The Measurement of Technical and Scale Efficiency of Maize Production of Agricultural Cooperatives in Loei Province, Thailand

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Abstract

Loei Province contributes significantly to Thailand's total maize output with production primarily focused on feed maize. The research objectives focused on measuring the technical and scale efficiency of maize production of agricultural cooperatives in Loei Province. The study population was 35 agricultural cooperatives. The purposive sampling technique was applied. It turned out of 10 agricultural cooperatives as the sample size. Data were collected from the Cooperative Auditing Department from 2020 to 2024. Technical and scale efficiency were examined by the Data Envelopment Analysis (DEA) model. The findings expressed that 6 out of 10 agricultural cooperatives achieved the technical efficiency of maize production with an efficiency score of 1.00 which expressed these agricultural cooperatives operated their maize production with technical efficiency. On the other hand, there were 4 out of the agricultural cooperatives who achieved the technical efficiency of maize production with an efficiency score of less than 1.00. This meant that these agricultural cooperatives operated maize production under the technical efficiency. There were 3 agricultural cooperatives, Tha Li Agricultural Cooperative Limited, Dan Sai Agricultural Cooperative Limited, and Na Duang Agricultural Cooperative Limited would decrease their inputs of maize production to get the maximum total revenue. On the other hand, there was only one agricultural cooperative, Tha Li Agricultural Cooperative Limited would increase their inputs of maize production to get the maximum total revenue. The findings would lead agricultural cooperatives to be the import area of maize production in Thailand.

Keywords: Technical Efficiency, Scale Efficiency, Maize Production, Agricultural Cooperatives

Introduction

Maize (Zea mays L.), also known as corn, is one of the most widely grown crops globally, with a crucial role in food security, livestock feed, and industrial applications. Research on maize production focuses on enhancing yield, combating pests and

diseases, and mitigating the effects of climate change (Pingali, 2001). In addition, maize is a staple food for more than 1 billion people worldwide. Its adaptability to diverse agro-climatic conditions and high yield potential make it a key crop for ensuring food security. In addition, maize contributes significantly to the livestock feed industry and biofuel production (Pingali, 2001; Farooq & Kadambot, 2009).

In Thailand, Maize is one of the major crops cultivated in Thailand, primarily used as animal feed, especially in the poultry and livestock industries. It ranks among the top export commodities for the country and plays a significant role in the agricultural economy. However, maize production in Thailand faces challenges related to land use, environmental sustainability, and global market competition (Food and Agriculture Organization, 2022). Maize contributes significantly to Thailand's agricultural sector, particularly as a feed crop for the growing poultry and livestock industries. In 2022, Thailand produced approximately 5 million tons of maize, with most of it consumed domestically to support the country's animal feed industry (Food and Agriculture Organization, 2022). Over 90% of maize produced in Thailand is used in animal feed industries. A smaller portion is exported to neighboring countries such as Vietnam and the Philippines. Maize starch is used in the production of food and beverages. (Rerkasem, 2016; Food and Agriculture Organization, 2022).

The major maize-growing regions in Thailand are Chiang Mai, Chiang Rai, and Nan the Northern region of Thailand leads in maize cultivation due to favorable soil and climatic conditions. In the Northeastern region of Thailand, Loei and Nakhon Ratchasima are also significant contributors. Also, in the Western region of Thailand, Kanchanaburi, and Tak are emerging regions for maize production (Rerkasem, 2016; Food and Agriculture Organization, 2022).

Loei, a province in northeastern Thailand, plays a significant role in the country's maize production. Known for its mountainous terrain, diverse climate, and fertile soils, Loei has emerged as one of the key regions for growing maize, primarily for animal feed. The province's maize farming contributes to Thailand's broader agricultural economy, especially in meeting the increasing demand for livestock feed (Office of Agricultural Economics, 2022).

Figure 1: Map of Loei Province, Thailand
Source: https://en.wikipedia.org/wiki/Loei_province

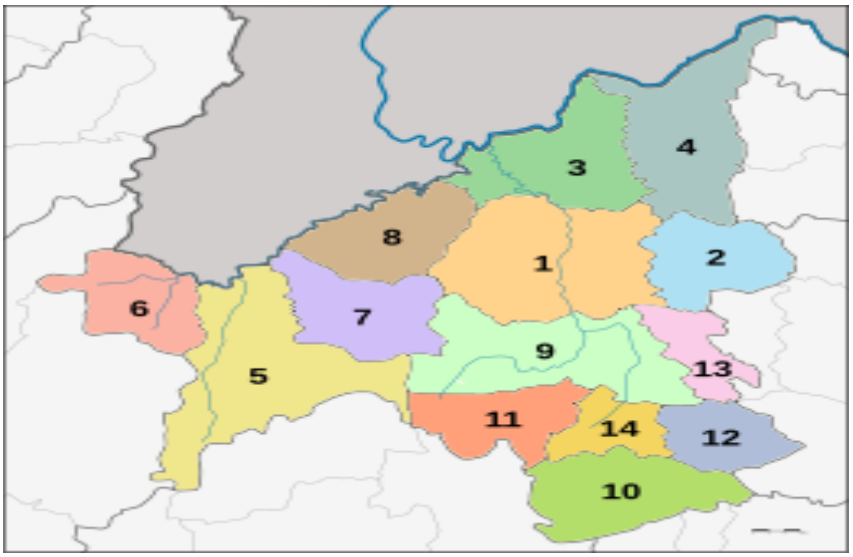

Figure 2: Map of 14 Districts in Loei Province, Thailand
Source: https://en.wikipedia.org/wiki/Loei_province

According to figure 2, Loei Province is comprised of 14 districts which are: 1) Mueang Loei, 2) Na Duang, 3) Chiang Khan, 4) Pak Chom, 5) Dan Sai, 6) Na Haeo, 7) Phu Ruea, 8) Tha Li, 9) Wang Saphung, 10) Phu Kradueng, 11) Phu Luang, 12) Pha Khao, 13) Erawan, and 14) Nong Hin.

Loei's geography and climate make it well-suited for maize farming. The province experiences a tropical savanna climate, characterized by a pronounced rainy season and a cooler dry season. Most maize in Loei is grown during the rainy season from May to October which provides the necessary water supply for crop growth. Due to its hilly topography, maize fields in Loei often utilize terrace farming to minimize soil erosion and improve water retention. Farmers cultivate hybrid maize seeds for higher yields, improved pest resistance, and suitability to Loei's environment. The province's soil, sandy loam, is ideal for maize cultivation, though consistent use of fertilizers and soil conditioners is needed to maintain fertility (Office of Agricultural Economics, 2022).

Loei contributes significantly to Thailand's total maize output, with production primarily focused on feed maize. The yield in Loei averages around 3.5 to 4 tons per hectare, depending on weather conditions and farming practices (Office of Agricultural Economics, 2022; Suwankiri & Pannangpetch, 2021).

This research evaluated the technical efficiency of maize production in Loei Province, Thailand, using Data Envelopment Analysis (DEA). DEA, a non-parametric linear programming method, is employed to estimate the efficiency levels of maize farms based on their input-output data. The study identifies the scale efficiency, pure technical efficiency, and overall technical efficiency of maize production through the agricultural cooperatives in Loei Province of Thailand.

In this research paper with the information mentioned, the researcher conducted the research paper of the measurement of technical and scale efficiency of maize production of agricultural cooperatives in Loei province, Thailand. This would give a better understanding of the technical efficiency of maize production in Loei province which is crucial for addressing production gaps and improving overall output. Technical efficiency refers to the ability of farmers to maximize output given a specific set of inputs and technologies (Farrell, 1957). The research results would be applied for the maize production guideline for agricultural cooperatives to improve their maize production with technical applied for the utilizing resources optimally to maximize output while minimizing waste of agricultural cooperatives performances. The maize production cost reduction which streamlined their processes of waste reduction and lowering production and operational expenses on maize production to achieve the maximum output level along with existing resources enhances maize production efficiency.

Objectives

The research objectives were to measure the technical and scale efficiency of maize production of agricultural cooperatives in Loei Province, Thailand.

Hypothesis

Agricultural cooperatives in Loei Province operated their maize production with technical efficiency expressing their scale efficiency of 1.00.

Concept theory framework

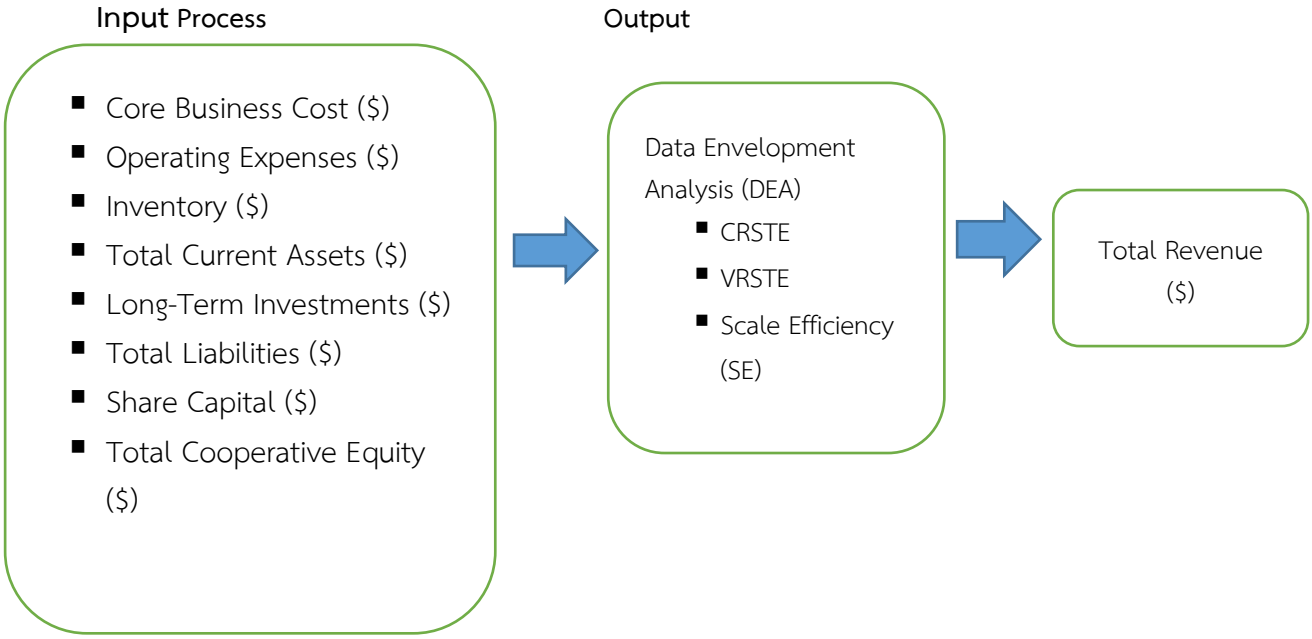

Figure 3: Conceptual framework

Research Methodology

The methodology was quantitative research applying the Data Envelopment Analysis (DEA) Model to measure the technical and scale efficiency of maize production of Agricultural Cooperatives in Loei Province, Thailand.

Data Collection

The study focused on a population of 35 agricultural cooperatives in Loei Province, Thailand. A purposive sampling method was used to select cooperatives that had been continuously producing maize for five years. Based on these criteria, 10 agricultural cooperatives were selected: Muang Loei Agricultural Cooperative Limited, Wang Saphung Agricultural Cooperative Limited, Phu Ruea Agricultural Cooperative Limited, Phu Kradueng Agricultural Cooperative Limited, Tha Li Agricultural Cooperative Limited, Dan Sai Agricultural Cooperative Limited, Na Duang Agricultural Cooperative Limited, Phu Luang Agricultural Cooperative Limited, Pha Khao Agricultural Cooperative Limited, and Erawan Agricultural Cooperative Limited.

Secondary data were obtained from the Cooperative Auditing Department's database for the period 2020–2024. The dataset included the following financial indicators: (1) total revenue, (2) core business costs, (3) operating expenses, (4) inventory,

(5) total current assets, (6) long-term investments, (7) total liabilities, (8) share capital, and (9) total cooperative equity. With five consecutive years of time-series data from 10 agricultural cooperatives, the study comprised a total of 50 observations.

Data Analysis

To evaluate the technical and scale efficiency of maize production among agricultural cooperatives in Loei Province, Thailand, the Data Envelopment Analysis (DEA) model was utilized as the analytical tool. The assessment included: (1) technical efficiency based on the Constant Returns to Scale (CRS) DEA (CRSTE), (2) technical efficiency based on the Variable Returns to Scale (VRS) DEA (VRSTE), and (3) Scale Efficiency (SE).

Results

In line with the research objectives, the technical and scale efficiency of maize production among agricultural cooperatives in Loei Province, Thailand, were measured as follows:

Table 1: The technical and scale efficiency of maize production among agricultural cooperatives in Loei Province, Thailand

Order	Cooperatives Name	CRSTE	VRSTE	Scale	Explanation
1	Muang Loei Agricultural Cooperative Limited	1.000	1.000	1.000	-
2	Wang Saphung Agricultural Cooperative Limited	1.000	1.000	1.000	-
3	Phu Ruea Agricultural Cooperative Limited	1.000	1.000	1.000	-
4	Phu Kradueng Agricultural Cooperative Limited	0.959	0.960	0.999	DRS
5	Tha Li Agricultural Cooperative Limited	0.917	0.928	0.988	IRS
6	Dan Sai Agricultural Cooperative Limited	0.894	1.000	0.894	IRS
7	Na Duang Agricultural Cooperative Limited	0.981	1.000	0.981	IRS
8	Phu Luang Agricultural Cooperative Limited	1.000	1.000	1.000	-
9	Pha Khao Agricultural Cooperative Limited	1.000	1.000	1.000	-
10	Erawan Agricultural Cooperative Limited	1.000	1.000	1.000	
	Average	0.975	0.989	0.986	

Source: Calculation

Note: CRSTE = technical efficiency from CRS DEA

VRSTE = technical efficiency from VRS DEA

Scale = scale efficiency = CRSTE/ VRSTE

According to Table 1, there were six out of 10 agricultural cooperatives in Loei province who achieved technical efficiency from Constant Return to Scale (CRS), technical efficiency from Variable Return to Scale (VRS), and Scale Efficiency (SE) of 1.00. The six agricultural cooperatives were comprised of 1) Muang Loei Agricultural Cooperative Limited, 2) Wang Saphung Agricultural Cooperative Limited, 3) Phu Ruea Agricultural Cooperative Limited, 4) Phu Luang Agricultural Cooperative Limited, 5) Pha Khao Agricultural Cooperative Limited, and 6) Erawan Agricultural Cooperative Limited.

There were four out of 10 agricultural cooperatives achieved technical efficiency from Constant Return to Scale (CRS), technical efficiency from Variable Return to Scale (VRS), and Scale Efficiency (SE) less than 1.00 which comprised 1) Phu Kradueng Agricultural Cooperative Limited, 2) Tha Li Agricultural Cooperative Limited, 3) Dan Sai Agricultural Cooperative Limited and 4) Na Duang Agricultural Cooperative Limited.

Phu Kradueng Agricultural Cooperative Limited achieved technical efficiency from Constant Return to Scale (CRS), technical efficiency from Variable Return to Scale (VRS), and Scale Efficiency (SE) of 0.959, 0.960, and 0.999, respectively. The result expressed that Phu Kradueng Agricultural Cooperative Limited would increase the use of maize production inputs which were 1) increasing in share capital, 2) total cooperatives equity, and 3) long-term investments. The share capital was expressed as the total amount of money that the agricultural cooperatives raised by issuing shares to its members or investors. It represents the financial contribution made by shareholders in exchange for ownership stakes in the organization. The total cooperatives equity functioned as the overall financial ownership value of agricultural cooperatives which included members' share capital, retained earnings, and other reserves. It represented the cooperative's net worth after deducting total liabilities from total assets. In addition, long-term investments indicated to assets or financial investments that a cooperative or business holds for an extended period, typically longer than one year. These may include stocks, bonds, real estate, or other investments intended to generate returns over time rather than for immediate use or resale.

The Li Agricultural Cooperative Limited achieved technical efficiency from Constant Return to Scale (CRS), technical efficiency from Variable Return to Scale (VRS), and Scale Efficiency (SE) of 0.917, 0.928, and 0.988, respectively.

Dan Sai Agricultural Cooperative Limited achieved technical efficiency from Constant Return to Scale (CRS), technical efficiency from Variable Return to Scale (VRS),

and Scale Efficiency (SE) of 0.894, 1.000, and 0.894, respectively.

Na Duang Agricultural Cooperative Limited achieved technical efficiency from Constant Return to Scale (CRS), technical efficiency from Variable Return to Scale (VRS), and Scale Efficiency (SE) of 0.981, 1.000, and 0.981, respectively.

The three above agricultural cooperatives in Loei Province would decrease the inputs of maize production which were 1) core business cost, 2) operating expenses, 3) inventory, 4) total current assets, and 5) total liabilities.

The decrease in the core business cost indicated the total expenses related to the agricultural cooperative's main operations. This included costs such as raw materials, production expenses, labor, and other essential expenditures necessary to sustain the primary business activities.

The decrease in operating expenses was expressed to the costs incurred in the day-to-day operations of agricultural cooperatives. These expenses included salaries, rent, utilities, administrative costs, and other overhead expenses necessary to maintain business activities but were not directly tied to production.

The decrease in inventory indicated the goods, raw materials, and products that agricultural cooperatives hold for production, resale, or daily operations. It included finished products ready for sale, work-in-progress items, and raw materials used in production.

The decrease in total current assets included the sum of all short-term assets that a cooperative can convert into cash or use within one year. These typically included cash and bank deposits, accounts receivable (money owed by customers), inventory (raw materials, work-in-progress, and finished goods), Short-term investments, prepaid expenses (payments made in advance for future expenses), total current assets were crucial for assessing a cooperatives' liquidity and ability to meet short-term financial obligations.

Conclusions and Discussion

Maize (Zea mays L.), commonly known as corn, is one of the world's most extensively cultivated crops, playing a vital role in food security, animal feed, and various industrial uses. Studies on maize production primarily aim to improve yield, manage pests and diseases, and address the challenges posed by climate change.

In Thailand, maize is a key agricultural crop primarily grown for use as animal feed, particularly in the poultry and livestock industries. It is also one of the country's major export commodities, contributing significantly to the agricultural sector and overall economy.

Loei, a province in northeastern Thailand, is an important hub for maize production. With its mountainous landscape, diverse climate, and fertile soil, the region has become a key area for cultivating maize, for use as animal feed.

There were six out of 10 agricultural cooperatives in Loei Province who achieved a technical efficiency score of 1.00 across all three efficiency measures: Constant Returns to Scale (CRS) technical efficiency, Variable Returns to Scale (VRS) technical efficiency, and Scale Efficiency (SE). The six agricultural cooperatives were comprised of 1) Muang Loei Agricultural Cooperative Limited, 2) Wang Saphung Agricultural Cooperative Limited, 3) Phu Ruea Agricultural Cooperative Limited, 4) Phu Luang Agricultural Cooperative Limited, 5) Pha Khao Agricultural Cooperative Limited, and 6) Erawan Agricultural Cooperative Limited.

There were four out of 10 agricultural cooperatives that demonstrated technical efficiency below 1.00 in Constant Return to Scale (CRS), technical efficiency in Variable Return to Scale (VRS), and Scale Efficiency (SE). These cooperatives include: 1) Phu Kradueng Agricultural Cooperative Limited, 2) Tha Li Agricultural Cooperative Limited, 3) Dan Sai Agricultural Cooperative Limited, and 4) Na Duang Agricultural Cooperative Limited.

The result indicated that Phu Kradueng Agricultural Cooperative Limited should enhance its use of maize production inputs. Li Agricultural Cooperative Limited, Dan Sai Agricultural Cooperative Limited, and Na Duang Agricultural Cooperative Limited would decrease core business costs, operating expenses, inventory, and total current assets to get the maximum total revenue for agricultural cooperatives.

The research results were consistent with Phuphisith, Gheewala, and Sampattagul (2022) who conducted their study on the promotion of sustainable maize production in Northern Thailand, the country's largest maize-producing region, is crucial to securing the supply of the nation's feed manufacturing, as well as protecting environmental resources, enhancing social welfare, and improving the livelihoods of farmers and communities. According to Chaovanapoonphola and Somyana (2020) who studied the production efficiency of maize farmers under contract farming in Laos PDR found that the efficiency of contract maize farmers in Lao PDR was on average 0.85 and that the main factors affecting maize production efficiency were the age and education level of the farmer and area of planted land. The research outcomes also were consistent with Khongdee, Hilger, Pansak, and Cadisch (2022) who conducted their works on optimizing maize sowing under irregular rainfall distribution in northern Thailand: A model approach for improved decision-making. Also, the research findings were consistent with Charoenratan, Anukul, and Rosset (2021) found that Northern Thailand was the center of several controversies surrounding changing cropping patterns, related to deforestation

driven by the expansion of maize mono-cropping by peasant farmers.

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