TECHNICAL EFFICIENCY AND ITS DETERMINANTS IN DAIRY FARMERS IN KURUNEGALA DISTRICT: STOCHASTIC FRONTIER PRODUCTION FUNCTION

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Abstract

The objectives of this study are to estimate the technical efficiency and examine the impact of demographic and farming characteristics on technical efficiency among smallholder dairy farmers in Maho Divisional Secretariat in Kurunegala district during 2022. A structured questionnaire was used to collect information about milk production inputs and outputs, as well as other pertinent data, from 150 dairy farmers through convenience sampling. Maximum likelihood estimates of a stochastic production function were employed in the study and its results revealed that milk output was positively influenced by the number of milking cows and negatively influenced by the expenditure on veterinary at a 1% significant level. The average technical efficiency of the selected milk production farmers given by the Cobb – Douglas production function was 91% with minimum and maximum efficiency levels of about 73% and 96% respectively. This indicates that there is a scope and exists room for improving the existing level of milk production through enhancing the level of technical efficiency by 9% without increasing the level of input. In order to identify the impact of demographic and farming characteristics on technical efficiency, the Tobit model was applied. The results showed that age, sex, family size, and the number of milking times positively influenced the technical efficiency of milk production while access to credit marginally and positively influenced the efficiency of milk production in the study.

Keywords: Expenditure on veterinary, Number of milking cows, Smallholder dairy farmers, Stochastic production function, Technical efficiency

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1. Introduction

Small –scale dairy farming plays a crucial role in sustaining the livelihoods and ensuring food security of numerous smallholders and rural communities in Sri Lanka. Despite the potential, domestic dairy production falls short, leading to a significant reliance on imported milk powder to meet the demand for dairy products. Domestic dairy production costs are relatively low for farmers but the development of the industry is hindered by a shortage of steady supplies of feed. Therefore, milk production has to be increased by improving the technical efficiency. Through Technical Efficiency, the small-scale dairy industry is well equipped to supply dairy and dairy products to meet consumer demand reducing the forex burden on imported dairy products. Local small holder producers have benefited from the new knowledge, skills and infrastructure to make dairy economically viable and boost their income in the long-run and it will contribute to environmental sustainability by reducing the pressure from overgrazing and associated soil erosion and the burning of agricultural residues and by products. Increased feed production and improved management practices will continue to improve the productivity of cows and improved milk production will benefit the lives of stakeholders throughout the value chain. (Food and agriculture organization of United Nations, 2017).

1.1 Research problem

The purpose of this study is to analyze efficiency and determine the factors that affect small-scale dairy farming in Sri Lanka in order to provide useful information for improving smallholder dairy farmers' efficiency and profitability. The findings of this research will assist dairy farmers, value chain actors, policymakers, and researchers in upgrading the dairy value chain. So that it generates more income, hence reducing poverty and helping farmers increase their income to improve their standard of living. Furthermore, it encourages farmers to develop an efficient and competitive livestock industry, commercially on an international basis. Socio-economic, farming, and farm management practices among the farmers in the study area can be influenced through this study. Small-scale dairy farmers are now facing many problems due to the economic crisis in Sri Lanka. By improving the use of inputs and demographic and management practices, efficiency towards the frontier curve can be improved. Therefore, in order to determine how farmers will be efficient and how the above factors will affect technical efficiency, this study will be more useful in the future.

1.2 Objectives

- To estimate the level of technical efficiency among the dairy farmers in the study area.
- To examine the impact of demographic and farming characteristics on the technical efficiency of dairy farmers.

1.3 Literature Review

Many researchers have discussed the Technical efficiency of dairy farmers in the world. Edirisinghe and Sampath (2009) estimated the technical efficiency of smallholder dairy farmers in Kurunegala and Anuradhapura districts in Sri Lanka based on data collected from 150 smallholder dairy farmers in these two districts

using a pre-tested questionnaire. They used maximum likelihood estimates of stochastic production function to estimate the milk production and the Cobb-Douglas and Translog models were used to estimate the technical inefficiency. The mean of technical efficiency was found to be nearly 45 percent and the study further revealed that age, gender, focus on dairy farms, training programs, extension services and membership in the milk cooperative have the major factors influencing the technical inefficiency of milk production in the study area.

In 2003, Gunarathne, Mahipala, and Serasinghe estimated the technical efficiencies of two major farming systems in the up - country wet zone. They used stochastic frontier production (SFA) analysis and data envelopment (DEA) analysis. Also, they compared the results of these two approaches. The data used in this study were collected from the cattle farming system in Nuwara Eliya district. Also, they considered monthly milk revenue and monthly total revenue of outputs from both systems. They conducted a comparison between the milk-based system and the vegetable-based system. The stochastic Frontier analysis revealed that milk production operates on constant returns to scale and ML frontier function provides a more accurate representation. This is evident when comparing the figures of 0.402 and 0.667 (milk revenue as the dependent variable) 0.401 and 0.653 (total revenue as the dependent variable) for the milk-based system and vegetable-based system respectively The DEA estimation was based on an output-oriented CRS model and respective technical efficiencies obtained were 0.386 and 0.633 (milk revenue as the dependent variable) and 0.447 and 0.728 (total milk revenue as the dependent variables) in the both cases. However, the differences were found to be statistically significant at p=0,05 implying integrated vegetable-based systems are more efficient than milk-based systems. Finally, the overall results corroborate the findings found that vegetable-based systems are more economically viable than milk-based systems.

In 2016, Prasanna and Lakmali conducted a study to assess the technical efficiency and identify determinants associated with the technical inefficiency of potato farms in the Welimada area. The Stochastic Production Frontier Model was employed to calculate technical efficiency and pinpoint determinants of inefficiency. Data collection at the farm level involved interviews with 100 farmers in the study area conducted from February to March 2016. The study results indicated that output could increase by 28% without additional inputs and available technology at the farm level. Farmers with better education, experience, and training in potato farming who apply both organic and inorganic fertilizers and employ more family labour tend to be more efficient. Additionally, a positive correlation between farm size and technical efficiency indicated the potential for enhancing potato yield by expanding the cultivated area or consolidating land.

In 2014, Macharia, et, al (2014), evaluated the technical efficiency of dairy Cow farms in Embu and Meru Countries of Kenya. They used the stochastic frontier approach. The data were randomly collected from 135 dairy farms. The sample size was determined using Cochran's formula. Data were analyzed using the SPSS, frontier 4.1, and STATA computer software. The Stochastic frontier production function was estimated using the maximum likelihood estimation techniques. The final results revealed that the number of lactating cows and the amount of roughages, concentrates, and mineral supplements. The animals were overstocked and underfed

in an average two-acre mixed livestock farm. The mean farm technical efficiency was 83.7% representing that milk production could be increased by 16.3% through better use of available resources, given the current state of technology without extra cost. Also, dairy farms operate at an average of 83.7% technical efficiency, implying that one can lower the milk production input by 16.3% without reducing the milk output quantities.

Estimated the technical inefficiency in milk, production of smallholder dairy farmers in the highlands of Ethiopia identifies factors associated with the observed inefficiency using a stochastic frontier production function approach by Gebremedhin, Shiferaw, and Adanc in 2016. The research utilized cross-sectional data obtained from 1277 rural farm households selected from the major four regions of the country to assess the level of technical efficiency and identify factors that are associated with the observed inefficiency in the stochastic production frontier framework. The final result further shows that household wealth, education level and access to markets and institutions are the main drivers of technical efficiency in dairy production. However, finally they concluded the evidently by improving smallholder access to market and institutions as well as investing on adult education. Also, they said it is possible to bring considerable gain in milk production.

2. Material and Methods

In this study, data was collected from, Maho divisional secretariat in the Kurunagala district. Kurunegala is a District in the North-western Province, of Sri Lanka, the rainfall of Maho varies from 1100mm with 60-80 rainy days for the year. The Soil Organic matter level is rich and the farm soil is fertile. Most of the area is suitable for cultivation. However, there are many rural people who work in agriculture. The people of Maho in the Kurunegala district, do the husbandry of cows from one to herds. Also, dairy farming is a popular rural occupation in the said area. Therefore, Maho was chosen for the study, because the area is the most suitable area to estimate the technical efficiency of dairy farming.

The total population in Maho is 57,485. This study was conducted in the Maho area which included 150 dairy farmers who were selected through the Convenience sampling method. Data collection consisted of both primary and secondary data. Questionnaires were used to collect the primary data. The preliminary questionnaire was validated by piloting with a sample. Further information on this study was collected from the National Livestock Development Board, Agriculture Department, Department of Census and Statistical, Central Bank report and other related institutes.

The demographic and farming characteristics of the farmers that were influencing the technical efficiency of dairy farming and the measurements are given in Table 1.

Table 1: Measurements of the variables

Variables	Measurements
Income by dairy farming	Measured in Rupees
Age	Measured in number of years
Education	Measured by categorical variables coded as 1 for primary, 2 for up to G.C.E (O/L) and 3 for up to G.C.E (A/L)
Marital status	Measured by nominal data coded as 1 for married and 0 for single
Family size	Measured in numbers
Farming experience	Measured in number of years
Attending of training programs	Nominal data coded as 1 for yes, 0 for no
Access to credit market,	Nominal data coded as 1 for yes, 0 for no
Member of dairy organization	1 for member and 0 for non – member
Milking times per a day	Measured in numbers

Source: Developed by the researcher based on previous literature, 2022

2.1 Stochastic frontier approach

The technical efficiency of each individual dairy farmer was estimated using Stochastic frontier production function, which is generally expressed as;

$$\boldsymbol{Y_i = f(x_i, B_i)\, e^{Vi-Ui}}$$

Where,

Y_i =output for the i^{th} sample farm,

f () = appropriate functional form,

xi= vector of inputs,

Bi=vector of unknown parameters associated with explanatory variables in the production function,

V_i = random error term and

U_i= non-negative one-sided error term that measures inefficiency.

Cobb-Douglas production function

The measure of the efficiency scores of individual farmers Cobb - Douglas production function that was used in the study where the dairy production, the output was taken and four inputs such as expenditure on animal feed, number of milking cows, labour hours per day and expenditure on veterinary defined as production inputs. The production function illustrates the highest achievable quantity of dairy output achievable through an alternative combination of the mentioned five inputs. The empirical model of the Cobb - Douglas production function is given by (Coelli, 1996).

$$\boldsymbol{LnY_i = \beta_0 + \beta_1\, lnX_{1i} + \beta_2\, lnX_{2i} + \beta_3\, lnX_{3i} + \beta_4\, lnX_{4i} + V_i - U_i} \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where, *ln* represents the natural logarithm and *i* refers to the i[th] farm in the sample.
$\boldsymbol{Y_i}$ = Milk yield output in litters per month.
$\boldsymbol{X_{1i}}$ = Expenditure on animal feed in month.
$\boldsymbol{X_{2i}}$ = Number of milking cows.
$\boldsymbol{X_{3i}}$ = Labour hours spend on dairy activities per day.
$\boldsymbol{X_{4i}}$ =Expenditure on veterinary and medicine per month.
$\boldsymbol{\beta_1 - \beta_4}$ are parameters to be estimated.
β_0 = Constant term.
$\beta_1, \beta_2, \beta_3,$ and β_4 are the coefficients of each independent variable.
$\boldsymbol{V_i}$ = Independently and identically distributed random error.
μ_i = Non-negative random variables which are independently and identically distributed.

Tobit regression model

After estimating the technical scores using Maximum likelihood estimates of Cobb - Douglas production function Tobit regression model also was employed to identify the impact of farmers' demographic and farming characters on technical efficiency. For this purpose, variables related to demographic and farming characteristics among the dairy farmers were collected from the respondents and they were taken as explanatory variables and the technical efficiency scores was taken as the dependent variable as given below:

$$\boldsymbol{TE_i = \delta_0 + \delta_1\, Age + \delta_2\, Sex + \delta_3\, Family\ size + \delta_9\, Access\ to\ credit + \delta_{10}\, member + \delta_{11}\, Milking\ time + \varepsilon_i} \quad \ldots\ldots (2)$$

$\boldsymbol{TE_i}$ is technical efficiency score, $\boldsymbol{\varepsilon_i}$ is the error term and δ is the regression coefficient for the above explanatory variables used in the Tobit model.

3. Results and Discussion

The collected data were analyzed using different analytical tools such as descriptive statistics, frequency analysis, correlation analysis, Cobb - Douglas production function, and Tobit regression model. The results derived from each analytical tool are described in the following section.

Results of descriptive statistics

Descriptive statistics of the output and inputs used in this study are presented in Table 2 and it reveals that the average milk yield received by farmers was 318 liters per month with the standard deviation of 159. The average number of milking cows was 2 average as a farmer spends Rs.2890.00 and Rs.4137.00 for animal feed and animal veterinary respectively. Also, a farmer spends 5 hours on average for dairy activities per day. Further this study found that an average milking cow of 2 for dairy production which implies that the farmers in the study area are significantly smallholder farmers.

Table 2: Descriptive statistics of the output and inputs

Variables	Minimum	Maximum	Mean	St. Deviation
Milk yield	100	800	317.97	159.247
Expenditure on animal feed	500	10000	2890.00	2088.535
Number of milking cows	1	7	2.49	1.225
Labour hours per day	2	12	5.29	1.884
Expenditure on veterinary	1000	10000	4136.67	2047.995

Source: Estimated by the author using SPSS,2022

Therefore, the table above presents a summary of the study's inputs and outputs in relation to the mean and other significant statistical findings.

The other part of the analysis is descriptive statistics which consist of the demographic and some farming characteristics of dairy farmers in the study area.

Descriptive statistics related to the demographic and some farming characteristics in this study are presented in Table 3. On average, Rs 33,300.00 of income farmers are earning from them with a minimum income of Rs 12,000 and a maximum of Rs 80,000. The sampled population had an average age of 53 years, with the youngest dairy farmer being 35 years old and the oldest being 76 years.

The mean age of 53 years indicates that dairy production in the study area is mainly dominated by elders. So, the younger generations do not have a large idea of improving dairy farming in the surveyed area. On average, smallholder dairy farmers have been involved in dairy cow management for 9 years. The most experienced farmer in this regard has 33 years of experience, while the least experienced farmer has 2 years of engagement in dairy cow keeping.

The study additionally found that the farmers, on average, have a household size of five. This size ensures the availability of labor, and the involvement of more family members can contribute to an increase in dairy production. Consequently, they managed to decrease the expenses associated with hired labor in their dairy farming activities.

Table 3: Descriptive statistics of the demographic and farming characteristics

Variables	Minimum	Maximum	Mean	Std. Deviation
Income by dairy	12000	80000	33283.33	15826.176
Age	35	76	52.58	8.356
Experience	2	33	9.39	5.116
Family size	2	7	4.77	.942

Source: Estimated by author using SPSS,2022

In addition to the descriptive statistics, frequency analysis of the selected variables related to demographic and farming characteristics were examined and its results are given below.

Table 4 shows the statistical distribution of demographic and farming characteristics of dairy farmers in the study area. According to the above table, the majority of the sample respondents were male (86%). Also, the majority (98%) of the farmers were married, while only 8% were single. If the farmer is married their family family members help him to do the dairy farming in the study area but they do not agree to improve dairy farming so, they can increase their output.

All respondents had primary education and 70% had been educated beyond primary level. This suggests that the majority of smallholder farmers possess a fundamental capacity to acquire new skills and embrace technology to efficiently manage their dairy farms.74.7% of respondents had only attended training programs and 77.3% of respondents accessed the credit market. However, a few farmers reported that they had access to a formal credit market and reserved the government subsided but 93% of respondents had a membership of a dairy organization. Because most of the smallholder dairy farmers in this area sell milk, the village-wise milk collecting societies, Milko, Newdale, and Highland, are the companies collecting milk in this area. Also, dairy farmers have a society with a fund. That's why most of the farmers have membership in a dairy organization. 28% of farmers collect milk once a day and others collect milk twice a day.

Table 4: Frequency of the demographic and farming characteristics

Variables	Frequency	Percent
Gender		
Male	129	86
Female	21	14
Civil status		
Married	147	98
Single	3	2
Education		
Primary	45	30
Up to O/L	26	17.3
Up to A/L	79	52.7
Attending of training programs		
Yes	112	74.7
No	38	25.3
Access to credit market		
Yes	116	77.3
No	34	22.7
Member of dairy organization		
Yes	139	92.7
No	11	7.3
Milking times per a day		
One time	42	28
Two time	108	72

Source: Estimated by author using SPSS,2022

The correlation analysis presented in Table 5 depicts the associations between milk yield and the inputs employed by the farmers. It shows the strength and relationship between the variables. The findings reveal that the volume of milk production positively correlated with all the above inputs and they are statistically significant at 1% level. Specifically, the milk yield exhibits a nearly 80% positive correlation with the number of milking cows, surpassing the correlations with other variables. Following this, the milk yield demonstrates a 57% positive correlation with the daily labor hours.

Table 5: Results of correlation

Variables		Milk yield	Expenditure on animal feed	Number of milking cows	Labour hours	Expenditure on veterinary
Milk yield	Pearson Correlation	1	.430**	.805**	.571**	.430**
	Sig. (2-tailed)		.000	.000	.000	.000
Expenditure on animal feed	Pearson Correlation	.430**	1	.566**	.255**	.288**
	Sig. (2-tailed)	.000		.000	.002	.000
Number of milking cows	Pearson Correlation	.805**	.566**	1	.538**	.478**
	Sig. (2-tailed)	.000	.000		.000	.000
Labour hours	Pearson Correlation	.571**	.255**	.538**	1	.383**
	Sig. (2-tailed)	.000	.002	.000		.000
	N	150	150	150	150	150
Expenditure on veterinary	Pearson Correlation	.430**	.288**	.478**	.383**	1
	Sig. (2-tailed)	.000	.000	.000	.000	

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Estimated by author using SPSS, 2022

This indicates that, when the number of milking cows in the study area increases, average milk yield also will increase. All the input variables do not highly correlate with the production of milk but the correlations between each set of inputs also positively correlated with 1% level of significance indicating that, as one input increases other inputs also should be increased.

3.3 Results of Cobb –Douglas production function

The first objective of the study is to estimate the technical efficiency of dairy farming and for this, the Cobb- Douglas production function using the Maximum Likelihood estimate method was applied in the beginning and its results are shown in Table 6.

Table 6: Maximum-likelihood estimates of the Cobb-Douglas production function

Variables	Coefficient	Standardized coefficient	t- ratio
Constant	6.18	0.30	20.90
Ln Expenditure on animal feed	0.02	0.02	0.85
Ln Number of milking cows	0.33	0.04	7.34
Ln Labour hours	0.08	0.05	1.54
Ln Expenditure on veterinary	-0.06	0.03	-2.37

Source: Estimated by author using Frontier 4.1

The technical efficiency of sampled farmers in milk production in the Kurunegala district was analyzed by specifying and estimating the stochastic production frontier model through the Maximum Likelihood method. The elasticities of milk production with respect to each input are represented by the coefficients of the Cobb-Douglas production function. The elasticity of expenditure on animal feed

shows a positive sign, but it is not statistically significant. The elasticity of the number of milking cows is positive and significant at a 1% level and it represents that as the number of milking cows increases by one percent it could increase the milk production on average by 0.33%. This implies that the number of milking cows remains an important contributor to the improvement of technical efficiency in dairy production practiced in the study area. The coefficient of expenditure on veterinary has a negative sign and is significant at a 5% level which indicates that, as expenditure on veterinary increases by 1%, on average the milk production decreases by 0.06%.

Finally, the overall results reveal that milk production is mainly determined by the number of milking cows and expenditure on veterinary and it does not depend on expenditure on animal feed and labour hours.

3.4 Distribution technical efficiency scores

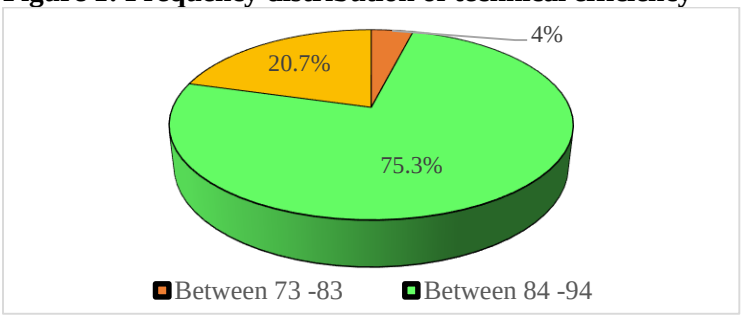
The average technical efficiency of the surveyed milk production farmers during the 2022 production year stood at 91%, ranging from a minimum of approximately 73% to a maximum of 96%. The average technical efficiency of the surveyed milk production farmers during the 2022 production year stood at ranging from a minimum of approximately 73% to a maximum of 96%. This indicates that there is a significant disparity among milk producers in their level of technical efficiency, which may in turn indicate that, there exists room for improving the existing level of milk production through enhancing the level of farmers' technical efficiency. The average level of technical efficiency further tells that the level of milk output of the sample households can be increased, on average, by 9% if appropriate measures are taken. Fundamentally, there exists the potential to enhance milk production efficiency by approximately 9% through the judicious utilization of available resources, without incorporating advanced external inputs and technologies.

Table 7: Estimates of technical efficiency scores of the sample households

Descriptions	Technical efficiency scores
Mean	0.91
Maximum	0.96
Minimum	0.73
Standard deviation	0.03

Source: Own computation results based on survey data of 2022

Figure 1: Frequency distribution of technical efficiency



Source: Compiled by the researcher using field survey data, 2022

According to Figure 1, the results reveal that 4% of the dairy farmers operated in the technical efficiency range between 73% to 83% while 75.3% of them operated in the range between 84% to 94%. Among the 150 dairy farmers, 20.7% of them operated at a higher technical efficiency level between 95% to 100% in the study area.

3.5 Results of the Tobit regression model

The analysis of technical efficiency estimates unveiled noteworthy variations among the farmers engaged in dairy production within the study. Within the framework of a specific set of technologies and inputs, certain farmers demonstrated elevated technical efficiency in milk production, while others exhibited inefficiency. This divergence may be attributed to various factors, underscoring the importance of identifying the determinants influencing the technical efficiency of dairy producers. Such identification is essential for targeted interventions aimed at enhancing milk production within the study area.

The determinants of technical efficiency in a given period vary considerably depending on the demographic and farming conditions of the study area as well as pertaining to managerial characteristics and other related factors. Thus, to evaluate the impact of the above characteristics on technical efficiency scores, the Tobit model was applied, and the estimated results are shown in Table 7.

Table 7: Results of Tobit regression model

Variables	Coefficients	Standard error	t - value	Significant
Age	0.67	0.07	8.61	0.000
Sex	11.76	2.25	5.22	0.000
Family size	5.15	0.77	6.68	0.000
Access to credit	3.47	1.95	1.77	0.078
Member	4.02	3.47	1.16	0.249
Number of milking time	5.35	1.77	3.02	0.003
Number of observations		150		
Uncensored		150		
Left - censored		0		
Right – censored		0		
F (6, 144)		2069.12		
Probability > F		0.000		
Pseudo R^2		0.3729		
Log - likelihood		-558.43		

Source: Estimated by author using Stata 17

Out of 6 variables considered in the model, 4 variables as age, sex, family size and number of milking times a significant influence is discovered and the efficiency of milk production is at 1% level while access to credit influencing the technical efficiency is at 10% level. However, members of the organization are insignificant in the model and it suggests that, for technical efficiency, there is no influence by the farmer whether he is a member or not in the farmers' organization. The computed coefficient for the age variable exhibits a positive sign and holds statistical significance at the 1% level. This implies that older farmers tend to manifest higher efficiencies compared to their younger counterparts.

Thus, as the age of the farmer increases, he will be able to use resources in such a way that yields the maximum possible output and the highest scores of efficiencies in milk production. The positive relationship between age and efficiency in this study aligns with the results documented by Bardhan and Sharma. (2013), Lemma et al. (2013) and Masunda and Chiweshe (2015).

The coefficient of sex is positive and statistically significant inefficiency of milk production, which implies that male farmers were more efficient in milk production than female farmers. Compared to female farmers, male farmers are able to actively engage in dairy production which helps them to become more efficient. In many cases, farming is disproportionate to their responsibility and they may therefore have acquired relatively more technical and managerial expertise on the job than women.

The variable for family size is significant at 1% level and it reveals that, as the number of members in the family increases, it is possible to increase the technical efficiency by spending more time on dairy farming activities by each member in the family. Thus, increased household size means, it provides more labour force for dairy production activities which enhances the efficiency in dairy farming.

Access to credit market has positive sign which indicates that, the farmers who have credit facilities, tend to improve the levels of the efficiencies in dairy farming than other farmers who don't have it. This result suggests that technical efficiency depends on where the farmers have credit facilities or not in the study.

Milking frequency was also found to significantly impact on technical efficiency which revealed that, farmers milking their cows more than twice per day were more efficient than those with a milking frequency of just one time per day. This result agrees with the literature. Indeed, Erdman and Varner (1994) reported that daily milking frequencies of 3× and 4× have, respectively, 3.5 and 4.9 kg of additional milk produced per day per cow. In addition, Dahl et al. (2004) reported that more frequent milking in early lactation stages was found to improve milk production efficiency.

4. Conclusion

This paper estimated the technical efficiency of smallholder dairy farmers and analyzed factors that affect their technical efficiency in Kurunegala District, Sri Lanka using a stochastic production frontier methodology under the Cobb-Douglas functional form. The technical efficiency measurement showed that the efficiency scores ranged between 73% and 96% with a mean 91% and the standard deviation of 0.03%. The results of the maximum-likelihood estimate of the Cobb-Douglas production function suggest that, the number of milking cows and expenditure on veterinary significantly influenced the milk yield while expenditure on animal feed and labour hours are insignificant in the study.

The impact of demographic and farming characteristics on technical efficiency was identified using Tobit regression model where age, sex, family size and number of milking time or frequency of milking times were positively influencing the technical efficiency of milk production while access to credit marginally and positively influencing the efficiency of milk production in the study. Other factors that the member of the farmers' organization found, had positive influence on technical efficiency but were not statistically significant in the model.

However, according to the milk farmers' information in the interviews, some socio-economic situations, the attitude of farmers, and the environmental situations affected the efficiency which are not taken in this study.

When farmers' income increases, they can earn higher profits, and dairy farming can be promoted as a valuable occupation among the people. Also, it can increase the public consumption of cow milk and it can reduce the cost of milk powder for imports. Thus, technical efficiency in milk among the dairy farmers can help to promote the dairy farms as an industry as well as a profitable business among the people.

These findings may be beneficial to farmers who do not understand the production technologies or inputs that strongly influence milk yield. It also would facilitate policymakers to formulate appropriate policies on how they should focus on institutional and socio-economic factors to fill the gap between the high and low technical efficiency performance, thereby enhancing milk production in the country.

In addition, as indicated, for the above factors to identify the technical efficiency, further studies are also necessary to concentrate on marketing, farm extension, rainfall data, and general policies which could be important to explain the productivity and efficiency of dairy farming in the country. Further, it would help to formulate appropriate policies to enhance dairy production while improving the economic welfare of dairy farmers in Sri Lanka.

Recommendations for dairy farmers

- Reduce the significant cost of feed and ensure availability of this major feed component during off season and reduce the unnecessary cost incurred by farmers due to price rise during off-season and veterinary services costs can also be reduced by taking preventive measures through regular vaccination of cows. This will reduce costs incurred by farmers increasing gross profit levels.
- It is necessary to concentrate on marketing, farm extension, rainfall data, and general policies of dairy farming in the country.

Recommendations for policymakers

- To increase the technical efficiency of dairy farmers, awareness programs should be conducted for them to build valuable attitudes and ideas in dairy farming.

Recommendations for the Government

- Training for new farmers who enter in the dairy enterprises should be promoted so that they get experience that will reduce inefficiencies.
- Better policies should be established so that there will be better education and nature-related experiences which are recommended.
- Subsidies should be provided to face environmental, economic, and political challenges and introduce the species bovines to the farmers because most farmers have the low-efficiency milking cows.

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