



Analysis of Production Efficiency of Dairy Cows of Households in Soc Trang Province of Vietnam

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ABSTRACT

Background: The dairy sector encompasses a variety of products, including liquid milk, milk powders, cheese, butter, yogurt and ice cream. Several factors, such as genetics, animal breed, environmental conditions, stages of lactation, parity and nutrition, collectively influence the final composition of milk. In Vietnam and specifically in Soc Trang province, the dairy industry has seen significant growth over the years, aiding many people, particularly the ethnic minorities, in overcoming poverty. The study evaluates the efficiency of dairy cow production among farmers in Soc Trang province. Data were collected from 100 dairy households in the districts of My Xuyen, My Tu and Tran De, focusing on their income generated from this sector by the end of 2021.

Methods: In addition to using secondary data, preliminary research was conducted through expert interviews, including discussions with members of the Soc Trang dairy project management board, to identify relevant factors and suitable methods for the study. For the quantitative aspect, the official research involved gathering feedback from 100 dairy farmers across three districts in Soc Trang province regarding the risks associated with dairy farming, utilizing a structured questionnaire.

Result: The data envelopment analysis (DEA) results indicated that technical efficiency varied between 70% and 100%, with a technical efficiency score (TEcrs) of 0.751, suggesting that dairy farmers could enhance production efficiency by up to 24.90% through better input resource management. Inefficiencies were attributed to factors such as grass shortages during the dry season, poor management of breeding stock and inadequate family labor allocation. Additionally, factors positively correlated with technical efficiency included years of experience in dairy farming, membership in livestock cooperatives or organizations, participation in technical training and access to financing, showing statistical significance. Finally, the study emphasizes the necessity of proposing practical solutions to enhance dairy cow milk.

Key words: CRS, Dairy cow, DEA models, Households, TE.

INTRODUCTION

Milk production is widely accepted and valued both by consumers and industry globally. To qualify as a dairy product, food must be derived from the milk of animals such as cows, buffaloes and goats (Burke *et al.*, 2018). The dairy sector encompasses a variety of products, including liquid milk, milk powders, cheese, butter, yogurt and ice cream. Several factors, such as genetics, animal breed, environmental conditions, stages of lactation, parity and nutrition, collectively influence the final composition of milk (Burke *et al.*, 2018).

In Vietnam and specifically in Soc Trang province, the dairy industry has seen significant growth and aiding many people, particularly the ethnic minorities, in overcoming poverty. The project "Improving Rural Life in Soc Trang," funded by the Government of Canada, initially transferred over 2,400 dairy cows to Khmer communities in communes as part of the "Government's Program 135" across four districts: My Xuyen, My Tu, Thanh Tri and Tran De. Additionally, the project "Development of Dairy Cows in Soc Trang Province (2014-2019)" was launched to promote dairy farming, enabling farmers to escape poverty more rapidly and sustainably since its implementation in early 2014.

Since the inception of support from the CIDA-Canada project, the four targeted districts have consistently focused

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on economic development, particularly by promoting and replicating dairy cow farming as a means of effectively implementing poverty reduction strategies. This initiative is combined with programs aimed at investing in infrastructure and supporting policies that help residents increase production and stabilize their livelihoods. As a result, the average livestock scale per household has reached 3.08 animals (Dau Van Hai *et al.*, 2016). In line with the Scheme for restructuring the agricultural sector to enhance product value and ensure sustainable development in the province, policies have been introduced to convert inefficient rice land into grasslands for dairy cows, yielding

greater economic benefits than before. In addition, resultant decreased dry matter intake (DMI) and inability of cow to cope with the increasing energy demands of lactation during the first phase of lactation lead to negative energy balance (Sidhu *et al.*, 2021). Currently, the dairy farming model in the region has significantly contributed to poverty alleviation and has increased the proportion of wealthier households.

Despite the strong development of the dairy industry in Soc Trang Province, several challenges still hinder the dairy farming process. This research aims to identify the factors that influence breeding practices and to propose solutions to overcome these obstacles, thereby contributing to the sustainable development of the dairy farming model and enhancing household incomes. Consequently, the study titled "Analysis of Production Efficiency in Dairy Cows of Households in Soc Trang Province" was carried.

MATERIALS AND METHODS

To proceed with given objectives, studies related to production efficiency of agricultural products have been discussed. Firstly, examined the technical efficiency levels of 150 cow milk producers in Kurunegala District, Sri Lanka, analyzing data collected through structured questionnaires in 2022. Using data envelopment analysis (DEA) and Tobit regression, they found average technical efficiency scores of 0.782 for constant returns to scale and 0.887 for variable returns to scale, indicating significant inefficiencies among farmers. Among the 150 dairy farmers, 21 operated under constant returns, while 122 and 7 experienced increasing and decreasing returns, respectively. Factors such as age, gender, family size, access to credit and milking frequency significantly influenced technical efficiency, suggesting potential improvements in milk production and efficiency in the region. In addition, Jerop *et al.* (2023) investigated the determinants of technical efficiency among smallholder dairy farmers in South and West Pokot Sub-Counties, Kenya, using descriptive and cross-sectional research methods. Data collected from 383 farmers revealed an average age of 45.6 years and an average ownership of five dairy cows producing 1.97 liters of milk per cow daily. Maximum likelihood estimates indicated that improvements in feeding, labor, water availability, lactation, mineral salts, animal health and silage positively impacted milk production. The mean technical efficiency was found to be 61%, with potential increases of 39% in production through better resource utilization. The study recommends tailored dairy extension programs for farmers. Thirdly, Shamebo *et al.* (2021) focused on the technical efficiency of smallholder dairy farmers in Sululta Town, Ethiopia. Data collected from 112 farmers in 2017/18 used systematic random sampling and included both descriptive and econometric analyses, identifying a stochastic production frontier as the best fit. The average technical efficiency score was 81%, with a discrepancy ratio (γ) of 91%. Factors such

as the number of crossbreed cows, concentrate, roughage and labor positively affected milk output, while local breed cows, grazing land and veterinary costs were insignificant. The study highlighted the need for policymakers to improve efficiency among farmers rather than solely focusing on the introduction of new inputs. Fourthly, Bahta *et al.* (2021) examined the technical efficiency of milk producers in Tanzania, analyzing a sample of 469 producers using Stochastic Frontier Analysis (SFA). The average technical efficiency was estimated at 80%, with variations across regions. Results indicated that increasing the number of cattle, crossbreeds and inputs like veterinary care and feed boosted efficiency. The study emphasized both direct and indirect effects of commercialization on productivity and recommended partnerships to support commercialization while improving efficiency. Fifthly, Lal *et al.* (2020) explored the determinants of technical efficiency among dairy farmers in the Sirsa Cooperative Milkshed, Haryana. Data showed that technical efficiency was generally high across all herd size categories, with the medium herd size exhibiting the highest efficiency at 86%. Key determinants included the farmer's age, duration of cooperative membership, fixed costs and marketed surplus. Lastly, Shkodra *et al.* (2020) investigated the technical efficiency of dairy farms in Central Kosovo, noting the challenges of small, fragmented farms. The Ministry of Agriculture began supporting dairy farmers with direct payments in 2009, but support specifically for milk quality started later. Through DEA under variable returns to scale, the study found that not all farms were fully efficient, with larger farms and those using seasonal grazing achieving higher efficiency. However, education levels did not significantly impact efficiency.

Most studies utilized descriptive statistics, data envelopment analysis (DEA) and regression models to assess the production status and factors affecting efficiency in livestock farming. Some applied probit models to explore the factors influencing technical efficiency. This paper aims to use comparative and descriptive statistical methods to assess the current state of dairy farming in Soc Trang, employing DEA for technical efficiency analysis and the probit model to identify influencing factors. The findings will inform solutions to enhance production efficiency for dairy farmers in Soc Trang province and Vietnam as a whole.

Methodology

Data

In addition to using secondary data, preliminary research was conducted through expert interviews, including discussions with members of the Soc Trang dairy project management board, to identify relevant factors and suitable methods for the study. For the quantitative aspect, the official research involved gathering feedback from 100 dairy farmers across three districts in Soc Trang province regarding the risks associated with dairy farming, utilizing a structured questionnaire. To fulfill the research objectives,

interviewees were selected using a non-probability sampling method, specifically convenience sampling. The questionnaires were administered through direct interviews until the desired sample size was reached. This approach was chosen for its simplicity and cost-effectiveness in terms of time.

Interview approach

Given the nature of livestock farming, the interviewer visited the residences or farms of the participants to conduct interviews using the questionnaire.

Analytical procedure

Data envelopment analysis (DEA)

Difference from the method suggested by Liu *et al.*, (2023), The initial DEA model was developed by Charnes, Cooper and Rhodes in 1978. It offers two approaches for estimating production capacity limits: one under CRS and the other under variable returns to scale (VRS). Both DEACRS and DEAVRS models aim to minimize input factors without reducing output and to maximize outputs based on available inputs. For this paper, only the CRS method is used, as most farms are small-scale, with many households classified as near-poor or medium-sized with financial constraints. Thus, researching minimum input costs is critical.

Data analysis using DEA involves two main steps: first, estimating the technical efficiency of all observed households and second, conducting regression analysis to assess how various factors-related to institutions, policies and socio-economics-impact production efficiency. The DEA model is based on input volumes and outputs for each production household. For the i^{th} household, the product and input amounts are represented by the output vector y_i and input vector x_i , respectively. The input matrix X ($m \times n$) and output matrix Y ($s \times n$) encompass all data from the surveyed households.

According to Coelli *et al.* (2002), the DEA model is structured to manipulate technical efficiency (TE) as follows:

$$\text{Min } \theta_k \quad (k \in i; i = 1, 2, \dots, n) \quad \dots(1)$$

λ, θ_k

$$\begin{aligned} \text{Obligatory condition:} \quad & -y_{rk} + Y\lambda \geq 0 \quad (r = 1, 2, \dots, s) \\ & \theta_k x_{jk} - X\lambda \geq 0 \quad (j = 1, 2, \dots, m) \\ & \lambda_i \geq 0 \end{aligned}$$

$$\text{vô } \lambda = (\lambda_1, \lambda_2, \dots, \lambda_n)$$

Where,

θ = Scalar quantity.

λ = Vector $n \times 1$ of the weights.

The value of λ expresses the degree of influence of the reference households to the point of effective production that the inefficient households are aiming for. The efficiency point that the household aims for is determined by the linear connection between that point and the production points of the reference households. The greater the λ_i value, the greater the influence of the i^{th} reference household. The following model depicts the production function.

$$\text{Min } \theta_B \quad (B \in i; i = 1, 2, 3) \quad \dots(1')$$

λ, θ_B

$$\begin{aligned} \text{Obligatory condition} \quad & -y_{1B} + (y_{1A}\lambda_A + y_{1B}\lambda_B) \geq 0 \\ & \theta_B x_{1B} - (x_{1A}\lambda_A + x_{1B}\lambda_B + x_{1C}\lambda_C) \geq 0 \\ & \theta_B x_{2B} - (x_{2A}\lambda_A + x_{2B}\lambda_B + x_{2C}\lambda_C) \geq 0 \\ & \lambda_i \geq 0 \end{aligned}$$

The value θ obtained from model (1) is the technical efficiency coefficient of the k^{th} production household. θ always has a value less than or equal to 1, with a value equal to 1 indicating that the production household is on the productive production boundary and is therefore considered to be completely technically efficient (according to Farrell's definition, 1957).

Output variable

Y : Milk yield (kilogram/year).

Input variables

X_1 : Planted grass area (m^2).

X_2 : Barn area (m^2).

X_3 : Number of cows giving milk (calves).

X_4 : Veterinary drugs (once/year).

X_5 : Amount of industrial feed (kg/year).

X_6 : Labor volume (days/year).

X_7 : Amount of electricity used (kw/year).

Tobit regression model

The outcomes of dairy farming include milk yield and the number of calves born. To assess factors affecting dairy farming efficiency, the study employs a Tobit regression model. This model, introduced by economist James Tobin in 1958, examines the relationship between the degree of fluctuation in dependent variables and independent variables. In this study, the Tobit model identifies factors influencing the technical efficiency of farmers.

Tobit regression is formulated as follows:

$$E_i = E_i^* = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_6 X_6 + u_i$$

$$E_i = 1 \text{ nếu } E_i^* \geq 1$$

$$E_i = E_i^* \text{ nếu } E_i^* < 1$$

Where,

E_i : The coefficient of technical efficiency or distributive efficiency or economic efficiency estimated by the DEA method (dependent variable or interpreted variable).

β : The coefficients of the Tobit regression equation need to be estimated; these coefficients reflect the extent to which each factor affects the analytical.

$X_1, X_2, X_3, \dots, X_7$: Factors that affect the analytical index (independent variables or explanatory variables).

u_i : Standard error.

RESULTS AND DISCUSSION

General information of dairy farmers in soc trang province

Previous research on production efficiency indicates that demographic factors significantly affect efficiency in livestock production, particularly in dairy farming. Studies

by Dau Van Hai (2016) and colleagues highlight that factors such as age, farming experience and training play vital roles in enhancing production efficiency. Additionally, Tran (2013) found that the gender of the household head positively impacts the technical efficiency of the household. Based on these findings, the current research incorporates these factors into its analysis.

Overview of household heads

The survey results presented in Table 1 reveal that male heads of households constitute 65.00% of the sample, while female heads make up 35.00%. This distribution reflects a common trend in rural Vietnam, including Soc Trang province, where men typically hold primary responsibilities within the family. Furthermore, it is noteworthy that in most surveyed households, the individuals answering the questions were predominantly men, highlighting their role as the main decision-makers in agricultural practices (Table 1).

The average age of household heads in the study area is 45.68 years, with a standard deviation of 8.50 years, slightly higher than the average age of 43.6 years reported by Singh and Sharma (2011). Notably, 95.00% of the household heads are between 18 and 60 years old, while only 5.00% are over 60, indicating that most dairy farmers are of working age and relatively young.

Technical efficiency

The study estimated the technical efficiency of dairy farming households from the processing of data collected through the use of DEAP software version 2.1. The output and input variables used to estimate the technical efficiency coefficients in the model include.

Output variables

Y: Milk yield (kg/year).

Input factors

X_1 : Planted grass area (m^2).

X_2 : Barn area (m^2).

X_3 : Number of cows giving milk (calves).

X_4 : Veterinary drugs (once/year).

X_5 : Amount of industrial feed (kg/year).

X_6 : Labor volume (days/year).

X_7 : Amount of electricity used (kw/year).

The results of data processing are shown in Table 2.

The data in the table above indicate that the technical efficiency coefficient derived from the DEA models, the technical efficiency under the assumption of constant scale is concentrated in the range of 75%-100%, with an average of 75.07% higher than the coefficient of 68.7% of Florence (2018), Singh and Sharma (2011). The technical efficiency assumes that the scale of change is concentrated in the range of 80%-100%, with an average of 92.57%. The average size efficiency of the survey sample was 82.01% with the lowest being 25.60% and the highest being 100%. This finding is not confirmed for the study of Selvaraj *et al.* (2018). These indicators indicate the existence of inefficiencies in terms of the use of resources in the production of the study area. However, the low constant-scale technical efficiency coefficients indicate that there is a possibility for increasing output without additional investment in production scale that can be kept at the current scale. The output will be increased by a) Replacing with low-quality grass varieties being planted with high-quality grass varieties such as large lemongrass grass, Halmin grass, VA06 grass, ... b) Provide clean water regularly by building automatic drinking troughs, accurately monitoring estrus cycles and carrying out timely breeding. This differ from the study of Prasanna Sai *et al.* (2021) concluding that the productive performance of crossbred cows was better than that of indigenous cows (Table 3).

Table 1: General information on households' head.

Head households' information		Frequency	Percentage (%)
Gender	Man	65	65,00
	Female	35	35,00
Age	18-60 years	95	95,00
	>60 years	5	5,00
Educational level	Illiteracy	2	2,00
	Primary	17	17,00
	Secondary	53	53,00
	High school	28	28,00
Production experience	Intermediate/College/University	0	0,00
	Less than 5 years	4	4,00
	From 5-10 years	83	83,00
	Above 10 years	13	13,00
Nationality	Vietnamese	11	11,00
	Khmer	85	85,00
	Chinese	4	4,00

Table 2: Technical efficiency and scale efficiency ranks of dairy farming households.

Efficiency (%)	Frequency			Frequency percentage (%)		
	TE _{CRS}	TE _{VRS}	SE	TE _{CRS}	TE _{VRS}	SE
1,00-10,00	0	0	0	0,00	0,00	0,00
10,01-20,00	0	0	0	0,00	0,00	0,00
20,01-30,00	1	0	1	1,00	0,00	1,00
30,01-40,00	5	0	5	5,00	0,00	5,00
40,01-50,00	5	0	3	5,00	0,00	3,00
50,01-60,00	13	0	10	13,00	0,00	10,00
60,01-70,00	9	6	7	9,00	6,00	7,00
70,01-80,00	28	10	11	28,00	10,00	11,00
80,01-90,00	18	19	15	18,00	19,00	15,00
90,01-100,00	21	65	48	21,00	65,00	48,00
Total	100	100	100	100,00	100,00	100,00
Average	75,07	92,57	82,01			
Standard Deviation	18,26	10,54	20,04			
Min	25,60	62,50	25,60			
Max	100,00	100,00	100,00			

Table 3: Technical efficiency and scale efficiency of cow production.

Number of households	TE _{CRS}	TE _{VRS}	SE
1	0,585	1,000	0,585
2	0,675	0,785	0,859
3	0,566	1,000	0,566
4	0,742	1,000	0,742
5	0,566	0,693	0,817
.....			
98	0,823	0,826	0,997
99	0,828	0,829	0,998
100	0,737	0,745	0,988
Average	0,751	0,926	0,820

The results in Table 3 show that the average technical efficiency achieved by dairy households under the constant scale hypothesis (TECRS) is 0.751. The TE_{CRS} = 0.751 result indicates that dairy farmers can increase production efficiency by 24.90% if they use a better combination of input factors, especially the choice of using cow feed in the rearing process that is not confirm for the study of Tahlaiti *et al.*, (2020). This coefficient is 6.4% lower than the study by Florence (2018).

Difficulties of dairy farmers in Soc trang province

In animal husbandry in general or dairy farming in particular, young cows play a significant role in the output of the crop, but most households when asked, said that they only evaluate breeds based on their senses and experience, on the other hand, based on the reputation of the place of sale. 26.48% of the total opinions of the surveyed households that they often encounter breeding cows of poor quality, equivalent to 67 households.

Another difficulty raised by farmers is that the current milk collection point is far from home, thereby increasing

transportation costs in the process of consuming products, there are 21 farmers who agree with this opinion, equivalent to 8.31% of the total opinions given by farmers. Comparing to study of Sherasia *et al.* (2016) suggesting that feeding nutritionally balanced rations improved milk production, feed conversion efficiency and reduced methane emission in lactating cows under field conditions. However, this difficulty depends on geographical factors as well as the production management of the purchasing company, so it is very difficult to overcome this factor.

In addition, the lack of capital in production and business is also a huge difficulty, which is an important factor in all inputs of cattle breeding. Up to 57 households, equivalent to 22.53% of the total number of farmers' opinions, said that the current difficulty of households is that they are using temporary barns in livestock and do not have the capital to build barns properly (Table 4).

Some other difficulties in the process of raising dairy cows include low farming techniques, with 46 households accounting for 18.18% of the total opinions; did not understand how to assess milk quality with 44 households, accounting for 17.39% of the total opinions; epidemic in cows with 12 households accounting for 4.74% of the total opinions; and lack of grass in the dry season with 6 households accounting for 2.37% of the total opinions. However, although these problems are detrimental to farmers, farmers also assess that these are not big problems that farmers themselves have a method to solve.

Advantages of dairy farmers in Soc trang province

Through field surveys in the research area, the study has obtained different opinions on the advantages that farmers self-assess, specifically as follows (1) Almost all households surveyed said that they participated in and received support from livestock cooperatives. Most of them think that when participating in cooperatives with

Table 4: Some difficulties of farmers in dairy farming.

Technique	Frequency	Percentages (%)
Farming techniques are still low	46	18,18
It is not clear how to assess the quality of milk	44	17,39
Veterinary diseases	12	4,74
Bad breed	67	26,48
Lack of grass in the dry season	6	2,37
The collection point is far from home	21	8,31
Lack of capital to build barns	57	22,53

Source: Surveyed by the author and his colleagues, 2021.

the main purpose of learning about farming techniques, sharing experiences among members, being trained in farming techniques, care, breeding, disease prevention, etc. (2) Farmers also said that these training classes are carried out regularly to update the latest information on farming techniques as well as market information related to dairy farming. In addition, they also receive other social benefits such as revolving capital support among team members, or participate in training classes on financial management, spending management, gender equality, etc.

Because the interviewees are Khmer ethnic people and most of them are poor households, they have received great support from the projects. Through the survey, it is known that the support projects include the province's dairy cow development project and CIDA with the main form of support is lending breeding cows, then collecting calves.

CONCLUSION

The research has been shown that the dairy farming of people in Soc Trang province has been around for a long time and in recent years has developed more and more strongly. Most households produce on a relatively small scale, but most households participate in cooperatives and sign sales contracts, which is a great convenience with connecting with distributors and buyers. In addition, although farmers are guided and trained by relevant departments, the ability of producers to apply to production practices is also limited in terms of qualifications and capital capacity. In recent years, international economic integration has also paved the way for dairy companies around the world to access the Vietnamese market more easily due to the pressure to apply technical advances to improve quality as well as reduce production costs is an urgent requirement. This is also a motivation for households to maintain and expand the production scale, the current herd size of households on table plates in Soc Trang province, it is also on par with other countries in the region (over 5 animals/household), the technical efficiency achieved is also higher (on average 75%) and the technical efficiency under the hypothesis of variable scale

collection is 0.926. And factors that have a significant positive impact on the technical efficiency of production households include: Years of experience in dairy farming; Participating in livestock cooperatives, mass organizations; Number of technical trainings; Access to credit.

Recommendations

The findings suggest the possible recommendations to improve the cow milk production as follow. Firstly, develop a dairy farming process based on households with optimal technical efficiency, organize training classes and visits for households that have not achieved efficiency according to the method of farmer training for farmers. Secondly, encourage farmers to participate in livestock cooperatives and mass organizations so that they can enhance experience sharing, better management of veterinary health and vaccines, access credit programs and develop agricultural services in dairy farming. In addition, Strengthen agricultural extension, technical training and skills in variety selection. Thirdly, Assessment of agricultural by-product stocks and the ability to reserve grass substitution during the dry season in the region and surrounding areas (e.g. straw sources) to develop an input linkage plan. Fourthly, The State needs to review the current status of breed quality and develop variety selection programs in accordance with local conditions. Lastly, develop programs on access to credit, agricultural insurance to access credit for farming households to improve the quality of breeds, agricultural services such as agricultural pumping, soil preparation, collecting and distributing straw and agricultural by-products.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

All animal procedures for experiments were approved by the Committee of Experimental Animal care and handling techniques were approved by the University of Animal Care Committee.

Conflict of interest

The author declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish or preparation of the manuscript.

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