The Organic Raw Milk Production Responding to the Bio Circular Green Economy Model in Saraburi Province, Thailand: From Beginning to Practice

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Abstract

Organic raw milk production is a key component of the Bio Circular Green Economy (BCG) Model in Saraburi Province, Thailand. The research objectives focused on factors affecting the technical efficiency and efficiency scales of the organic raw milk production in Saraburi province base area. The quantitative research was applied. The study population was 1,260 dairy farmers in Saraburi province. The purposive sampling technique was applied. With the inclusion criteria of farmers who operated their dairy product with BCG model, it turned out to be 390 samples. The primary data was collected from dairy farmers applying the questionnaire as a data collection tool. The Stochastic Production Frontier Analysis (SPFA) was exploited to determine the estimated parameters, factors affecting Technical Efficiency (TE) of organic raw milk production. The findings showed that variable costs and fixed costs of organic raw milk production in the base area of Saraburi Province had a positive impact on organic raw milk output with statistical significance at the 99 percent and 95 percent levels, respectively. This indicated that an increase in variable costs leads to an increase in organic raw milk production. The average technical efficiency (TE) score for organic raw milk production was 0.845, indicating a prominent level of efficiency. According to the results of the Stochastic Production Frontier model, efficiency scores ranged from high to extremely high. Specifically, 210 producers (53.846 percent) demonstrated high technical efficiency, while 146 producers (37.436 percent) achieved exceedingly high technical efficiency. The successfulness of organic raw milk production is driven by the adoption of technology and innovation and creating environmentally friendly farm practices for long-term sustainability.

Keywords: Organic Raw Milk, Bio Circular Green Economy Model, Technical Efficiency

Introduction

The inclusion of organic raw milk production within Thailand's Bio-Circular Green Economy (BCG) Model marks a strategic shift towards sustainable development, balancing economic growth, environmental protection, and social welfare. This initiative has evolved

from concept to practice. The BCG Model in Thailand emphasizes efficient use of biological resources, promotes the circular economy, and addresses environmental issues. It aligns with the country's commitment to sustainable development and the United Nations' Sustainable Development Goals (SDGs). Organic raw milk production fits seamlessly into this framework, as it prioritizes natural farming methods, minimizes chemical use, and supports sustainable agricultural practices (National Economic and Social Development Council, 2024).

Nowadays, Thailand's Bio-Circular Green Economy (BCG) Model aims for sustainability by incorporating biological, circular, and green principles into economic development. It focuses on efficient resource use, low-carbon initiatives, and minimizing waste, all in line with the country's commitment to the United Nations' Sustainable Development Goals (SDGs) (National Economic and Social Development Council, 2024).

Organic raw milk production is a key component of the BCG Model, supporting eco-friendly farming practices, lowering greenhouse gas emissions, and promoting social well-being. This article explores the development of organic milk production in Thailand, tracing its origins and its integration into the BCG framework (National Economic and Social Development Council, 2024).

The beginning of organic raw milk production has been emerged with the health and sustainability trends of Thai people. In the past decade, Thai consumers have become more health-conscious, leading to a growing demand for organic and chemical-free food products, including milk (Kaewwongsa et al., 2022). This shift in consumer preferences has accelerated the adoption of organic farming practices.

The Thai government, in partnership with NGOs and agricultural cooperatives, has supported organic farming initiatives. Policies from the Ministry of Agriculture and Cooperatives have focused on promoting sustainable livestock farming and providing certification programs (Ministry of Agriculture and Cooperatives, 2019).

With the economic Potential, the export market for organic dairy products has created opportunities for farmers to transition to organic practices, driven by the potential for premium pricing and access to niche markets (Food and Agriculture Organization, 2024)

The implementation in practice of Thai organic raw milk production has effectively been incorporated into the BCG Model through the following practices: 1) the organic farming practices which expressed as farmers adopted organic practices by removing the use of chemical fertilizers, antibiotics, and synthetic pesticides. The cows are provided with organic-certified feed and allowed to graze on free-range grass, promoting animal welfare (Kaewwongsa et al., 2020), 2) the circular economy integration explicated with the implementation of manure recycling. Cow manure is converted into organic fertilizers, minimizing waste and improving soil health (Ministry of Agriculture and Cooperatives, 2019).

Biogas Production: Livestock waste is transformed into biogas, a renewable energy source, which is either used for farming activities or sold locally (United Nations Development , 2021), 3) community-based models was functioned as Cooperatives like the Thai Dairy Cooperative Federation (TDCF) assist farmers in accessing resources, exchanging knowledge, and consolidating organic products to improve market access (Food and Agriculture Organization, 2020), 4) organic raw milk production assessed to the certification and market development. Certified organic raw milk is sold under organic labels both locally and internationally, with certifications from organizations such as the Organic Agriculture Certification Thailand (ACT). Niche markets, including health-conscious consumers and high-end exports, contribute to driving sales (National Economic and Social Development Council, 2024)

Despite its success, the production of organic raw milk faces several challenges with the excessive cost of production. Farmers faced significant expenses when shifting from conventional to organic farming including the costs of organic feed and certification (Kaewwongsa et al., 2020). Another issue was expressed as knowledge and skill gaps. Smallholder farmers often lacked the technical knowledge needed to adopt sustainable practices, making the transition difficult (Ministry of Agriculture and Cooperatives, 2024). Also, the organic sector struggles to compete with lower-priced conventional milk, hindering its growth.

To strengthen the synergy between organic raw milk production and the BCG Model with technology adoption. Farmers were introduced smart farming technologies to boost efficiency and lower production costs along with enhanced subsidies, training programs, and financial support to assist farmers in transitioning to organic practices (United Nations Development, 2021). Also, the consumer awareness was launched public campaigns that emphasize the health and environmental advantages of organic milk.

At the present time, Thailand's organic raw milk production is in line with the principles of the Bio-Circular Green Economy (BCG) Model by promoting sustainable agricultural practices, aiding rural communities, and supporting environmental conservation. With targeted policy support and market expansion, organic milk production could be a key driver in Thailand's path toward sustainable development.

Since, organic raw milk production was implanted and supported by the Royal Thai government in many places around Thailand. Saraburi province located in the central part of Thailand was one of several provinces of implemented area base. Bank for Agriculture and Agricultural Cooperatives (2025) reported that the growth of organic raw milk production in Saraburi Province, following the Bio-Circular-Green Economy model, has promoted sustainability within the raw milk sector. Farmers in the area have received assistance in adopting chemical-free and contaminant-free dairy farming practices, resulting

in a monthly output of 129,600 kilograms of organic raw milk. This increase in production has also led to higher earnings for farmers, as they can sell their organic milk at a premium price compared to conventional milk. Saraburi Province is the leading dairy-producing region in Thailand, where some farmers have transitioned to organic practices.

Successfulness in this sector is driven by the adoption of technology and innovation in cattle breeding and rearing, prioritizing animal welfare, and creating environmentally friendly farm practices for long-term sustainability. Farmers are encouraged to enhance self-reliance, minimize dependence on imported materials, and focus on producing high-quality animal feed. Meanwhile, the government is urged to provide support and raise awareness about the benefits of consuming organic milk (Bank for Agriculture and Agricultural Cooperatives, 2025).

Addressing the research, the aim of this research paper attempted to measure the technical efficiency (TE) of organic raw milk production in Saraburi province base area to make sure that the organic raw milk production project supported by the Royal Thai Government obtained the technical efficiency (TE) for the project implementation which also made the confirmation that this project met the requirement of TE for the on-going project supporting by the Royal Thai Government. Theatrically, the stochastic production frontier was adopted as the tool for TE measurement. Technical efficiency (TE) refers to the ability of a production unit, such as a farm, to produce the maximum output (raw milk) from a given set of inputs such as feed, labor, and capital. In the context of raw milk production, measuring technical efficiency helps identify whether dairy farmers are utilizing resources optimally and where improvements can be made to enhance productivity. (Kaewwongsa, P., et al, 2020).

The research results could be applied to support organic raw milk production which offered several benefits of higher nutritional value, free from synthetic hormones, antibiotics, and pesticides leading to sustainable farming practices. The integration of the Bio-Circular-Green (BCG) Economy Model into organic raw milk production obtained several advantages such as the enchantment of animal health, the research results would support and drive into probiotic-rich dairy products, bio-fermentation, and value-added organic dairy products. Cows in good health require fewer antibiotics, resulting in cleaner and safer milk. Transforms cow manure into organic fertilizer or biogas, creating a sustainable waste cycle.

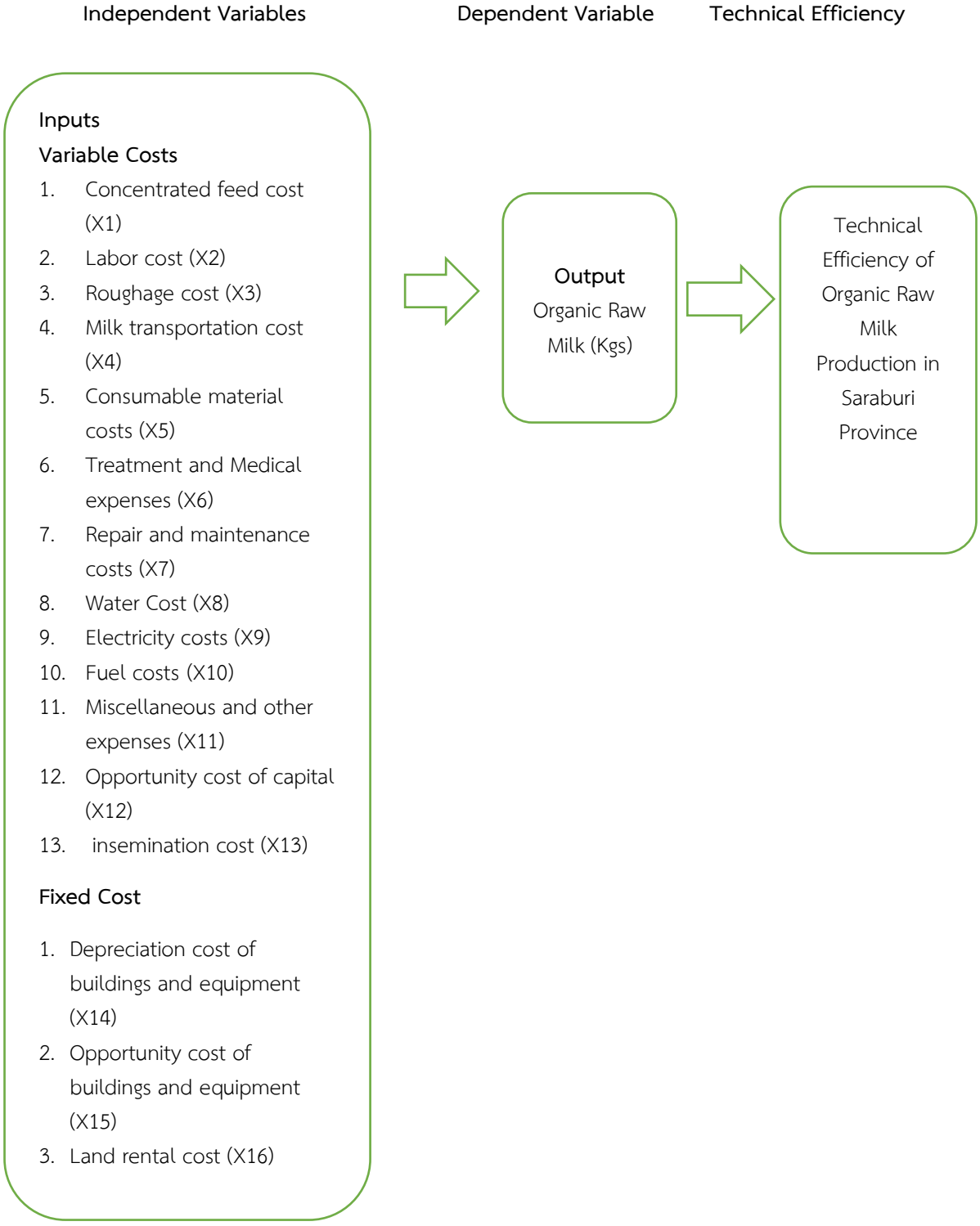
Objectives

The research objective was focused on factors affecting the measurement of technical and scale Efficiency of the organic raw milk production in Saraburi province base area.

Hypothesis

Dairy farmers who performed organic raw milk production responding to BCG model achieved technical efficiency.

Concept theory framework



Materials and Methods

The methodology was survey research applying the econometric methodology to estimate the organic raw milk production efficiency in Saraburi Province, Thailand exploiting the Stochastic Production Frontier Model to determine factors and the level of technical efficiency affecting the organic raw milk production efficiency.

Data Collection

The study population was composed of 1,260 dairy farmers in Saraburi province. The research in this study collects primary data obtained from the online questionnaire survey of organic raw milk producers in Saraburi province area base. The purposive sampling technique was applied as the inclusion criterion of dairy farmers who performed their organic raw milk production for over 2 years continuously. It turned out of 390 farmers which covered 13 districts in Saraburi province.

Table 1: Number of Samples of organic raw milk producers in Saraburi province area base

Districts in Saraburi Province	Number of Samples (Dairy Farmers' Households)
1. Mueang Saraburi	30
2. Kaeng Khoi	30
3. Nong Khae	30
4. Wihan Daeng	30
5. Nong Saeng	30
6. Ban Mo	30
7. Don Phut	30
8. Nong Don	30
9. Phra Phutthabat	30
10. Sao Hai	30
11. Muak Lek	30
12. Wang Muang	30
13. Chaloem Phra Kiat	30
Total	**390**

Source: The Researcher 's Calculation

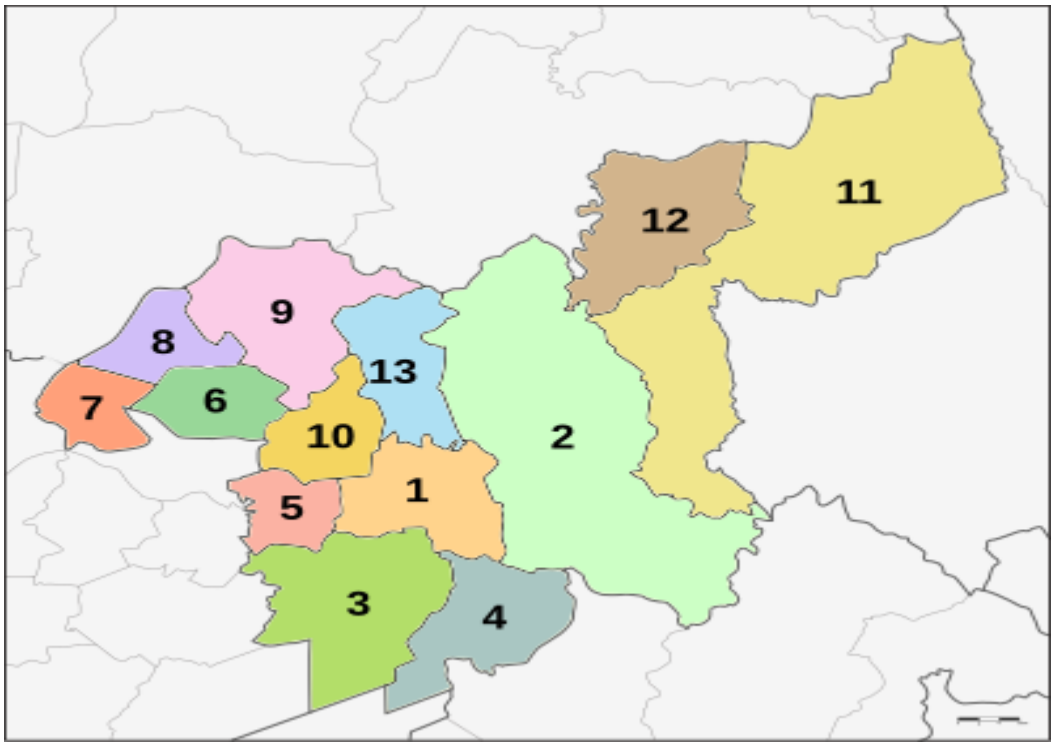


Figure 1: Map of Saraburi with 13 districts

Source: https://en.wikipedia.org/wiki/Saraburi_province

According to Figure 1, the geographic of Saraburi province is composed of 13 districts where the primary data were collected from. Theses 13 districts are: 1) Mueang Saraburi, 2) Kaeng Khoi, 3) Nong Khae, 4) Wihan Daeng, 5) Nong Saeng, 6) Ban Mo, 7) Don Phut, 8) Nong Don, 9) Phra Phutthabat, 10) Sao Hai, 11) Muak Lek, 12) Wang Muang, and 13) Chaloem Phra Kiat. The primary data were collected from 13 districts with equal numbers of 30 respondents. It turned out of the total numbers of 390 samples as sample size (Table1.)

Data Analysis

The research used cross-sectional primary data, analyzed to meet its objectives as follows:

Quantitative analysis

The study applied the Stochastic Production Frontier (SPF) method to evaluate the technical production efficiency of organic raw milk production in Saraburi Province. The analysis involved parameter estimation using the Maximum Likelihood method to determine their efficiency levels within the stochastic production model framework.

$$y_i = f(x_i;\ \beta).exp\,(v_i - u_i) \qquad (1)$$

Where:

y_i is the output for the i^{th} firm in terms of the natural logarithm.

x_i is a vector of inputs in terms of the natural logarithm?

β is a vector of parameters to be estimated.

v_i is the stochastic error term (assumed to be normally distributed).

u_i is the inefficiency term (usually assumed to be non-negative).

In this research work the Stochastic Production Frontier could be expressed as follows:

The output is expressed as:

y_i is the maize output for the i^{th} household in terms of the natural logarithm?

The inputs are expressed as:

x_1 is a vector input of concentrated feed cost in terms of the natural logarithm?

x_2 is a vector input of labor cost in terms of the natural logarithm?

x_3 is a vector input of roughage cost in terms of the natural logarithm?

x_4 is a vector input of milk transportation cost in terms of the natural logarithm?

x_5 is a vector input of consumable material costs in terms of the natural logarithm?

x_6 Is a vector input of treatment and medical expenses in terms of the natural logarithm?

x_7 is a vector input of repair and maintenance costs in terms of the natural logarithm?

x_8 is a vector input of water cost in terms of the natural logarithm?

x_9 is a vector input of electricity costs in terms of the natural logarithm?

x_{10} Is there a vector input of fuel costs in terms of the natural logarithm?

x_{11} is a vector of miscellaneous and other expenses in terms of the natural logarithm?

x_{12} Is a vector input of opportunity cost of capitals in terms of the natural logarithm?

x_{13} is a vector of insemination cost in terms of the natural logarithm?

x_{14} is a vector of depreciation cost of buildings and equipment?
in terms of the natural logarithm

x_{15} is it a vector of opportunity cost of buildings and equipment?
in terms of the natural logarithm

x_{16} is a vector of land rental cost in terms of the natural logarithm?

β is a vector of parameters to be estimated.

v_i is the stochastic error term (assumed to be normally distributed).

u_i is the inefficiency term (usually assumed to be non-negative).

Results

Part1 The estimation of factors affecting technical production efficiency of organic raw milk production in Saraburi Province, Thailand

The estimation of parameters based on the Stochastic Production Frontier equation using the Maximum-Likelihood method is Table 2 as follows:

Table 2: Factors Affecting Technical Production Efficiency of Organic Raw Milk Producers in Phetchabun Province, Thailand

Dependent Variable (y) : Organic Raw Milk Production

(n. = 390)

Independent Variables	Estimated Parameters	Coefficients	t-value
Stochastic Frontier			
Constant term	β_0	-236.860	(39.252)
Concentrated feed cost (x_1)	β_1	34.270	(34.627)**
Labor cost (x_2)	β_2	54.670	(23.425)**
Roughage cost (x_3)	β_3	29.290	(18.602)**
Milk transportation cost (x_4)	β_4	19.481	(23.146)**
Consumable material costs (x_5)	β_5	11.546	(22.462)*
Treatment and Medical expenses (x_6)	β_6	23.264	(32.164)*
Repair and maintenance costs (x_7)	β_7	16.412	(24.126)*
Water Cost (x_8)	β_8	18.641	(32.621)*
Electricity costs (x_9)	β_9	16.142	(41.213)**
Fuel costs (x_{10})	β_{10}	21.245	(19.143)**

Independent Variables	Estimated Parameters	Coefficients	t-value
Miscellaneous and other expenses (x_{11})	β_{11}	24.168	(22.463)*
Opportunity cost of capital (x_{12})	β_{12}	18.246	(23.164)**
Insemination cost (x_{13})	β_{13}	20.412	(18.154)*
Depreciation cost of buildings and equipment (x_{14})	β_{14}	26.156	(18.942)*
Opportunity cost of buildings and equipment (x_{15})	β_{15}	18.641	(19.126)**
Land rental cost (x_{16})	β_{16}	12.461	(23.246)*

**Statistical Significance at 99 percent

*Statistical Significance at 95 percent

Noted: Variables were expressed in a Natural logarithm form

According to table 2, the statistical results expressed that both variable costs and fixed cost of organic raw milk production in Saraburi province base area had positive impact on the organic raw milk production at the 99 and 95 percent Statistical Significance, respectively. This indicated that the increase of all variable cost of organic raw milk would increase the organic raw milk production as well. In this research outcomes, the variable costs were comprised of 13 factors which were: concentrated feed, labor cost, roughage, milk transportation cost, consumable material costs, treatment and Medical expenses, repair and maintenance costs, water cost, electricity cost, fuel costs, miscellaneous and other expenses, opportunity cost of capital and insemination cost. The fixed costs were composed of 3 factors which were the depreciation cost of buildings and equipment, opportunity cost of buildings and equipment and land rental cost.

Table 3: The level of technical efficiency of the organic raw milk in Saraburi Province, Thailand

(n=390)

Level of Technical Efficiency	Technical Efficiency Value	Number of Farmers	Percentage
Extremely low	(0.0000 - 0.5000)	2	0.513
Low	(0.5001 - 0.6000)	10	2.564
Moderate	(0.6001 - 0.8000)	22	5.641
High	(0.8001 - 0.9000)	210	53.846
Very High	(0.9001 - 0.9999)	146	37.436
Total		390	100.000
Maximum	0.921		
Minimum	0.438		
Average	0.845		

Source: The Researcher's Calculation

According to table 3, the technical efficiency scores of organic raw milk production in Saraburi province of Thailand were ranged from 0.438 to 0.921. The average efficiency score expressed as 0.845 which was in the high technical efficiency score. The research findings from the Stochastic Production Frontier model revealed that the efficiency scores for organic raw milk production ranged from high to exceedingly high. There were 210 producers of organic raw milk production in the prominent level of Technical Efficiency which accounted for 53.846 percent. Also, there were 146 producers of organic raw milk production at an exceedingly high level of technical efficiency, which accounted for 37.436 percent. In addition, there were 2, 10 and 22 producers of organic raw milk production in extremely low, low, and moderate levels of technical efficiency which accounted for 0.513, 2.564 and 5.641 percent, respectively.

Conclusions and Discussion

Organic raw milk production plays a vital role in the BCG Model, fostering sustainable farming methods, reducing greenhouse gas emissions, and enhancing social welfare. This article delves into the evolution of organic milk production in Thailand, highlighting its origins and incorporation into the BCG framework.

This research aimed to evaluate the technical efficiency (TE) of organic raw milk production in the base area of Saraburi Province. The goal was to ensure that the organic raw milk production project, supported by the Royal Thai Government, achieved the required TE for effective project implementation. Additionally, the evaluation confirmed

that the project met the necessary TE standards for its continued government support. To achieve this, the stochastic production frontier method was employed as the primary tool for measuring technical efficiency. The statistical analysis revealed that both variable costs and fixed costs of organic raw milk production in the base area of Saraburi Province had a positive impact on organic raw milk output, with statistical significance at the 99 percent and 95 percent levels, respectively. This indicates that an increase in variable costs leads to an increase in organic raw milk production.

The research findings identified 13 factors contributing to variable costs: concentrated feed, labor costs, roughage, milk transportation costs, consumable materials, treatment and medical expenses, repair and maintenance costs, water costs, electricity costs, fuel costs, miscellaneous expenses, opportunity cost of capital, and insemination costs. Fixed costs were categorized into three components: depreciation of buildings and equipment, opportunity costs of buildings and equipment, and land rental costs. The research found that the average technical efficiency (TE) score for organic raw milk production was 0.845, indicating a prominent level of efficiency. According to the results of the Stochastic Production Frontier model, efficiency scores for organic raw milk production ranged from high to exceedingly high. Specifically, 210 producers (53.846 percent) demonstrated high technical efficiency, while 146 producers (37.436 percent) achieved exceedingly high technical efficiency.

The research findings were consistent with the study of Madau, F.A., Furesi, R. and Pulina, P. (2024) who studied technical efficiency and total factor productivity changes in European dairy farm sectors focusing the organic dairy farms. In according with Linehan, K., Patangia, D.V. Ross, R.P., and Stanton, C. (2024) found that milk is one of the most valuable products in the food industry with most milk production throughout the world being carried out using conventional management, which includes intensive and traditional systems. The intensive use of fertilizers, antibiotics, pesticides and concerns regarding animal health and the environment have given increasing importance to organic dairy and dairy products in the last two decades. The research findings were consistent with the study of Grodkowski, G. et al. (2024) who studied organic milk production and dairy farming constraints and prospects under the laws of the European Union who addressed that consumers are increasingly opting for organic farming products, driven by the belief that organic farming avoids the use of pesticides and antibiotics while ensuring optimal living conditions for animals. The differences between organic and conventional dairy cattle housing systems focused on welfare assessment, breed selection, and product quality. Their findings indicated that cows raised in organic systems experience better welfare compared to those in conventional systems. In addition, the research findings were consistent with Yu, Z. et al. (2023) who conducted their research on production efficiency

of raw milk and its determinants: Application of Combining Data Envelopment Analysis and Stochastic Frontier Analysis. They found that raw milk production efficiency is significantly influenced by several factors, including the proportion of concentration to roughage consumption, medical and epidemic prevention investment, the price of raw milk, the wage level, and fixed assets.

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