiency or economic inefficiency, which are assumed to be independently and identically distributed as truncations at zero of the \N$(0,\sigma^2_u)$\ distribution, μ_{it} being a vector of effects specific to smallholder dairy farms, C_{it} is the cost associated with milk production, y_{it} is the milk output and w_{it} is the vector of input prices.

In the cost inefficiency effects model, the error term is composed of two components: cost inefficiency effects and statistical noise. The two error components represent two entirely different sources of random variation in cost levels that cannot be explained by output and input prices. The cost inefficiency effects could be specified as:

$$u_{it} = \delta z_{it} + W_{it} \quad (2)$$

Where z_{it} is a vector representing possible inefficiency determinants, and δ is a vector of parameters to be estimated. W_{it}, is defined by the truncation of the normal distribution with mean zero and variance σ^2. The parameters of the stochastic frontier and the inefficiency model are simultaneously estimated. u_{it} provides information on the level of cost inefficiency of farm i.

The level of cost inefficiency CI_{it} may be calculated as the ratio of frontier minimum cost (on the cost frontier) to the observed cost conditioned on the level of the farm output. This measure has a minimum value of one. Cost inefficiency can therefore be defined as the amount by which the level of production cost index for the firm is greater than the firm cost frontier. An estimated measure of cost inefficiency index for dairy farm i is:

$$CI_{it} = \exp(-u_{it}) \quad (3)$$

Econometric specification and estimation of the empirical model

The translog cost function which is a second-order approximation of the output, input prices and fixed factors was used in the current study. The translog cost function was chosen due to its flexibility and its variability in elasticity as compared to the Cobb-Douglas functional form which is simple but more restrictive (Chambers and Quiggin, 1998). The advantage of the translog cost function is that it contains fewer parameters than some other flexible functional forms. The stochastic frontier translog cost function is defined as:

$$\ln C_{it} = \alpha + \alpha_q \ln Q_{it} + \Sigma_i^n \alpha_i \ln P_{it} + \tfrac{1}{2}\beta_{qq}(\ln Q_{it})^2 + \tfrac{1}{2}\Sigma_{it}^n \beta_i \ln P_{it} \ln P_{it} + \Sigma_i^n \beta_{ij} \ln P_{it} \ln P_{it} + \Sigma_{i=1}^n \beta_{qi} \ln \mathrm{Q}_{it} \ln P_{it} + \gamma_m inZ_m + \tfrac{1}{2}\gamma_{mm}(\ln Z_m)^2 + \Sigma_{mi}^n \gamma_{mi} \ln Z_m \ln P_{it} + \Sigma_{mq}^n \gamma_{mq} \ln Z_m \ln Q_{it} + e_{it} \quad (4)$$

The symmetry assumption holds i.e. $c_{ij}=c_{ji}$ and $h_{im}=h_{mi}$. The inefficiency model (u_{it}) is defined as:

$$u_{it} = \delta_0 + \Sigma_{d=1}^n \delta_d W_d + \omega \quad (5)$$

Where: C_{it} represents total production cost, Q_{it} represents the output of milk (litres), P_{it} is a vector of variable input prices, Z_m is the vector of fixed inputs and e_{it} is the disturbance term. W_d is a vector of variables explaining inefficiency in the model.

Following Kumbhakar *et al.* (1991), the disturbance term (e_{it}) is assumed to be a two-sided term representing the random effects in the empirical system. The error term, e_{it} is taken to behave in a manner consistent with the stochastic frontier. The estimation procedure utilizes Coelli *et al.* (2005) model by postulating a cost function, which is assumed to behave in a manner consistent with the stochastic frontier concept. The stochastic frontier cost model, equation 4 with the behavioural inefficiency model, equation 5 are estimated in a one-step maximum likelihood estimation using STATA (StataCorp, 2013; Greene, 2003).

Data and variables

The data used in this study originate from households that were involved in the "More Milk" project in Tanzania during the years 2014 and 2016 as explained by (Bayiyana *et al.,* 2018). The survey data collected were used to create the appropriate variables for the analysis. The dependent variable is the natural logarithm of the total variable costs of milk production; the total variable cost is the sum of expenditures for concentrates, purchased fodder, locally purchased feeds, tick control, cattle treatment and labour. The independent variables used in estimating the stochastic frontier translog cost function were natural logarithms of milk output value, price of animal feeds, price of animal health, labour wage rate, and areas of dairy grazing as fixed inputs. Milk output value variable was computed by multiplying the total milk produced in during the study period by average milk price.

To compute the price of feeds variable, the total expenditure and quantities for each respective feed was obtained for each household. The price was then obtained by dividing expenditure by the respective quantities of feed purchased in six months. The prices were added together across the feeds and a natural logarithm was obtained for the price of a bundle of feeds. The feeds included were concentrates, purchased fodder and crop residues.

The price of animal health variable was estimated by dividing the annual expenditure on tick control and cow treatment by the total number of the respective administrations, to get the price per treatment. The two prices were added together and the natural logarithm was computed for the total price of animal health treatment. However, this was removed from the model because it was not significant. The labour wage rate was computed by calculating the total monthly expenditure of labour on dairy cattle and the total number of person-hours. A division between these two variables resulted in the prevailing monthly wage rate for each household. All of the above four variables were expected to have a positive effect on the dependent variable. The fixed costs included in the analysis were the areas of dairy cattle grazing and these were taken as a proxy of cultivated land.

This calculation assumes that the cost of producing non-milk products is equal to their value. Although the translog cost function can accommodate multiple outputs, this approach and approximation to estimating the cost of non-milk products can be justified because the sales of non-milk products were small compared to the milk sales (less than 10%) for each farm in the survey, and that small percentage represents mostly by-products from milk production, such as calves, skins and hides, fermented milk and cull dairy cows.

Several variables were hypothesised as being responsible for the estimated farm-specific cost/economic inefficiencies (Table 1). On an *a priori* basis, age and education level were expected to have a positive effect on the level of economic efficiency as they embody strength and skills which can improve cost efficiency. The *a priori* expectation is that the level of market integration in dairy production would increase economic efficiency as it allows a household

Table 1: Definition of variables hypothesized as accounting for economic inefficiency

Variable	Description
AGE	Age of household head (years)
EDUC	Years of schooling (household head)
SQEDUC	Square of years of schooling
NUMCOW	Number of lactating cows
EXTNV	Number of extension visits
WATERDS	Distance from farm to the watering point for cattle (Kilometers)
FODDER	Dummy variable = 1 if household grows improved fodder
CREDIT	Dummy variable = 1 if household used credit
TRADCDS	Distance from homestead to the nearest trading centre (Kilometers)
Location	Dummy variable = 1 if Lushoto
OFFARM	Dummy variable = 1 if household had off-farm employment
LANDC	Cultivated land (acres)
Belong_hub	Dummy variable = 1 if belong to hub

to acquire market information that enables it to have higher economic efficiency. Furthermore, most of the dairy inputs and dairy production technologies are interlocked with milk markets and they embody the number of milk cows kept. As such, the number of milk cows is expected to be positively associated with efficiency.

The availability of extension services, credit and production of fodder were expected to increase efficiency. The distance from the farm to the watering point was placed on off-farm employment. Engagement in off-farm income generating activities can reduce the amount of labour available for on-farm production. Nevertheless, off-farm incomes can be used to purchase inputs and hiring of labour thereby enhancing efficiency. The distance from homestead to the nearest trading centre is the section of infrastructure which is expected to influence efficiency. Expectations were that a higher distance would reduce efficiency since being far away from urban areas makes it difficult to access urban markets (Kavoi *et al.,* 2010).

Farmers in Lushoto and Mvomero districts were relatively more intensive and commercial oriented hence expected to be more economically efficient than their counterparts in Handeni and Kilosa districts. Therefore, intensifying and commercialising dairy farming in marginalised areas was expected to reduce inefficiency.

For the average dairy farmer to attain the level of the most economically efficient farmer in the sample, he or she requires a cost saving of $\left[1-\frac{mean}{maximum}\right]\times 100\%$. The least economically efficient farmer requires a cost saving of $\left[1-\frac{minimum}{mean}\right]\times 100\%$ [1-minimum/mean]x100% if he or she is to attain the level of the average dairy farmer in the sample.

Results and discussion

The descriptive statistics for the survey data are presented in Table 2. Participation in the hubs was voluntary, so that these households are not drawn randomly from a population of Tanzania dairy farming households. Since the hubs targeted pre-commercial dairy farming households, the households participating in hub activities may be regarded as low input using less and pre-commercial Tanzania dairy farming households.

Table 2: Descriptive statistics of the survey data

Variable Description	Mean	Standard Deviation
Age of household head (years)	48.39	13.49
Years of schooling	4.71	3.49
Number of lactating cows	4.66	1.79
Number of extension visits	0.01	0.09
Distance from farm to the water point for cattle (km)	1.52	1.40
Dummy variable = 1 if household grows improved fodder	0.30	0.46
Dummy variable = 1 if household used credit	0.05	0.23
Dummy variable = 1 if household had off-farm employment	0.41	0.49
Distance from household to the nearest trading centre	3.02	4.28
Farming system: Dummy variable = 1 Intensive	0.37	0.48
Cultivated land (acres)	4.85	3.85
Monthly wage (Tshs)	53129.53	12230.52
Milk price (Tshs/ltr)	656.05	118.26
Total variable cost (Tshs)	346398.80	108957.80

Source: ILRI-SUA 2014 and 2016 household surveys

Table 3 shows the maximum likelihood estimates of the cost frontier for dairy farmers in Tanga and Morogoro regions. Likelihood ratio test for the choice between a Cobb-Douglas and translog form of the cost function was performed and the null hypothesis was rejected in favour of the translog production function. The sigma ($\sigma^2 = 0.24$) and the gamma ($\gamma = 0.999$) are quite high indicating the goodness of fit and that the assumptions of the error terms distribution were correctly specified.

Table 3: Translog cost functional form of stochastic frontier analysis

Variable	Parameter	Coefficient	Standard error	t-value
Constant	β0	3.066125***	0.12199	25.14
Milk output	β1	0.316581***	0.01742	18.18
Feed price	β2	0.293952***	0.00889	33.07
Wage	β3	0.577475***	0.02585	22.34
Cultivated land	β4	-0.550975***	0.02479	-22.22
Milk output* Milk output	β5	0.000004	0.00003	0.13
Feed price* Feed price	β6	0.014352***	0.00037	38.36
Wage* Wage	β7	0.056151***	0.00306	18.32
Cultivated land* Cultivated land	β8	0.000044	0.00032	0.14
Milk output* Feed price	β9	-0.000132***	0.00004	-3.36
Milk output* Wage	β10	-0.029115***	0.00160	-18.17
Milk output* Cultivated land	β11	-0.000005	0.00006	-0.08
Feed price* Wage	β12	-0.031537***	0.00089	-35.46
Feed price* Cultivated land	β13	-0.000536**	0.00024	-2.21
Wage* Cultivated land	β14	0.050657***	0.00229	22.09
Diagnostic statistics				
Total variance	σ2	0.240	0.0025117	
Variance ratio	γ	0.999	0.0000002	
Log likelihood		928.970		
Mean Economic efficiency		0.932		

Source: Authors' calculation based on ILRI-SUA2014 and 2016 household surveys

***, **, *: Significant at the 1%, 5% and 10% levels respectively.

The gamma value of 0.999 implies that 99.9% of the random variation in the model is due to economic inefficiency. Most of the interactions were significant at the 1% level hence suggesting the suitability of the translog model.

Most of the independent variables had the expected positive signs. Maina *et al.* (2018) and Kavoi *et al.* (2010) reported similar findings in their economic efficiency studies of smallholder dairy farmers in Kenya. The coefficients of milk output, feed price, wage rate and land were highly significant at the 1% level, indicating how important these variables are in the cost structure of the farmers. This implies that increasing milk output, feed price, wage rate and the price of cultivated/ grazed land by 1% would respectively be associated with 0.32%, 0.29%, 0.58% and -0.55% change in the total cost of milk production. Milk output was positively associated with the cost of milk production. With higher productivity, fewer cows are needed to produce more litres of milk, hence reducing shelter and labour costs plus the amount of feed energy needed in production (FAO, 2018). The coefficient of feed price variable was positively related to the cost of milk production and significant at 1% level. Maina *et al.* (2018) and Kavoi *et al.* (2010) reported similar findings. A plausible reason for the positive relationship is that although feeding has the greatest potential for improving profitability of the majority of farming units, it contributes significantly to the cost of milk production (Bennett *et al.,* 2005). To reduce feed related costs, there is a need to promote greater reliance on forage in general and grass in particular since dairy costing often shows worthwhile reductions in concentrate and other purchased feed costs regardless of the production level (AHDB, 2018).

Land holding affected the cost of milk production negatively and was significant at 1% level. A plausible reason for the negative relationship is that the study was done in marginalized rural areas where farmers occupied larger pieces of land and some grazing land is sometimes deserted and not grazed (Hogg, 1987). So, land for grazing was not costly.

The economic efficiency levels ranged from 0.003–0.999 and the mean was 0.932 (Table 4). The observation of wide variation in economic efficiency is similar to the results from previous studies (Maina *et al.,* 2018; Kavoi *et al.,* 2010; Parikh and Ali, 1995). Despite the wide variation in efficiency in this study, about 74% of the farmers seemed to be skewed towards economic efficiency level of 0.932 and above. Generally, the results indicate that about 74 % of the farmers had lower per unit costs when compared with the average farmer in the sample.

From our findings, the average dairy farmer would require a cost saving of (1-(0.932/0.999))*100=6.71%) to attain the level of the most economically efficient farmer in the sample. The results, therefore, imply that there are limited opportunities to increase profit through increased efficiency in resource utilisation. This suggests the need for technological improvement for instance by adopting higher milk yielding cows which would raise the profit margins of farmers.

It can be recalled that dairy value chain upgrading is generally low in the dry pre-commercial marginalised areas because of their perceived low economic efficiency due to a limited orientation towards milk production and commercialisation. This argument is examined by categorising and comparing the farm-specific economic efficiencies of the hub and non-hub members, intensive and extensive farmers, and Lushoto and other farmers (Table 5).

Table 4: Frequency distribution of economic efficiency indices

Economic efficiency index	Frequency	Percentage
<0.5	15	2.63
0.51 - 0.60	8	1.41
0.61 - 0.70	8	1.41
0.71 - 0.80	21	3.68
0.81 - 0.90	54	9.47
0.91–1.0	464	81.40
Total	570	100
>=0.932	422	74.04
Maximum efficiency	0.999	
Minimum efficiency	0.003	
Mean efficiency	0.932	

Source: Authors' calculation based on ILRI-SUA2014 and 2016 household surveys

Although the economic efficiency levels were higher for the hub than non-hub farmers in this study, the differences were not statistically different from zero. The economic efficiency levels for intensive farmers were significantly higher than those of extensive farmers by about 2.6% points at a 5% level. The study also found that the mean economic efficiency for Lushoto farmers was about 7.6% points higher than that of other farmers at 1% level. This difference could be attributed to the cool and wet hilly environment in Lushoto and the proper planning and management of resources by Lushoto farmers to minimise wastage (Maina *et al.,* 2018; Swai and Karimuribo, 2011; Omore, 2013). Overall, the results show that there exists unexploited potential of increasing dairy production and income across all farmers through investing in the dairy value chain in the marginalised areas of Tanzania.

Table 5: Mean of economic efficiency by hub membership and location

Variable	Mean economic efficiency
Hub farmers	0.939
Non-hub farmers	0.928
Combined	0.932
Difference	0.011
Lushoto	0.987
Other districts	0.911
Combined	0.932
Difference	0.076***
Intensive system	0.946
Extensive system	0.919
Combined	0.932
Difference	0.026**

Source: Authors' calculation based on ILRI-SUA 2014 and 2016 household surveys
***, **; *: Significant at the 1%, 5%; 10% levels respectively.

Sources of economic inefficiency

Given that the levels of economic efficiency differ among dairy farmers, it is necessary to investigate why some farmers can achieve relatively higher efficiency levels while others are economically less efficient. The findings of that analysis among sampled farmers in Tanga and Morogoro regions were summarised in Table 6. A negative sign on a parameter means that the variable decreases inefficiency, while a positive sign increases inefficiency.

The coefficients for education level, farm location and hub membership were negative and highly significant at 1% level. This implies a negative relationship between these variables and economic inefficiency among sampled farmers. This is in line with the human capital theory which suggests that education embodies strength and skills which can improve resource utilisation (Kwabena *et al.,* 2006) but contradicts Maina *et al.* (2018) findings. As the farmer becomes more educated, he or she becomes more able to combine his or her resources optimally given the available technology. However, the coefficient on squared years of schooling was positive and significant at 1% level, implying that the effect of education had diminishing marginal returns.

The effect of off-farm employment was negative although not significant. This suggests that having off-farm employment reduces inefficiency. This is reasonable because off-farm incomes can be used to purchase dairy inputs and hire farm labour thereby enhancing efficiency. The coefficient on hub membership was negatively related with economic inefficiency and significant at 1% level. This implies that farmers in the DMHs were less inefficient and closer to the minimum cost frontier than the non-hub farmers. Thus, the finding is an indication that farmers who belonged to the hubs reduced economic inefficiencies of dairy production and performed better than the non-hub members.

The effect of farm location was negative and significant at 1% level. This implies that a farmer being in Lushoto district which has a cool environment significantly reduces inefficiency compared to when he or she is located in another district. This could be attributed to the higher level of intensification among dairy farmers in Lushoto hence higher production. Land size had a negative but not significant effect on economic inefficiency.

Table 6: Determinants of economic inefficiency in dairy production (maximum likelihood estimates)

Variable	Parameter	Coefficient	Standard error	t-value
Constant	δ0	-2.073***	0.435	-4.76
AGE	δ1	0.019**	0.007	2.58
EDUC	δ2	-0.232***	0.063	-3.71
SQEDUC	δ3	0.020***	0.005	3.96
CREDIT	δ5	0.050	0.421	0.12
OFFARM	δ6	-0.373	0.256	-1.46
TRADCDS	δ7	-0.028*	0.016	-1.71
LOCATION	δ8	-14.830***	1.392	-10.65
LANDC	δ9	-0.008	0.006	-1.29
Belong_hub	δ10	-0.707***	0.232	-3.05

Source: Authors' calculation based on ILRI-SUA 2014 and 2016 household surveys
***, **; *: Significant at the 1%, 5%; 10% levels respectively.

The coefficient of age was positive and significant at 5% level. This suggests that as the farmer grows older, he or she becomes less able to look after cattle and work on the farm. Similar findings were obtained by earlier studies (Maina *et al.,* 2018; Kavoi *et al.,* 2010; Okoye and Onyenweaku, 2007) which indicated that the older a farmer becomes, the less able he or she becomes to combine his or her resources optimally given the available technology.

Distance to the trading centre/hub was negatively associated with economic inefficiency and weakly significant at 10% level. This could be attributed to the value that dairy farmers attach to the services they get from the hubs compared to those who are near trading centres. Nonetheless, this finding is an indication that being far away from the hubs or trading centres is not necessarily a barrier to improved performance. The coefficient on credit was positive but not significant. Extension visits and distance to water source were omitted from the model due to collinearity.

Conclusion

The study has shown that dairy farmers in Tanga and Morogoro regions were generally close to being fully economically efficient. Economic efficiency indices ranged from 0.003-0.999 with a mean of 0.932 which implies that the sampled farmers were close to high economic efficiency in the allocation of resources for producing a given level of milk output. This reflects farmers' tendency to optimise resources allocation associated with the production process, thus, allocative inefficiency is not a big problem among sampled farmers. Therefore, profitability can only be improved via technical efficiency for instance through adoption of higher milk yielding breeds in order to enhance output. Important factors indirectly related to cost inefficiency were education, off-farm employment, farming system, age and squared years of schooling.

These results indicate that new entrants especially the youths need to be encouraged to rear dairy cows. In addition, farmers may consider changing the technology that they are using for instance by adopting higher milk yielding breeds so as to improve their productivity and hence economic efficiency. There is a need to provide farmers with basic information through trainings on profitable dairying, better technology and practices to improve their knowledge and skills. This would enhance proper planning and management hence minimise unnecessary wastage.

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