Journal of Logistics and Digital Supply Chain

# Applying DEA to Measure Supply Chain Performance in Local Coffee Shops: A Case Study Near Naresuan University

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**Abstract**

This study examines the supply chain efficiency of local coffee shops near Naresuan University, Thailand, using a Data Envelopment Analysis (DEA) approach. The research evaluates the performance of four coffee shops by identifying key indicators based on the Balanced Scorecard (BSC) framework, encompassing Customer, Financial, Internal Processes, and Learning and Growth perspectives. The performance factors were validated by five relevant experts using the Content Validity Ratio (CVR) and the Index of Item-Objective Congruence (IOC). The validated performance indicators include resource utilization measures, such as transportation and production costs, and outcome metrics, including customer satisfaction and coffee production volume. The performance data for the case study were collected through a questionnaire administered to informants, covering the period from June 2023 to March 2024. The results reveal varying levels of efficiency among the four coffee shops. Coffee Shop A achieved the highest efficiency score (0.947), closely followed by Coffee Shop B (0.941). Coffee Shop C demonstrated moderate inefficiency (0.897), while Coffee Shop D had the lowest score (0.772), indicating substantial room for improvement. Inefficient coffee shops can improve performance by aligning their resource utilization and outputs with the benchmark of efficient coffee shops. These findings highlight specific operational gaps and opportunities for optimization. The study provides actionable recommendations to enhance supply chain practices, contributing to the competitiveness and sustainability of small-scale coffee businesses in an increasingly demanding market.

**Keywords**: Coffee Shop Operations, Data Envelopment Analysis (DEA), Performance Measurement, Supply Chain Efficiency

Received: December 18, 2025; Revised: March 06, 2025; Accepted: March 12, 2025

## 1 INTRODUCTION

Coffee shops have gained significant popularity among younger generations due to their inviting atmosphere and distinctive flavors. In 2018, Thailand hosted approximately 8,025 coffee shops, with an average annual growth rate of 6.2% over the preceding five years. Although Thailand is not ranked among the highest coffee-consuming nations, the average Thai consumer drinks approximately 300 cups of coffee per year, signaling substantial potential for future growth within the industry (Khamsuri, 2022).

The intensifying competition in the coffee shop sector has necessitated that operators adapt by emphasizing differentiation in taste, unique branding, and superior customer service. Supply Chain Management (SCM) plays a pivotal role in this adaptation, serving as a critical process for optimizing production and service efficiency, reducing costs, and mitigating waste. The coffee supply chain is typically categorized into three segments: (1) upstream, encompassing coffee farmers; (2) midstream, involving collectors, processors, and exporters; and (3) downstream, which includes coffee shops and consumers. Effective supply chain management not only reduces production costs but also enhances product quality.

Coffee shops, situated at the final stage of the supply chain, are integral as they maintain the closest interactions with consumers. Understanding and responding to consumer needs are essential for market expansion. To achieve this, coffee shops often implement strategies that emphasize uniqueness, differentiation, and operational efficiency to ensure business sustainability. Coffee shops located near Naresuan University serve as an intriguing case study due to their target customer base, which primarily consists of university students and staff. The shops benefit from their strategic location and competitive pricing but must contend with a highly competitive market, necessitating innovative strategies to attract and retain customers.

This study focuses on assessing the supply chain management efficiency of local coffee shops in the vicinity of Naresuan University, Phitsanulok Province. While supply chain efficiency is crucial for business sustainability, studies on small-scale coffee shops, particularly in Thailand, remain limited, leaving a gap in understanding their operational challenges. The research aims to enhance efficiency and quality in supply chain management practices, ultimately driving business improvements, personnel development, and cost reductions within the coffee industry. The primary objectives include examining current supply chain management practices, developing a framework for performance evaluation, and comparing the efficiency of at least four coffee shops in the study area. The research methodology employs questionnaires and interviews with coffee shop operators to gather relevant data. The anticipated outcomes of this study include a deeper understanding of supply chain management processes within the coffee industry, the identification of key factors influencing efficiency, and insights into operational practices that contribute to enhanced supply chain performance. This study is expected to provide valuable implications for improving competitiveness of local coffee businesses.

## 2 BACKGROUNDS

### 2.1 Coffee shop supply chain efficiency

Supply chain efficiency is a critical factor in the success of coffee shops, particularly in the competitive market where customer expectations for quality, cost, and service are continuously increasing (Roz, 2021). An efficient supply chain ensures that resources, such as raw materials (coffee beans, milk, and other ingredients), labor, and technology, are effectively utilized to deliver high-quality products while minimizing waste and operational costs. The coffee shop supply chain typically involves upstream activities, such as sourcing coffee beans from farmers, midstream processes like roasting, packaging, and distribution, and downstream activities that include serving the end consumer (Rahmadyahningrum et al., 2024). Effective coordination across these stages ensures smooth operations, enhances customer satisfaction, and strengthens the competitiveness of coffee shops in the market. By integrating technologies like inventory management systems, demand forecasting, and supplier collaboration tools, coffee shops can achieve greater supply chain efficiency (Zisimopoulos & Tsoulfas, 2022).

For small, local coffee shops, achieving supply chain efficiency is particularly vital due to their limited resources and high competition (Anand & Grover, 2015; Llivisaca et al., 2020). Streamlining processes, such as procurement, inventory management, and delivery systems, allows coffee shop operators to optimize input usage and reduce unnecessary costs. For instance, maintaining optimal inventory levels prevents stockouts and overstocking, while efficient delivery systems ensure on-time product availability and reduce transportation costs (Shukaili et al., 2023). Coffee shops can further improve their efficiency by analyzing key performance indicators (KPIs), such as delivery time, production costs, and customer satisfaction, to identify bottlenecks and implement targeted improvements (Irjayanti & Azis, 2023).

### 2.2 Content Validity Ratio: CVR

The Content Validity Ratio (CVR), developed by Lawshe (Lawshe, 1975), is a widely utilized statistical method for evaluating the content validity of individual items in an assessment. This approach ensures that each question measures the intended characteristic or construct accurately, thereby improving the overall validity of the instrument. The CVR methodology involves experts reviewing each item to determine whether it is essential for measuring the defined construct. Experts provide their evaluations by assigning a score of +1 if the item is deemed essential and aligns with the defined characteristic, or -1 if it does not. The CVR for each item is then calculated using the formula:

$$\mathrm{CVR} = \frac{n_e - \frac{N}{2}}{\frac{N}{2}}$$

Where:

$n_e$: Number of experts who consider the item essential.

N = Total number of experts participating in the evaluation

The Content Validity Ratio (CVR) score ranges from -1 to +1, with higher positive values reflecting stronger agreement among experts regarding the relevance of an item. According to Lawshe (Lawshe, 1975), a CVR threshold of 50% agreement is generally considered sufficient to establish some degree of content validity. This method has proven to be highly effective in ensuring content validity during the development of assessment tools. Its versatility is evidenced by its widespread application across various research domains, including the validation of social content management frameworks (Ahmad et al., 2017), educational assessment tools Ikhsanudin, 2018 #8}, data integration frameworks (Hassan et al., 2022), employee engagement models (Shrotryia & Dhanda, 2019), and healthcare instruments (Anuar & Sadek,

2018). These studies highlight the adaptability and reliability of the CVR method in assessing content validity across diverse fields and contexts.

### 2.3 Index of Item Objective Congruence: IOC

The Index of Item Objective Congruence (IOC) is a widely used method for evaluating the alignment between assessment content and its intended objectives. This method involves experts assessing the extent to which each question accurately measures the specified objective (Phonphotthanamat, 2022). The evaluation process is essential for ensuring content validity, particularly in research and assessment contexts. While there are no strict guidelines on the minimum number of experts required, it is generally recommended to involve at least three experts, preferably an odd number, to ensure a balanced and comprehensive evaluation. These experts should collectively possess expertise relevant to the content being assessed (Pasunon, 2015).

The IOC process requires experts to rate each question based on the following scale:

- +1: Indicates the expert is confident that the question aligns with the intended objective.
- 0: Indicates uncertainty about the question's alignment with the objective.
- -1: Indicates the expert is confident that the question does not align with the objective.

The IOC score for each question is calculated using the following formula:

$$\text{IOC} = \frac{\sum_{i=1}^{N} R_i}{N}$$

Where:

$R_i$: Scale provided by the *i-th* expert.

$N$: Total number of experts involved in the evaluation.

According to Ronna Turner (Turner & Carlson, 2003), an IOC score of 0.50 or higher is generally considered acceptable for determining the validity of an item, although a score closer to 1.00 indicates stronger alignment. Items with scores below 0.50 are typically excluded or revised to improve their congruence with the intended objectives. This threshold provides a benchmark for researchers to evaluate the quality and validity of their assessment items. This method is a valuable tool for assessing content validity in test development, overall, the method proves to be a crucial tool in test development and validation across various fields, including education, business, and government (Turner & Balkin, 2002)

### 2.4 Data Envelopment Analysis: DEA

Data Envelopment Analysis (DEA) is a widely applied non-parametric method for evaluating the efficiency of decision-making units (DMUs) in performance measurement. DEA assesses relative efficiency by comparing inputs (resources used) and outputs (results achieved) of multiple units operating under similar conditions. Developed by Charnes, Cooper, and Rhodes (Charnes et al., 1978), the method identifies efficient and inefficient units by constructing an efficiency frontier based on best-performing units. DEA does not require pre-specified functional forms, making it particularly effective for handling multiple inputs and outputs in diverse industries. For instance, DEA has been successfully applied to measure efficiency in education (Janmontree et al., 2024), healthcare (Chilingerian & Sherman, 2011), manufacturing, and supply chain systems (Cooper et al., 2011; Patitad; & Watanabe, 2022). In the context of supply chain performance, DEA is used to evaluate operational efficiency by analyzing resource usage, such as labor, production costs, and delivery time, relative to outputs like customer satisfaction and profitability.

DEA's strength lies in its ability to provide insights into performance gaps and improvement opportunities for inefficient units. In the retail and service sectors, such as coffee shops, DEA can identify inefficiencies in supply chain processes by benchmarking units against the most efficient ones. For example, Liang et al. (Liang et al., 2006) applied DEA to measure supply chain performance, demonstrating how inefficient stores could improve operations by optimizing resource allocation and reducing waste. Similarly, DEA has been applied to assess the efficiency of small and medium enterprises (SMEs), helping businesses identify key performance indicators and adopt best practices from more efficient peers (Tone & Tsutsui, 2014). The method's flexibility in handling both quantitative and qualitative data further extends its applicability across industries. In coffee shop operations, DEA also identifies the most efficient coffee shops by constructing an efficiency frontier based on best-performing units and benchmarking other shops against this ideal. Inefficient shops can then analyze their resource utilization and performance gaps to adopt strategies for improvement, such as optimizing labor allocation, reducing waste, or enhancing supply chain processes (Joo et al., 2009). By implementing DEA, coffee shop managers can systematically identify inefficiencies, enhance resource management, and deliver better value to customers, ultimately achieving operational excellence in a competitive market.

## 3 METHODOLOGY

The research methodology, as illustrated in Figure 1, is structured into three main phases: Performance Framework Development, Performance Measurement, and Result Interpretation and Integration. In the first phase, a performance assessment framework was developed by identifying primary indicators using the Balanced Scorecard (BSC) framework, which encompasses four perspectives: Customer, Financial, Internal Processes, and Learning and Growth. A total of 11 relevant indicators were selected and validated for content accuracy and relevance using the Content Validity Ratio (CVR) and the Index of Item-Objective Congruence (IOC), with input from six experts. This process ensured the development of a framework tailored to evaluate the supply chain efficiency of local coffee shops.

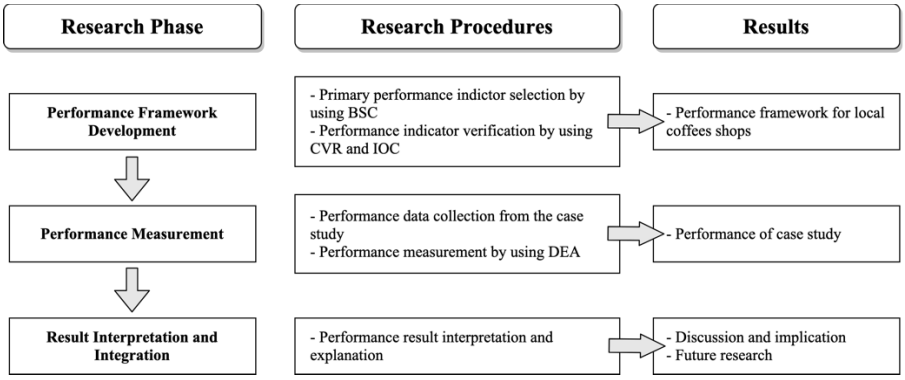


**Figure 1** Research methodology

In the second phase, data were collected from four coffee shops near Naresuan University, selected using purposive sampling, to measure performance. Interviews and questionnaires were conducted with case study informants to gather qualitative and quantitative data on operational efficiency. Data Envelopment Analysis (DEA) was employed to calculate efficiency scores, enabling the identification of resource utilization (inputs) and outcomes (outputs) for each shop. In the third phase, the efficiency results were interpreted to highlight areas for improvement and provide actionable recommendations. The findings were analyzed to discuss their implications for coffee shop operations and propose directions for future research.

## 4 RESULTS AND DISCUSSION

This section covers the analysis of the data. It should include statistics in tables, charts, graphs, or pictures analyzed against hypotheses or in answering the research question(s) in quantitative research, or descriptive analyses of categories in qualitative research. Result is purely descriptive. Discussion describes and interprets the findings, placing them in a bigger context, relating them to other work(s) and issues outlined in the Introduction.

### 4.1 Performance measurement framework

The performance indicators selected for evaluating supply chain efficiency, organized under the four perspectives of the Balanced Scorecard (BSC): Customer, Financial, Internal Processes, and Learning and Growth are shown in **Error! Reference source not found.**. Each indicator is linked to specific m easurements and validation results. Under the Customer perspective, key indicators include on-time delivery rate, measured as the time for production and delivery to customers; order error rate, quantified by the number of errors per month; and customer satisfaction level, assessed through average customer satisfaction scores. These indicators emphasize service quality and customer experience. For the Financial perspective, indicators such as transportation cost, production cost, and store sales focus on profitability and cost efficiency. The Internal Processes perspective evaluates operational aspects such as coffee production volume, store operating hours, and the number of customer visits, reflecting process efficiency. Finally, the Learning and Growth perspective considers the number of technological tools used and employee satisfaction levels, highlighting the importance of innovation and organizational well-being

**Table 1** Performance measurement framework

| Perspective | Indicators | Measurement | CVR | IOC | Type of indicator |
|---|---|---|---|---|---|
| **Customer** | On-time delivery rate | Time for production and delivery to customers (hours) | 1 | 0.67 | Input |
| | Order error rate | Number of errors per month | 1 | 1 | Input |
| | Customer satisfaction level | Average customer satisfaction score | 1 | 1 | Output |
| **Financial** | Transportation cost | Monthly transportation cost | 1 | 0.83 | Input |
| | Production cost | Monthly production cost | 1 | 1 | Input |
| | Store sales | Monthly store sales revenue | 1 | 1 | Input |
| **Internal Processes** | Coffee production volume | Monthly production volume (cups) | 1 | 1 | Output |
| | Store operating hours | Monthly total operating hours | 1 | 1 | Input |
| | Number of customers visiting the store | Monthly total customer visits | 1 | 1 | Output |
| **Learning and Growth** | Number of technological tools | Number of technological tools per unit | 1 | 0.83 | Input |
| | Employee satisfaction level | Average employee satisfaction score | 0.67 | - | - |

Each indicator underwent validation using the Content Validity Ratio (CVR) and the Index of Item-Objective Congruence (IOC). All indicators achieved a CVR of 1.0, demonstrating high relevance, except

for the average employee satisfaction score, which scored below the CVR threshold. According to the CVR threshold reference, indicators must meet or exceed 0.80 to be considered acceptable for further analysis. The IOC values further confirmed their validity, with most indicators scoring 1.0, except for the on-time delivery rate (0.67) and technological tools (0.83), which still met the acceptable threshold.

Based on the validated indicators, inputs and outputs were classified for use in Data Envelopment Analysis (DEA). Inputs include transportation cost, production cost, store operating hours, and the number of technological tools, representing resource utilization. Outputs consist of customer satisfaction level, coffee production volume, and the number of customer visits, reflecting the results achieved from the inputs. This classification ensures a robust framework for evaluating supply chain efficiency by linking resource utilization to performance outcomes effectively. The exclusion of the average employee satisfaction score ensures the model focuses only on highly relevant and valid indicators, enhancing the accuracy and reliability of the analysis.

### 4.2 Coffee shop performance

The efficiency score of the case study is shown in Table 1. Efficiency scores, derived from DEA, quantify how well coffee shops transform inputs into outputs, whereas operational performance, based on collected data, reflects overall business success beyond resource utilization, including factors such as customer satisfaction, revenue, and service quality. Coffee Shop A achieved the highest efficiency score of 0.947, indicating strong operational performance with a small gap of 0.053 from the ideal score of 1.00. Coffee Shop B followed closely with an efficiency score of 0.941, exhibiting a slightly larger gap of 0.059. Coffee Shop C demonstrated moderate inefficiencies with a score of 0.897 and a gap of 0.103 from the ideal. In contrast, Coffee Shop D recorded the lowest efficiency score of 0.772, highlighting significant inefficiencies and the largest gap of 0.228 compared to the ideal benchmark.

**Table 1** Efficiency score

| Coffee shop | Efficiency Score |
|---|---|
| A | 0.947 |
| B | 0.772 |
| C | 0.897 |
| D | 0.941 |
| Ideal | 1.000 |

These findings underscore the differences in operational efficiency among the coffee shops. While Coffee Shops A and B demonstrate relatively high efficiency and require only minor adjustments to achieve optimal performance, Coffee Shop C exhibits moderate inefficiencies, necessitating targeted improvements in resource utilization and supply chain management. Coffee Shop D, with the lowest efficiency score, faces the most substantial challenges and requires a comprehensive review of its operations to address inefficiencies. By systematically addressing these gaps, all coffee shops can improve their efficiency and enhance overall supply chain performance.

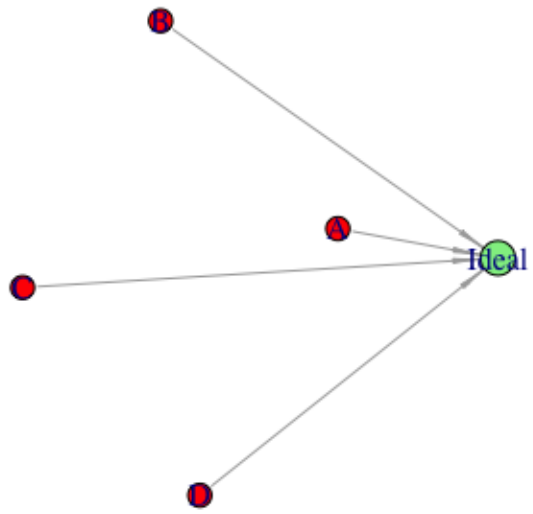


**Figure 2** Case study comparison

Figure 2 illustrates the projection of coffee shops within the efficiency analysis framework. The green circle represents the "Ideal" benchmark, indicating the optimal level of efficiency, while the red circles correspond to coffee shops operating below this standard, signifying inefficiencies in their operations.

To improve performance, inefficient coffee shops can align themselves with the "Ideal" benchmark by adjusting their resource utilization and outputs to closer resemble the levels demonstrated by the efficient standard. For example, coffee shops labeled A, B, C, and D are positioned at varying distances from the ideal efficiency point. Each of these coffee shops can evaluate the gaps in their performance and use the "Ideal" as a reference to make necessary adjustments, enhancing their efficiency and moving closer to the optimal frontier. optimize its performance and bridge the small gap between its current score and the ideal benchmark.

## 5 CONCLUSION

This research underscores the critical role of supply chain efficiency in the operations of small-scale coffee shops, particularly in highly competitive environments. By applying DEA, the study assessed the performance of four coffee shops near Naresuan University, revealing significant disparities in operational efficiency. Coffee Shop A demonstrated the highest efficiency (0.947), reflecting strong operational practices, while Coffee Shop D recorded the lowest efficiency score (0.772), indicating substantial challenges in resource utilization and process optimization. Coffee Shops B and C performed moderately, with scores of 0.941 and 0.897, respectively, and require targeted improvements to reach optimal efficiency.

These results emphasize the need for less efficient coffee shops to adopt best practices from their efficient counterparts, focusing on optimizing resource utilization, reducing operational waste, and enhancing customer satisfaction. While the findings provide actionable insights, the study is limited to a small geographic area and specific performance indicators. Future research should broaden the scope to include more coffee shops, dynamic supply chain factors, and external influences such as digital transformation and sustainability practices. Expanding these areas will deepen the understanding of supply chain efficiency and further support the application of DEA in similar industries.

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