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**ARTICLE**

# Evaluating the Production Efficiency of Smallholder Dairy Farms in Vietnam: A Case Study in Can Tho City

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## ABSTRACT

This study investigates the production efficiency of smallholder dairy farmers in Dai Tam commune, Can Tho City, Vietnam, with the aim of identifying the key factors that influence productivity and sustainability. To achieve this objective, the research applies a combination of Data Envelopment Analysis (DEA) and Tobit regression models. The DEA approach is used to measure both Technical Efficiency (TE) and Scale Efficiency (SE), while the Tobit model is employed to examine the socio-economic determinants affecting production performance. The results show that the average technical efficiency of dairy farmers under constant returns to scale and variable returns to scale is 0.732 and 0.904, respectively. These findings suggest that milk output could be improved by approximately 26–27% through more efficient use of existing inputs, without requiring an expansion in herd size. The Tobit regression results further indicate that farming experience, participation in cooperatives, technical training, and access to credit have significant positive effects on production efficiency. Although the overall performance of the surveyed farmers is relatively stable, production efficiency remains constrained by uneven adoption of technology, limited capital resources, and the use of substandard breeds. Based on these findings, the study recommends strengthening technical training programs, promoting cooperative linkages, improving farmers' access to financial resources, and enhancing farm management practices. These measures are expected to contribute to higher productivity and support the sustainable development of the dairy sector in the Mekong Delta.

***Keywords:*** Dairy Farming; Technical Efficiency; Scale Efficiency; Data Envelopment Analysis (DEA); Tobit Regression; Vietnam

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# 1. Introduction

In recent years, the dairy farming sector has become one of the important agricultural economic sectors, contributing to raising incomes, contributing to job creation and sustainable poverty reduction in rural areas of Vietnam [1]. The farmer-scale dairy farming model has helped many households improve their lives and transform their livelihoods more effectively than traditional farming [2]. However, in order for the dairy industry to develop sustainably and bring higher profits to farmers, it is necessary to focus on improving milk productivity and quality, combined with increasing product value through processing products with high market value such as pasteurized milk, etc yogurt and condensed milk [3, 4]. According to the Department of Livestock, Ministry of Agriculture and Rural Development the country's dairy herd will reach about 375,000 heads, with fresh milk production in 2023 estimated at more than 1.2 billion L, an increase of nearly 7% compared to 2020 [2, 4]. However, this output only meets about 45–50% of domestic consumption demand, the rest must be imported in the form of milk powder or reconstituted milk [4].

This shows that the production efficiency and productivity of the domestic dairy herd are still low, especially in the small-scale farming sector, which accounts for more than 60% of the total dairy herd in the country. Besides the achieved results, many challenges still exist for small livestock households. Recent studies have shown that productivity and production efficiency are affected by many factors, such as Seed quality, barn conditions, nutrition, heat stress conditions, and the technical level of farmers [5, 6]. In low tropical regions such as the Mekong Delta, Vietnam. In particular, dairy farming is often subjected to high temperature pressure, leading to reduced production and fertility [5]. In addition, the feed ration of many farmers in the livestock production process still lacks a balance of energy and protein, mainly relying on self-grown grass, straw, and agricultural by-products [4].

Several empirical studies in Vietnam, particularly in provinces such as Long An and Lam Dong, have analyzed the technical performance of dairy farming by applying DEA and SFA models. Findings indicate that the average efficiency level of dairy households typically varies between 0.26 and 0.78, with potential improvements of around 20–30% when farmers manage feed expenses and herd sizes more effectively [7]. Nonetheless, most of these investigations have been conducted at the provincial or regional scale rather than at the commune level studies (the smallest level in the farming area), which reflect the specific situation of each livestock farming community and are still very limited. In particular, in Dai Tam commune, Can Tho city, the farming of dairy cows has been considered a potential agricultural development direction, contributing to the transformation of the structure of crops and livestock, improving the efficient use of land, and improving the economic value per unit area. However, so far, there has been no research to comprehensively evaluate the production efficiency of dairy farming households in this locality, as well as clearly identify the factors affecting that efficiency. The implementation of production efficiency analysis not only helps to measure the rational use of input factors (labor, feed, capital, breed, herd size) but also helps to provide specific solutions to improve productivity, reduce costs, and increase income for farmers [7].

Consequently, this research, entitled "Evaluating the Production Efficiency of Smallholder Dairy Farms in Vietnam: A Case Study in Can Tho City," aims to assess technical efficiency, while allocative and economic efficiency are discussed conceptually based on Farrell's framework [4] in milk production. Based on the findings, the study proposes feasible measures to enhance productivity, raise profitability, and promote the sustainable development of the local dairy sector. Furthermore, it seeks to address the existing research gap regarding smallholder dairy farming efficiency in the Mekong Delta of Vietnam, thereby providing a valuable reference for policymakers, agricultural management bodies, and rural development organizations.

# 2. Materials and Methods

## 2.1. The Concept of Household and Farmer Household

The concept of "Household" is a long-standing social unit, which still exists and develops through different socio-economic periods. Although manifested in many forms, the deep essence of the "Household" is an internal production and business unit, where family members coordinate the use of labor and resources to create wealth, feed the family, and gradually accumulate value for themselves as well as contribute to society [8]. In economic theory, "Household" is understood in many ways, such as according to Swartz [9] of the Oxford Press Dictionary of Linguistic Economics, "Household" is a group of people living under the same roof, including people who are related by blood or who participate in common economic activities [10]. According to Linh [11], "Households" are individuals who live together, share the same budget, and have common living needs in a residential space.

According to Ellis [6], the concept of "Peasant Household" is defined in an academic and comprehensive way. Farming households are families that farm on their land, employ labor mainly from family members, live largely on agricultural production, and participate in the market to a limited extent [12]. Outstanding characteristics of farmer households include: small scale, capital use, and family labor mainly. Agricultural production is affected by limited market conditions, which means that it is not possible to fully optimize production factors like large economic units. Farmers carry out both production and exchange activities, as well as self-consumption and internal distribution [12]. Therefore, farmer households differ from specialized economic units in households in that there is a unity between the ownership, management and use of production elements, the process of production, exchange, use and consumption is closely integrated in the same system [8, 12].

## 2.2. Concept of Efficiency and Production Efficiency

Efficiency is a category that reflects the degree to which the desired outcome is achieved relative to the goal or resources expended [13]. In a general sense, efficiency represents the correlation between the output and the input factors used to produce that result [14]. In manufacturing, efficiency is understood as labor efficiency or productivity, while in business, efficiency is often measured by the level of profit or return on costs [13]. Thus, efficiency is not only manifested by the results achieved, but also demonstrates the level of rational use of resources to maximize results and minimize costs [13]. According to Farrell [4], the theoretical foundation for the study of modern production efficiency, consists of three basic components: TE, AE, and EE.

Technical Efficiency (TE) refers to the capacity of a producer to generate the highest possible level of output using a specific combination of inputs and existing technology. In other terms, a production unit is considered technically efficient if it cannot enhance output unless at least one input is increased [14, 15]. According to Kaliba et al., the classic definition is "A producer is considered technically efficient if the addition of one output requires a decrease in at least one other output or an increase in at least one input." Technical efficiency is measured by an index in the range of $0 \leq TE \leq 1$, where the closer the value to 1, the more efficient the use of inputs [15]. In agricultural production, TE demonstrates the ability to convert inputs (such as labor, feed, land, and capital) into maximum agricultural output under specific technical conditions [15, 16].

Allocative Efficiency (AE) reflects how effectively producers can allocate inputs at optimal proportions according to prevailing market prices and available technology [5]. A farmer has a high allocation efficiency if they choose the input combination ratio so that the production cost is the lowest for a specified level of output [3]. The AE value is also in the range of $0 \leq AE \leq 1$, reflecting the extent to which the manufacturer adjusts the cost structure reasonably to achieve maximum cost effectiveness.

According to Charnes et al. [16], it is shown that the factors of feed prices, costs, and capital costs are important variables that affect AE in farmers. Economic Efficiency (EE) is a general indicator, reflecting two aspects simultaneously: technical efficiency and allocation efficiency. According to the Farrell [4] formula, $EE = TE \times AE$. Economic efficiency represents the degree to which maximum output results are achieved at minimum cost, which is an important measure of the level of organization and management of production [17–20]. In agriculture, economic efficiency refers to the capability to utilize labor, land, capital, and material resources in the most effective way to attain maximum productivity and profitability under given environmental and market circumstances. According to the OECD [18], improving the economic efficiency of farmers is a core factor to ensure food security, sustainable development and increase the competitiveness of the agricultural sector in developing countries, including Vietnam.

Economic efficiency is the result achieved including technical efficiency and distribution efficiency.

$$(0 \leq EE \leq 1).$$

$$EE = TE \times AE$$

In addition, profit efficiency is also understood as economic efficiency, which is the ability to achieve maximum profits of farmers corresponding to the fixed prices and inputs of farmers in advance. Production efficiency is an integrated concept, reflecting the capacity of a production unit to combine input resources to create optimal output value under specific technical, economic and market conditions. Assessing technical, allocative, and economic efficiency enables the identification of how effectively resources are utilized and reveals areas where productivity among smallholder farmers can be enhanced.

## 2.3. Indicators of Production Efficiency

Production efficiency: In animal husbandry, production efficiency is understood as the comparison between input factors and output volumes in the production process of dairy farming, which is usually referred to as profit margin.

Profit margin is the rate used to evaluate the profitability of costs. This ratio indicates how much profit is earned per dong of investment in production.

$$\text{Profit Margin}(\%) = \text{Profit/Cost}^{*}100.$$

The efficiency of production costs shows how much dong of the production value or how much dong of the income is spent on a cost.

$$\text{Expense Ratio}(\%) = \text{Cost/Income}^{*}100.$$

Technical efficiency is the use of resources (human, material, financial, etc.) to produce a certain output. TE refers to the capacity of a production unit to achieve a specified level of output using the least possible combination of inputs (human, material, and financial). Put differently, it indicates how effectively available resources can be used to reach the highest attainable output [5, 15].

## 2.4. Analytical Framework of the Topic

The study uses secondary data collected from the statistical report and summary of the situation of agriculture and livestock in the period 2018–2024 of the People's Committee of Dai Tam commune and the Farmers' Association to describe the socio-economic context, development trends of dairy herds and production characteristics of the study area. Primary data were collected through field surveys in Dai Tam commune, Can Tho city, where a significant number of dairy farming households in the region are concentrated. The data collection process is designed in two stages.

**Qualitative Phase**: Conduct semi-structured interviews with farmers' union officials, extension station leaders, and local agricultural experts to identify factors affecting production efficiency, revise the questionnaire content, and validate the suitability of the research model [6, 15].

**Quantitative Stage**: Conducting a direct survey of 100 dairy farming households in Dai Tam commune (Digital observation information is provided by the local government and the commune farmers' association). The interviews were conducted directly with the farmers and farms, facilitating respondents' comprehension of the questionnaire content and enabling on-site verification of production facilities, herd size, and management practices.

## 2.5. The Current Situation of Dairy Farming in Can Tho City

Since 2020, dairy farming in Can Tho city has developed in the direction of small-scale farmer households associated with the consumption chain. The total cow herd currently reaches about 1,300 heads, of which over 60% are lactating, with an average output of 12–15 t/day [21]. Milk is consumed mainly through Vinamilk and purchasing enterprises in the Mekong Delta region [20, 21]. Farmers receive technical support, breeds, credits and training through the Farmers' Association and the Agricultural Extension Center, contributing to increasing milk yield from 3,800 kg/head/cycle (2020) to 4,500 kg/head/cycle (2023)[21]. Local authorities encourage the application of high technology in waste treatment, feed mixing and herd management, towards a low-carbon agricultural model. However, the dairy farming industry in Dai Tam still faces small scale, lack of investment capital, dependence on purchasing enterprises, and risks of feed, milk prices and diseases[17, 18, 22–26]. Despite its limitations, the region is gradually shifting to a model of business cooperation linkages, laying the foundation for effective and sustainable development in the period 2025–2030.

# 3. Methodology

## 3.1. Methods of Data Analysis

Using comparison methods, descriptive statistical methods with the following indicators: average number, frequency, and the DEA data envelope method to find out the current situation of dairy farming of farmers in Dai Tam commune, Can Tho city.

### 3.1.1. Relative Quantitative Comparison Approach

It is the result of the division between the values of the analysis period compared to the original period of the indicators.

$$\Delta_{\mathrm{y}} = \mathrm{y}_1/\mathrm{y}_0 \times 100\%$$

Where $\mathrm{y}_0$: Previous year's target; $\mathrm{y}_1$: Next year's target; $\Delta_{\mathrm{y}}$: Indicates the growth rate of the indicators. This approach helps to explain variations in indicator levels over specific periods by comparing growth rates across years and among different indicators, thereby identifying the underlying causes and suggesting possible solutions.

### 3.1.2. Data Envelopment Method (DEA)

Data for technical efficiency (TE) evaluation according to the data envelopment analysis (DEA) model minimizes inputs in case the scale does not affect production results (CRS). The initial DEA framework was introduced by Charnes et al.[16]. There are two approaches to estimating the limits of production: two main approaches are used: Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) analyses. An input-oriented DEA is applied under both CRS and VRS assumptions to estimate technical efficiency, i.e., minimizing inputs for a given level of outputs. In the research project, both CRS, VRS, and DEA models are employed to decompose overall technical efficiency into pure technical efficiency and scale efficiency, rather than to assume that one returns-to-scale regime universally holds. Specifically, TE_CRS captures overall technical efficiency under CRS, while TE_VRS captures pure technical efficiency under VRS; scale efficiency is computed as SE = TE_CRS/TE_VRS. Therefore, it is necessary to study and minimize input costs. In the data envelope analysis model, the input minimization in case the scale does not affect the production results, the optimal coefficients of technical efficiency (TE), resource distribution (AE), and cost (CE) are equal to 1. From the data collected on the production situation of dairy farmers (A, B, and B'), the program builds a line that limits the production capacity of Ss' based on the units with the highest efficiency. The Ss' isometric line is a set of combinations of input production factors in order to reach an equivalent output level (**Figure 1**).

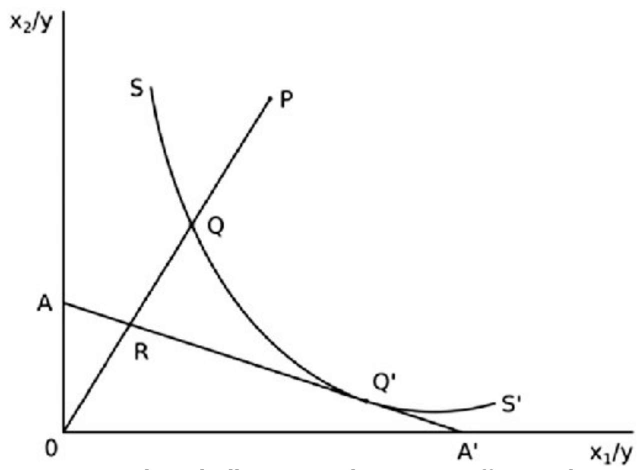


**Figure 1.** Technical, allocative and economic efficiency by Farrell[4].

The input minimization data envelope analysis model assumes that only 2 input factors ×1 and ×2 (×1 and ×2 are interchangeable) and 1 output is q as shown in **Figure 2**. B and B' located on SS Road are the most technically efficient farmers in the group. Conclusions B and B' achieve technical efficiency (TE). Based on the graph in **Figure 2**, the TE of the household is measured by the OB'/OB ratio, so the technical coefficient TE is always positive and less than or equal to 1. Also, from the graph above, the level of efficiency is measured by the ratio B'B/OB. This ratio is also positive and less than or equal to 1, and it is equal to 1−OB'/OB. Thus, when determining the level of technical efficiency (TE), let's say 80%, we can conclude that the level of inefficiency of household B is 20%.

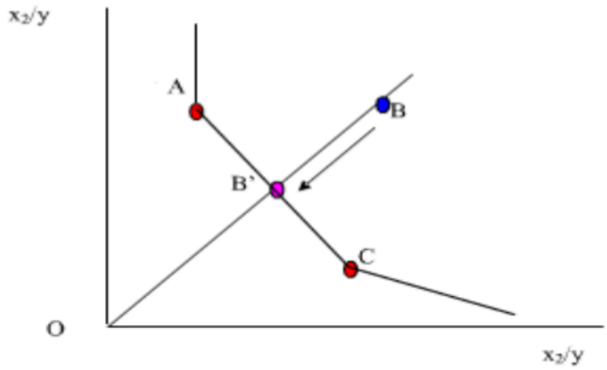

**Figure 2.** The efficient production frontier by Farrell [4].

In the DEA Envelope Analysis model, a farmer is seen as more efficient when using fewer inputs to produce the same output level, or achieving higher productivity while utilizing an equivalent amount of input resources as other households in the survey sample. Efficiency indicators are determined based on the largest proportion between output and input quantities, calculated for all units of observation in the model [15, 23]. DEA is widely used today in agricultural economics, thanks to its ability to evaluate relative efficiency without assuming a specific type of production function in advance [13, 23]. Compared to traditional econometric methods, DEA has the advantage of being computationally simple, does not require the determination of the function form, but still provides aggregate assessments of technical effectiveness through a linear planning model [16]. Effectiveness analysis by DEA usually involves two steps: (1) Estimate the technical effectiveness for each observation unit based on the DEA model; (2) Regression of efficiency indicators according to socio-economic, institutional and policy factors to identify the causes affecting the production efficiency of farmers [17].

The DEA model used here is based on the variable data of inputs and products per n households. For the first producer household, the data on product volume and input are shown in the yi and xi column vectors, respectively. The m × n input matrix (denoted by X) and the s × n output matrix (denoted by Y) collectively contain data for all surveyed producers. The DEA formulation employed to estimate technical efficiency (TE) [15]:

$$\text{Min } \theta_k \ (k \text{ E } i;\ i = 1, 2, \ldots n),\ \lambda,\ \theta_k \qquad (1)$$

Binding conditions:

$y_{rk} + Y\lambda \geq 0$ (r = 1, 2, …,s)

$\theta_k x_{jk} - X\lambda \geq 0$ (j = 1, 2, …,m)

$\lambda_i \geq 0$

$\lambda = (\lambda_1, \lambda_2, \ldots, \lambda_n)$

Where θ denotes a scalar value, while λ is an n × 1 vector representing the assigned weights. The magnitude of λ indicates the degree to which reference (efficient) households influence the target efficiency point that less efficient households attempt to achieve. The target efficiency point is established through a linear relationship between the reference point and the production positions of the evaluated households. A higher λi value indicates a stronger impact of the reference households in determining the target production point of the less efficient household.

$$\text{Min } \theta_B \ (B \text{ E } i;\ i = 1, 2, 3)\ \lambda,\ \theta_B \qquad (1a)$$

Binding conditions:

$y_{1B} + (y_{1A}\lambda_A + y_{1B}\lambda_B) \geq 0$

$\theta_B x_{1B} - (x_{1A}\lambda_A + x_{1B}\lambda_B + x_{1C}\lambda_C) \geq 0$

$\theta_B x_{2B} - (x_{2A}\lambda_A + x_{2B}\lambda_B + x_{2C}\lambda_C) \geq 0$

$\lambda_i \geq 0$

The θ value derived from Equation (1) represents the technical efficiency score for the *k*-th household. It ranges from 0 to 1, where θ = 1 implies that the household operates on the efficient production frontier and is thus regarded as technically efficient, following Farrell's [4] definition.

Yield variable: Y—Milk yield (kg/year);

Input variables: $X_1$—Planted grass area ($m^2$); $X_2$—Barn area ($m^2$); $X_3$—Number of lactating cows (head); $X_4$—Veterinary treatments applied (times/year); $X_5$—Quantityof industrial feed (kg/year); $X_6$—Labor utilization (days/year); $X_7$—Electricity usage (kw/year).

The Tobit regression equation looks like this:

$$E_i = E_i^* = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + u_i$$
$$E_i = 1 \text{ if } E_i^* \geq 1$$
$$E_i = E_i^* \text{ if } E_i^* < 1$$

In the second stage, we regress efficiency scores bounded between 0 and 1 on household characteristics using a Tobit model. Let Ei∗E_i^*Ei∗ denote the latent efficiency and EiE_iEi the observed score. The observed efficiency is censored at the bounds: $E_i = 0$ (if $E_i^* < 0$); $E_i = E_i^*$ (if $0 < E_i^* < 1$); $E_i = 1$ if $E_i^* \geq 1$.

Where: $E_i$: Represents the efficiency coefficient (technical, allocative, or economic) estimated through the DEA method, serving as the dependent variable. β: Denotes the Tobit regression coefficients, which quantify the influence of each factor on the dependent variable. $X_1$–$X_7$: Independent variables that describe the determinants influencing efficiency. $u_i$: The random error term (**Table 1**).

**Table 1.** Basis for variable selection in the Tobit regression model.

| Symbol | Meanings | Expected |
|---|---|---|
| $X_1$ | Age of the household head, measured in completed years at the time of the survey. | + |
| $X_2$ | Educational attainment of the household head, expressed in total years of schooling completed. | + |
| $X_3$ | Experience: Receive a value corresponding to the number of years of experience in dairy farming (years) | + |
| $X_4$ | Labor: Number of employees of households participating in dairy farming (people) | + |
| $X_5$ | Dummy variables showing that households participate in livestock cooperatives and mass organizations (1 = Yes; 0 = No) | + |
| $X_6$ | Number of times households have received technical training (times) | + |
| $X_7$ | Dummy variable represents access to credit (1 = yes; 0 = no) | + |

## 3.2. Statistical Sample Characteristics

### 3.2.1. Farmer Overview

Gender in the **Table 2** survey shows that men make up 59% of the total number of heads of households, while women account for 41%. This reflects the prevalent characteristics of rural areas in Vietnam, where men often play a major role in production management and decision-making. In addition, the fact that men often represent households in interviews is also a factor affecting this rate. The average age of heads of households is 47.68 years, of which 93% are in the working age group (18–60 years). The results show that the workforce in dairy farming is mainly young, capable of absorbing techniques and adapting to market changes. The average number of years of experience in dairy farming is 8.2 years. Most households have 5–10 years of experience (81%), reflecting that the dairy farming model has been maintained stably and has accumulated significant practical experience. The group of households with more than 10 years of experience accounted for 12%, while those with less than 5 years accounted for only 6%. The average education level of the head of the household is relatively low, about 8 classes. Up to 72% of households have a level 2 or lower degree, indicating that their access to technical information, financial management and scientific application is still limited, affecting production efficiency [17]. In terms of ethnic structure, Kinh people account for 90%, followed by other people (10%).

**Table 2.** Overview information about the head of household.

| | Householder Information | Frequency | Rate (%) |
|---|---|---|---|
| Gender | Female | 41 | 41.00 |
| | Male | 59 | 59.00 |
| Age | From 18–60 years old | 93 | 93.00 |
| | Older than 60 years old | 7 | 7.00 |
| Experience | Less than 5 years | 6 | 6.00 |
| | From 5–10 years | 82 | 81.00 |
| | Over 10 years | 12 | 12.00 |
| Education | No | 0 | 0.00 |
| | (Class 1 to 5) Level 1 | 20 | 20.00 |
| | (Class 6 to 9) Level 2 | 50 | 50.00 |

**Table 2.** *Cont.*

| | Householder Information | Frequency | Rate (%) |
|---|---|---|---|
| Education | (Class 10 to 12) Level 3<br>Intermediate/College | 30<br>0 | 30.00<br>0.00 |
| Nation | Other people<br>Kinh people | 10<br>90 | 10.00<br>90.00 |

Source: Survey Results.

Demographics and labor survey results show that the average household size is 4.51 people (SD = 1.05), with 2.11 workers/household (SD = 0.85), of which 2.03 people are directly involved in dairy farming (SD = 0.79). This reflects a high level of specialization in the use of family labor, which reduces production costs and makes the most of available human resources (**Table 3**).

Most households do not hire foreign workers (87%), only 13% have hired seasonal workers, an average of 1–2 people/household, with a salary of about 4.35 million VND/month. The restriction on the use of hired labor shows that the local dairy farming model is still household, labor-intensive, suitable for the current small scale [17, 18] (**Table 4**).

**Table 3.** Labor resources at farming households.

| | Average | Maximum | Minimum | Standard Deviation |
|---|---|---|---|---|
| Total Demographics | 4.51 | 7.00 | 1.00 | 1.05 |
| Total Labor | 2.11 | 6.00 | 1.00 | 0.85 |
| Laborers participating in dairy farming | 2.03 | 6.00 | 1.00 | 0.79 |

Source: Survey Results.

**Table 4.** Employment of hired workers.

| Evaluation | Criteria | | |
|---|---|---|---|
| Employment of hired workers | No | Frequency<br>Rate (%) | 87<br>87.00 |
| | Yes | Frequency<br>Rate (%) | 13<br>13.00 |
| Number of employees employed | Average<br>Standard Deviation | | 1.77<br>0.75 |
| Average salary/month | Average<br>Standard Deviation | | 4.35<br>0.20 |

Source: Survey Results.

The average landholding per household was 13.67 ha (SD = 15.16), including 12.31 ha of farmland and 3.48 ha of grassland. All land-area variables are reported consistently in hectares (ha), where 1 ha = 10,000 $m^2$, with large variations per household (SD = 15.16). Of this, farmland is 12.31 ha, grassland is 3.48 ha, and the remaining area is garden and residential lands. It is a norm in Vietnam to describe the area in terms of hectares and units in square meters, with 1 ha = 10,000 $m^2$, thus ensuring easier understanding in terms of agricultural farm size per household in the country. Grass cultivation, after converting rice lands due to inefficiency in those lands, also bears testimony to efficient farm use for the purpose of sustainable dairy farming in the region (**Table 5**).

Financial resources are about 36% of households borrowing from banks, mainly from the Bank for Social Policies (58.3%) and the Bank for Agriculture and Rural Development (36.1%). Informal loan sources are hardly used. Access to formal capital shows an improvement in financial management and credit risk awareness, and reflects the State's preferential agricultural credit policy. However, the loan limit is still low, not enough to meet the needs of expanding the scale of livestock (**Table 6**).

**Table 5.** Natural resources for farmers (Unit: ha).

| | Average | Maximum | Minimum | Standard Deviation |
|---|---|---|---|---|
| Total area | 13.67 | 100 | 0.50 | 15.16 |
| Farmland area | 12.31 | 88 | 1.50 | 14.38 |
| Garden land area | 2.30 | 4 | 0.50 | 1.20 |
| Grassland area | 3.48 | 15 | 0.50 | 2.42 |
| Other land areas | 2.20 | 5 | 1.00 | 1.79 |

Source: Survey Results.

**Table 6.** Situation of the financial capital of dairy farmers.

| Information | | Frequency | Rate (%) |
|---|---|---|---|
| Bank Loans | No Loans | 64 | 64.00 |
| | Yes Loans | 36 | 36.00 |
| Banks | Social Policy | 21 | 58.33 |
| | (AgriBank_Vietnam Bank for Agriculture and Rural Development) | 13 | 36.11 |
| | (SacomBank_Saigon Thuong Tin Commercial Joint Stock Bank) | 3 | 8.34 |
| Informal Loans | Yes Loans | 0 | 0.00 |
| | No Loans | 100 | 100.00 |

Source: Survey Results.

In social resources, only 15% of households participate in community-based organizations such as the Farmers' Association, Women's Union, and Youth Union, but up to 82% of households are members of cooperatives or cooperative groups. Joining the cooperative helps households access techniques, inputs, outputs and professional training, and is a prerequisite for consuming fresh milk. Most households (100%) have participated in training in breeding techniques, disease prevention and herd management, showing that the level of access to production knowledge is increasingly improved (**Table 7**).

**Table 7.** Situation of social capital of dairy farmers.

| | Information | Frequency | Rate (%) |
|---|---|---|---|
| Join the mass organization | No | 85 | 85.00 |
| | Yes | 15 | 15.00 |
| Name of the organization | Farmers' Union | 5 | 5.00 |
| | Women's Union | 5 | 5.00 |
| | Officer Youth Union | 3 | 3.00 |
| | Farmers' Union | 2 | 2.00 |
| Joining the Cooperative | No | 18 | 18.00 |
| | Yes | 82 | 82.00 |

Source: Survey Results.

The size and origin of the cow herd The survey results show that the size of the dairy herd of livestock households in Dai Tam commune is mainly at an average of 5–10 cows, accounting for 60% of the total number of households, while 22% have a scale of less than 5 cows and 18% have a scale of more than 10 cows. The average herd size reached 8.52 heads/household (SD = 7.65), reflecting a small but relatively stable production model. In terms of breed origin, 57% of the herd is bred from Sind cows, 19% are self-bred, 14% receive support from livestock development projects, and 10% import pure HF cows from hatcheries. This structure shows that farmers are mainly dependent on hybrid breeds and technical support, while the autonomy of purebred varieties is limited. The majority of farmers (82%) use captivity, while 18% combine free-range and captive farming. The common method is "holding the pole at the barn", which saves space but reduces the comfort of pets and increases the risk of hoof and joint pathologies. The average barn area reached 91.45 $m^2$ (SD = 105.81), showing a great diversity in the level of investment in facilities among households (**Table 8**).

**Table 8.** Types of feed and water sources for dairy farming.

| | Evaluation Criteria | Frequency | Rate (%) |
|---|---|---|---|
| Food | Grass | 100 | 100.00 |
| | Straw | 68 | 68.00 |
| | Refined feed | 14 | 14.00 |
| | Industrial Animal Feed | 100 | 100.00 |
| | Corn | 16 | 16.00 |
| | Potato wire | 3 | 3.00 |
| | Beer wort (by-product) | 9 | 9.00 |
| Water Source | River | 9 | 9.00 |
| | Well | 52 | 52.00 |
| | Tap water | 37 | 37.00 |
| | Ponds, lakes | 2 | 2.00 |
| | Total | 100 | 100.00 |

Source: Survey Results.

Sowing and reproduction have survey results showing that 97% of farmers apply artificial insemination, and only 3% still carry out direct propagation. Artificial insemination helps to create high-yielding hybrids, limits blood clotting and reduces the spread of infectious diseases, but requires estrus detection skills and precise technical support from fertilization staff[17, 26]. On average, each plant is sown 6.24 times/litter (SD = 1.58) at a cost of 124.770 VND/time (SD = 33.558), equivalent to about 870,000 VND/head for a seed cycle. This is a high cost, especially for small-scale livestock households (**Table 9**).

**Table 9.** Seeding method and the number of dairy cow breeding times of farmers.

| Evaluation Criteria | | Assessment | |
|---|---|---|---|
| Seeding method | Direct | Frequency | 3 |
| | | Rate (%) | 3.00 |
| | Man-made | Frequency | 97 |
| | | Rate (%) | 97.00 |
| Number of mixes | | Average | 6.24 |
| | | Standard Deviation | 1.58 |
| Unit price (VND/time) | | Average | 124.770 |
| | | Standard Deviation | 33.558 |

Source: Survey Results.

Vaccination and disease control Vaccination in the locality is quite adequate: 92% of households are vaccinated against Pasteurellosis, 97% are vaccinated against Foot-and-mouth disease, while 55% and 44% of households prevent helminths and blood-sugar parasites respectively. The first two types of diseases have the highest vaccination rates, indicating proper attention to dangerous infectious diseases, while also reflecting the effectiveness of the local veterinary system (**Table 10**).

Common diseases in dairy cows: mastitis (46%), hoof pain (17%), uterine inflammation (16%), pasteurellosis (14%), and foot-and-mouth disease (12%). These diseases directly affect milk yield and fertility, especially mastitis, which is considered a major cause of productivity losses and high treatment costs. Treatment measures when cows are sick, 98% of households call veterinary staff for treatment, only 2% buy them themselves. This proves that farmers trust the veterinary system, and at the same time shows the increasing level of professionalization in the management of local cow health (**Table 11**).

**Table 10.** The situation of vaccination against diseases in dairy cows.

| Types of Vaccines | Frequency | Rate (%) |
|---|---|---|
| Pasteurellosis | 92 | 92.00 |
| Foot-and-mouth disease (FMD) | 81 | 97.00 |
| Helminths | 55 | 55.00 |
| Blood-Sugar Parasites | 44 | 44.00 |

Source: Survey Results.

**Table 11.** The situation of vaccination against diseases in dairy cows and the methods of treatment.

| Evaluation Criteria | | Frequency | Rate (%) |
|---|---|---|---|
| Common diseases | Polio | 13 | 13.00 |
| | Bloating | 7 | 7.00 |
| | leg pain | 9 | 9.00 |
| | Nail pain | 17 | 17.00 |
| | Scabies | 2 | 2.00 |
| | Respiratory disease | 8 | 8.00 |
| | Foot-and-mouth disease (FMD) | 12 | 12.00 |
| | Reproductive disorder | 11 | 11.00 |
| | fever | 10 | 10.00 |
| | Typhoid | 2 | 2.00 |
| | Digestive disorder | 3 | 3.00 |
| | Pasteurellosis | 14 | 14.00 |
| | Arthritis | 6 | 6.00 |
| | Uterine inflammation | 16 | 16.00 |
| | Mastitis | 46 | 46.00 |
| Treatment methods | Call veterinary staff | 98 | 98.00 |
| | Buy your own medicine | 2 | 2.00 |

Source: Survey Results.

The survey results show that farmers in Dai Tam comply with the milking technique quite well, an average of 2 times a day (morning and afternoon). The average milk yield reached 24.86 kg/day/household (SD = 5.61), of which 14.56 kg was in the morning and 11.24 kg was in the afternoon. Each household has an average of 4.28 cows giving milk (SD = 3.92). Higher morning milk yield is due to cooler temperature conditions and longer resting periods, which is consistent with previous studies of day-cycle milking productivity (**Table 12**).

**Table 12.** Milk yield in communes.

| Evaluation Criteria | Mean | Standard Deviation |
|---|---|---|
| Number of milk-bearing cows (calves) | 4.28 | 3.92 |
| Milk Yield Per Day (kg) | 24.86 | 5.61 |
| Morning milk yield (kg) | 14.56 | 3.52 |
| Afternoon milk yield (kg) | 11.24 | 4.26 |

Source: Survey Results.

Method of product consumption: All households (100%) sell fresh milk to cooperatives or cooperative groups, which are in charge of purchasing, refrigerating and transporting it to the processing plant. The amount of milk consumed directly by households or retail to people is insignificant. In terms of payment methods, 77% of households receive cash, while 23% receive bank transfers every 15 days. The cooperative's support for opening bank cards for cooperative members helps to be financially transparent, reduce management costs and shorten payment time, contributing to the professionalization of the fresh milk value chain [17, 27, 28].

Production cost structure: The average total production cost reached 45.22 million VND/head/year (±26.84

million VND). In which: The cost of breeding accounts for 52.87% (23.91 million VND/head), fluctuating sharply depending on the quality of cows. Industrial feed accounted for 17.17% (7.77 million VND/head). The cost of family labor and hired labor accounted for about 29.7% and 9.6%, respectively, reflecting the characteristics of self-sufficient farmers. Small expenses such as breeding (126,000 VND/head), veterinary drugs (456,000 VND/head) and electricity (153,000 VND/head) represent a reasonable level of investment in the care and operation of the barn (**Table 13**).

Revenue and profit have an average revenue of 47.66 million VND/head/year (±29.83 million VND). After excluding production costs (excluding family labor), the average net profit reached 13.77 million VND/head/year (±10.36 million VND). This level of profit is relatively low but stable, reflecting the efficiency of the small-scale farming model, but there is still potential for improvement through high-quality breeds, improved nutrition and cost management (**Table 14**).

**Table 13.** Structure of livestock costs per dairy cow (Unit: VND).

| Average Cost | Average | Standard Deviation |
|---|---|---|
| Breeds | 23,906,000 | 21,119,450 |
| Industrial feed | 7,765,055 | 1,941,810 |
| Home Labor | 13,439,035 | 10,686,900 |
| Labor for hire | 4,362,500 | 207,289 |
| Breeding | 126,242 | 35,580 |
| Veterinary Drugs | 456,887 | 456,513 |
| Electricity | 153,325 | 96,785 |
| Other expenses | 1.731,239 | 1,055,314 |
| Total Cost | 45,218,447 | 26,840,680 |

Source: Survey Results.

**Table 14.** Revenue and profit of dairy farming households (Unit: VND).

| Evaluation Criteria | Average | Standard Deviation |
|---|---|---|
| Turnover | 47,665,934 | 29,825,141 |
| Profit (excluding family labor costs) | 13,772,495 | 10,363,620 |

Source: Survey Results.

### 3.2.2. Factors Affecting the TE of Dairy Farmers in Dai Tam Commune

### Technical Efficiency (TE)

The survey data were analyzed using the (DEA) approach implemented in DEAP 2.1 software. The output variable was milk yield (kg per year), while the input variables comprised grass cultivation area, barn size, number of lactating cows, use of veterinary drugs, amount of industrial feed, labor, and electricity consumption. The analysis revealed that under variable returns to scale (VRS), the mean technical efficiency (TE_VRS) was 0.904, while the mean TE_CRS was 0.732. The resulting scale efficiency (SE = TE_CRS / TE_VRS) was 0.810. These findings indicate that overall production efficiency among farmers is at a satisfactory level. However, indicating that there remains scope for improving efficiency through better input management, which could be realized if input utilization is optimized without necessarily expanding production scale [5, 15] (**Table 15**).

**Table 15.** Distribution of TE and SE among dairy farming households.

| Effective Range (%) | 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 | 2 | 0 | 2 | 2.00 | 0.00 | 2.00 |
| 30.01–40.00 | 4 | 0 | 3 | 4.00 | 0.00 | 3.00 |
| 40.01–50.00 | 6 | 0 | 3 | 8.00 | 0.00 | 3.00 |

**Table 15.** *Cont.*

| Effective Range (%) | Frequency | | | Percentage (%) | | |
|---|---|---|---|---|---|---|
| | $TE_{CRS}$ | $TE_{VRS}$ | SE | $TE_{CRS}$ | $TE_{VRS}$ | SE |
| 50.01–60.00 | 10 | 1 | 8 | 11.00 | 1.00 | 8.00 |
| 60.01–70.00 | 11 | 3 | 9 | 10.00 | 3.00 | 9.00 |
| 70.01–80.00 | 25 | 10 | 10 | 26.00 | 10.00 | 10.00 |
| 80.01–90.00 | 17 | 15 | 12 | 16.00 | 15.00 | 12.00 |
| 90.01–100.00 | 25 | 69 | 51 | 25.00 | 71.00 | 51.00 |
| Total | 100 | 100 | 100 | 100.00 | 100.00 | 100.00 |
| Mean | 73.20 | 90.40 | 81.00 | | | |
| Standard Deviation | 17.85 | 9.82 | 18.94 | | | |
| Minimum | 28.00 | 65.00 | 27.50 | | | |
| Maximum | 98.00 | 100.00 | 99.00 | | | |

Source: Survey Results.

## 3.3. Results

### 3.3.1. DEA Results

The $TE_{CRS}$ value = 0.732 indicates that households can increase milk production with the same current inputs if they operate more efficiently. This reflects marked differences in management and techniques among farmers, particularly with regard to the coordination of the use of feed, seeds and labor. Feed: Technical efficiency is strongly influenced by the mixing ratio of natural grass, cultivated grass and industrial feed. Households with stable grassland and know how to balance nutritional rations are significantly more effective than those who depend on concentrated feed purchased from outside, especially in the dry season. Breeds of cows: Breed quality is a major limiting factor.

Most cattle farming households buy breeds through traders with untested quality, leading to low milk yield. The selection of varieties by emotion and low prices has reduced the technical efficiency. It is necessary to have a financial support mechanism and technical advice on breed selection to help households access high-quality cows. Labor: Labor is mainly family labor, but the assignment is not reasonable and there is a lack of technical knowledge, causing time and effort to be wasted, reducing productivity. Training in care techniques, estrus detection, and feed management is key to improving TE [7, 17].

The results showed that the technical efficiency ($TE_{VRS}$) reached a high of 0.904, while the scale efficiency (SE) reached 0.810, demonstrating that the low efficiency is mainly rooted in the use of inputs, rather than the small scale of production. This implies that improving management, technical and nutritional skills is more important than expanding the herd in the current period (**Table 16**).

**Table 16.** TE and SE of dairy farming households.

| Number of Households | $TE_{CRS}$ | $TE_{VRS}$ | SE |
|---|---|---|---|
| 1 | 0.587 | 1.000 | 0.587 |
| 2 | 0.677 | 0.787 | 0.858 |
| 3 | 0.564 | 1.000 | 0.564 |
| 4 | 0.745 | 1.000 | 0.745 |
| 5 | 0.562 | 0.693 | 0.818 |
| ...... | ...... | ...... | ...... |
| 98 | 0.825 | 0.825 | 0.996 |
| 99 | 0.829 | 0.828 | 0.997 |
| 100 | 0.735 | 0.746 | 0.987 |
| Mean | 0.732 | 0.904 | 0.810 |

Source: Survey Results.

In short, the technical inefficiency of dairy farmers in Dai Tam commune is mainly due to limitations in the use of inputs, especially in feed, breeds and labor. Therefore, to improve productivity and production efficiency, it is necessary to focus on technical training, cost management and strengthening farmer support services rather than scaling up livestock.

### 3.3.2. Scale Efficiency (SE)

The findings obtained from the DEA analysis revealed that the average scale efficiency value (SE) of dairy farming households in Dai Tam commune reached 0.810, reflecting that most households have not yet maximized their production capacity. Among them, 21% of households achieved optimal scale efficiency (SE = 1), while the remaining 79% did not achieve the expected scale efficiency (SE < 1). Notably, 3% of households operate in decreasing returns to scale—meaning that if the herd continues to expand, their average productivity may decrease due to overload of labor, facilities or limitations in technical management. This is consistent with a study by Alemdar et al [28] of catfish farmers in the United States, which found that scaling up does not always lead to increased productivity.

In contrast, the remaining 76% of households are operating in the increasing returns to scale sector, indicating that expanding production scale combined with improved input management will significantly enhance production efficiency. This finding aligns with the assessment of Ören and Alemdar [19] in a study of tobacco farmers in Turkey, who argued that reasonable scaling can help achieve optimal production efficiency.

Overall, only 21% of farmers achieved optimal scale efficiency, reflecting significant room for scale expansion and improvement of technical efficiency through optimizing herd structure, investing in facilities, and applying modern production management. In the context that dairy farming in Dai Tam is still small, the development of the scale in the direction of cooperatives or the chain linkage model is a feasible direction to increase productivity and sustainable economic efficiency.

### 3.3.3. Analysis of Factors Affecting Technical Efficiency

TOBIT regression equation analysis is also used to identify the determinants influencing technical efficiency. There, the dependent variable was the technical efficiency index estimated through DEA analysis, while the independent variables are as follows: Age of the household head; Education level of the household head; Years of experience in dairy farming; Number of dairy farmers; Whether the household participates in livestock cooperatives or community organizations; The number of times households have received technical training; and household access to credit. The regression outcomes are presented in the following table.

The data in **Table 17** shows that there are four main factors influencing the technical efficiency of dairy farmers, namely: Years of experience in dairy farming; Participation in livestock cooperatives or community organizations; number of technical training sessions attended; and access to credit. All these variables positively affect technical efficiency, with significance levels of 1%, 5%, and 1%, respectively. In addition to evaluating the influence of these factors on dairy household performance, the study also examines the marginal effects of each variable on efficiency.

**Table 17.** Factors affecting the technical efficiency of dairy farming.

| Variable | Parameter Regression | Standard Error | Probability Value ($p$) |
|---|---|---|---|
| Education level of the head of the household | 0.0076 | 0.0054 | 0.1950$^{ns}$ |
| Age of the household head | 0.0002 | 0.0004 | 0.6950$^{ns}$ |
| Number of dairy farmers | −0.0114 | 0.0230 | 0.6210$^{ns}$ |
| Years of experience in dairy farming | 0.0204 | 0.0056 | 0.0000*** |
| Participation in livestock cooperatives and mass organizations Number of Technical Training Sessions | 0.1222 | 0.0382 | 0.0020** |
| Training | 0.0200 | 0.0063 | 0.0020** |
| Access to Credit | 0.1096 | 0.0301 | 0.0010*** |
| Constant | 0.2851 | 0.0727 | 0.0000*** |
| Number of Observations | 100 | | |
| Prob > chi2 | 0.0000 | | |

Notes: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$; ns: not significant.
Source: Survey Results.

## 4. Discussion

Results reflect that the smallholder dairy farmers operate below the optimal technical efficiency level in Dai Tam commune, and there is considerable potential for milk output to be increased through management improvements rather than scale expansion. Higher technical efficiency under variable returns to scale compared to scale efficiency confirms that inefficiency mainly originates from suboptimal input use, particularly from feed management, breed quality, and labor allocation. These findings are consistent with previous studies emphasizing the importance of management skills and technology adoption in smallholder dairy systems. The Tobit regression results also show that farming experience, participation in cooperatives, technical training, and access to credit increase technical efficiency significantly. This supports existing literature that human capital development, institutional linkages, and financial access have a crucial role in improving farm performance. In the context of Can Tho City and the Mekong Delta, strengthening cooperative models and farmer training programs seems to be more effective than encouraging rapid herd expansion.

Generally, it indicates that policies on capacity building, input management, and finance will go a long way to ensure sustainable dairy development. Future studies can further extend the analyses by incorporating environmental variables, technological adoption levels, and panel data to better capture efficiency dynamics over time.

# 5. Conclusions

The study has comprehensively assessed the current situation of dairy farming of farmers in Dai Tam commune, Can Tho city, thereby showing that this is an industry that has been established for a long time and is growing strongly thanks to stable market demand and the support of local authorities. Most of the livestock households are small-scale, but they have initially participated in cooperatives and cooperative groups to ensure product output, stabilize prices and improve production linkage. However, the technical level of farmers is still limited, the application of scientific and technological advances is uneven, and the quality of breeds has not been strictly controlled, leading to low productivity and production efficiency. The results estimated by the DEA model show that the average technical efficiency of households is good, with a $TE_{CRS}$ coefficient of 0.732 and a $TE_{VRS}$ of 0.904, reflecting the ability to use relatively reasonable inputs but still have the potential for significant improvement. Analysis of the Tobit model reveals that four factors have a positive and statistically significant influence on technical performance: dairy farming experience, participation in cooperative organizations or unions, number of technical training and access to formal credit. This shows that experience, capital support, collective linkages and technical training are key factors to help livestock households improve productivity and production efficiency.

From these results, the study proposes a number of key solutions to improve technical efficiency in local dairy farming. Specifically, farmers need to actively participate in technical training courses, boldly invest in seeds with clear origins, carry out livestock breeding in the right process, and at the same time expand the scale reasonably associated with optimizing input costs such as feed and labor. In addition, livestock households should take advantage of the available land area to plant grass and reserve green food sources to be proactive in the dry season, reduce dependence on industrial feed, and proactively access preferential credit capital sources to invest in upgrading facilities. On the side of the authorities and cooperatives, it is necessary to be transparent in the procurement and assessment of milk quality, promote technical transfer, and regularly organize workshops to share experiences and disseminate disease information. At the same time, it is necessary to expand preferential credit programs, simplify loan procedures and provide technical support for ethnic minority households and poor households.

In general, in order for the dairy farming industry in Dai Tam commune to develop sustainably, it is necessary to have synchronous coordination between farmers, cooperatives and local authorities in the direction of improving technical efficiency associated with training, financial support and collective production organization. When these factors are implemented in parallel, dairy farming not only helps to increase income and improve people's lives, but also contributes to promoting agricultural restructuring in the direction of modernity, sustainability and adaptation to the specific conditions of the Mekong Delta.

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## Informed Consent Statement

Not applicable.

## Data Availability Statement

Data will be made available on request.

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## Conflicts of Interest

The author declares no conflict of interest.

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