Improving the Order Response Process in Online Mattress Topper Retail with Lean Principles and Business Intelligence

Pornsiri Khumla[1], Chanatip Naka-in[1], Juraporn Jandai[1] and Kamthorn Sarawan[2*]

[1]Department of Logistics Engineering and Transportation Technology, Faculty of Engineering and Industrial Technology, Kalasin University, Kalasin, Thailand
[2]Department of Computer Engineering, Faculty of Engineering and Industrial Technology, Kalasin University, Kalasin, Thailand

*Corresponding Email: kamthorn.sa@ksu.ac.th

Received July 4, 2024, Revised March 22, 2025, Accepted April 29, 2025, Published December 30, 2025

Abstract. *Efficient order response processes and the adoption of information technology are critical for success in the competitive e-commerce market. This research analyzes the order response process of an online mattress topper store by applying Lean principles, particularly the pull strategy and the elimination of waiting waste, alongside the development of a Business Intelligence (BI) system using Power BI dashboards. The objective is to reduce non-value-added (NVA) time and improve operational efficiency. Primary data were collected through workflow analysis and time studies over 12 months. The initial process revealed a 40-minute waiting period as a major non-value-added activity, contributing to a total process time of 162 minutes. By coordinating proactive production with suppliers and leveraging sales insights from Power BI, the waiting time was eliminated, reducing the total process time to 122 minutes and increasing the Value-Added Ratio (VAR) from 40.12% to 53.28%. This study presents a novel integration of Lean methodologies with BI-powered analytics, utilizing the BI system to provide daily sales and inventory insights, enabling proactive inventory management and data-driven decision-making. The findings demonstrate that the synergistic application of Lean principles and BI-driven insights effectively streamlines order fulfillment processes, reduces lead times, and enhances agility and competitiveness in online retail operations.*

Keywords: lean principles, business intelligence, Power BI, process improvement, mattress topper retail

1. Introduction

Technological advancements drive a rapidly evolving business environment, where maintaining a competitive edge requires the ability to respond swiftly and efficiently to consumer demands. In particular, the online retail or e-commerce market in Thailand is expected to grow by 19% in 2023, reflecting consumer trends that favor online shopping [1]. This trend has compelled entrepreneurs across various industries, including the mattress and bedding sector, to continuously expand online marketing platforms to remain competitive.

The mattress and bedding industry in Thailand has experienced continuous expansion, driven by rising demand from households, hospitality businesses, and healthcare facilities. Following a downturn during the COVID-19 pandemic, the market rebounded, reaching 3.1 billion baht in 2023, up from 2.829 billion baht in 2022, with a projected valuation of 3.221 billion baht by 2024 [2]. Consumer preferences for ergonomic sleep solutions, memory foam, latex, and hybrid mattress toppers have fueled this growth [3]. As the industry becomes more competitive, businesses must enhance operational efficiency, improve supply chain coordination, and optimize inventory management to meet fluctuating customer demands effectively.

In the digital marketplace, efficient order response processes are essential for ensuring customer satisfaction and business success. Every stage of the supply chain, from order placement and processing to shipping and customer service, requires seamless coordination and accuracy. Inefficiencies such as delays, stock shortages, and mismanaged inventory can lead to lost sales opportunities and decreased competitiveness [4], [5]. To remain competitive, businesses must adopt advanced operational strategies that streamline workflows, minimize waste, and enhance responsiveness.

Lean methodology identifies and reduces eight types of waste: defects, overproduction, waiting, non-utilized talent, transportation, inventory, motion, and extra processing [6]. One widely adopted methodology for improving operational efficiency is Lean, which focuses on eliminating non-value-added activities, optimizing workflows, and continuously improving processes. Originally developed for manufacturing, Lean has been successfully applied in retail, logistics, healthcare, and technology sectors. A core concept of Lean, the pull strategy, emphasizes aligning production and inventory management with actual customer demand, reducing overproduction, excess inventory, and waiting times [7].

Alongside Lean, Business Intelligence (BI) technologies play a vital role in modern data-driven business operations. BI enables organizations to collect, analyze, and visualize data, providing insights that support strategic decision-making and operational improvements. Power BI, a widely used BI tool, allows businesses to generate interactive dashboards, track sales performance, and enhance inventory planning. By leveraging daily data updates, Power BI helps businesses monitor demand trends, manage stock efficiently, and improve supplier coordination, ultimately enhancing order response efficiency [8], [9].

To effectively enhance order response efficiency in e-commerce operations, businesses must adopt strategies that streamline workflows, optimize inventory management, and improve supply chain coordination. This case study is an online mattress topper retailer that faces challenges in order fulfillment, including delays in supplier coordination, inefficient inventory following, and lack of real-time insights for demand forecasting. These inefficiencies often result in longer lead times, wastes in operations, and reduced customer satisfaction. By integrating Business Intelligence (BI) into the order response process, businesses enable streamlined operations, enhanced efficiency, and minimized waste. This study aims to analyze the order response process of an online mattress topper retailer, applying Lean principles to eliminate inefficiencies and implementing a BI system using Power BI to support data-driven decision-making. Through a comprehensive analysis of the order fulfillment workflow, this research identifies key aspects of inefficiency and opportunities for improvement. The application of Lean methodologies reduces waste and optimizes process efficiency, while the development of a BI-powered system enables daily data analysis and visualization, facilitating proactive decision-making and strategic planning.

2. Theory and Literature Reviews

A. Lean principles

Lean principles involve improving work processes to increase efficiency and eliminate waste in both production and service sectors. The primary objective of Lean is to maximize customer value while minimizing resource usage, ensuring that operations remain cost-effective and highly responsive to demand [10]. By systematically analyzing workflows, Lean methodologies help identify and remove non-value-added activities, thereby improving process performance and overall productivity. These principles have been widely adopted across multiple industries, including manufacturing, services, healthcare, and supply chain management, demonstrating their broad applicability and effectiveness [11].

One of Lean's key principles is to use the push and pull strategy to improve work efficiency. In terms of the pull strategy, it is defined as producing or ordering goods based on actual customer demand [12], [13]. This approach helps reduce inventory levels, as well as the risk of overproduction and excess inventory. Additionally, lean principles focus on reducing eight types of waste: (1) defects, (2) overproduction, (3) waiting, (4) non-utilized talent, (5) transportation, (6) inventory, (7) motion, and (8) extra processing. By addressing these areas, lean aims to streamline processes, enhance productivity, and deliver greater value to customers [6], [14]. Implementing the lean concept within this framework ensures that resources are used efficiently, production is responsive to actual demand, and waste is minimized, adopting a more responsive and cost-effective operation.

The application of Lean principles in supply chain management involves integrating Lean methodologies at every stage, from raw material procurement to final product delivery. By systematically eliminating waste, Lean improves operational efficiency, reduces costs, and optimizes resource utilization. This approach minimizes inefficiencies such as production bottlenecks, transportation delays, and excess inventory storage while simultaneously improving the flow of information and goods through the supply chain. By fostering real-time adaptability to customer demands, Lean enables a more agile, responsive, and cost-effective supply chain.

Various industries have successfully leveraged Lean methodologies to refine their processes. For instance, applying Lean manufacturing combined with the ECRS (Eliminate, Combine, Rearrange, Simplify) framework has significantly enhanced overall equipment effectiveness in plaster mold production [15]. Similarly, a Khanom Jeen fermented flour rice noodles factory verified how Lean principles can streamline production workflows, effectively reducing lead times and increasing output efficiency [16]. Beyond traditional manufacturing, Lean has also proven valuable in digital transformation and education. A study on digital archiving for higher education student projects applied Lean methodologies to transition from paper-based documentation to a fully digital system, meaningfully reducing resource waste and improving accessibility. By automating manual processes, digitizing document management, and optimizing workflow efficiency, the study reinforced Lean’s fundamental goals of waste elimination and resource optimization [17].

In the retail sector, the 5S methodology has been widely embraced by grocery stores, fostering a systematically organized and well-maintained work environment that enhances operational efficiency and minimizes waste [18]. Likewise, in precast concrete manufacturing, the adoption of value stream mapping (VSM) has been involved in identifying inefficiencies, optimizing workflows, and improving warehouse management through a pull-based inventory system that aligns production with actual demand [14].

The extensive success of Lean principles across diverse industries underscores their versatility and enduring relevance. Whether applied in manufacturing, education, logistics, or digital transformation, Lean continues to serve as a basic methodology for sustainable process optimization, efficiency enhancement, and long-term business agility. By reducing production time, increasing equipment efficiency, and improving workplace organization, Lean methodologies contribute to streamlined supply chain operations, greater customer service, and overall cost reductions. These enhancements demonstrate Lean’s adaptability and impact, making it a powerful tool for driving continuous improvement and operational excellence in various sectors.

B. Work Study

Work study, also known as motion-time study, is an analytical technique used to evaluate work processes by measuring the duration of each movement or task. The objectives are to identify inefficiencies, enhance productivity, and minimize wasted effort. This involves recording the time taken to perform each task, deconstructing processes into individual components, and optimizing or eliminating unnecessary time. Two main categories of work study methodologies exist: method study and work measurement. Method study involves the systematic recording and critical examination of existing and proposed work methods to develop and implement more efficient techniques. This approach employs tools such as process charting, flow diagrams, and motion analysis. Conversely, work measurement focuses on establishing the time necessary for a qualified worker to perform a specified job at a defined performance level, utilizing techniques such as time study and predetermined motion time systems. [19], [20]. These methodologies collectively aim to streamline operations, improve efficiency, and enhance overall organizational performance.

Manufacturers extensively use motion-time study to streamline production processes and improve efficiency. For instance, a study on the manufacturing process of charcoal stoves demonstrated the effectiveness of work study in reducing production time and increasing efficiency in an assembly line [21]. Similarly, applications of workflow process study and information technology in small businesses in Thailand (SMEs) have shown significant improvements in operations to optimize inventory management [22].

Additionally, applications of lean management, such as process mapping and work study, in cancer healthcare hospital have shown significant improvements in patient flow processes in the outpatient department [23]. A study of pharmaceutical distributor processes utilized value stream mapping and motion-time analysis to scrutinize the workflows of an inventory control department and sub-unit departments within the pharmacy department's operations. This allowed for the identification of time-saving opportunities and increased overall hospital efficiency [24]. Therefore, work study applications in the healthcare sector have shown significant improvements in workflow processes.

In the garment production industry, integration of lean and work-study can be applied to assembly operation productivity improvement. The process of identifying and removing non-value-adding operations in a continuous, systematic improvement process is known as lean manufacturing [25]. While work study methods concentrate on the crucial aspects of the operation, lean techniques offer a comprehensive perspective of the operation, resulting in reduced time and costs [26].

Overall, the application of work study in various fields has consistently demonstrated its value in improving efficiency and productivity. By systematically analyzing work processes and identifying areas for improvement, businesses can achieve significant time and cost savings while enhancing the quality of their products and services.

C. Business Intelligence

Business intelligence (BI) involves using tools and techniques to transform raw data into actionable information for business analysis, supporting better decision-making, and improving organizational performance. BI encompasses processes, technologies, and methodologies to collect, integrate, analyze, and present business data. Tools such as dashboards, data visualization, reporting, and data mining enable real-time monitoring of operations, identification of trends, and insights into performance. BI provides historical, current, and predictive views of business operations, helping organizations understand past performance, identify trends, and respond immediately to operational issues and opportunities [27], [28].

The integration of BI with other business processes, such as e-commerce, supply chain management, and management support, can significantly enhance efficiency and effectiveness. For example, BI can leverage the comprehensive integration of information techniques to obtain real-time insights in the field of e-commerce [29]. In supply chain management, BI tools can enhance operational efficiency and decision-making capacities by providing information to firms that aim to efficiently navigate the complexity of integrating data-driven technology [30]. Furthermore, the development of Microsoft Excel and Power BI integrated production scheduling systems for micro, small, and medium enterprises (MSMEs) support predictive analytics for ideal inventory levels, resource needs, and supply chain risks, in addition to managing operations [31].

Additionally, adopting various business processes enables organizations to achieve real-time insights, improve operational efficiency, and make informed decisions. By integrating BI tools, companies can effectively manage and optimize their e-commerce platforms, streamline supply chain operations, improve processes, and enhance overall management support, leading to a competitive advantage and preferential organizational performance.

The implementation of Lean concepts, work study, and business intelligence (BI) fulfills unique, thus far synergistic functions in process optimization. Lean largely emphasizes waste reduction and enhancement of process efficiency, whereas work study examines operations to optimize processes and reduce delays. At the same time, BI technologies facilitate data-driven decision-making by offering insights into sales patterns and inventory control. The amalgamation of these theories seeks to create a more efficient, responsive, and data-driven order fulfillment system.

3. Methodology

A. Data Collection

This study focuses on analyzing and improving the order response process. The scope covered the manufacturer, online retailer, shipper, and customers. The data collection phase involved gathering detailed information about the order response process at the selected online mattress topper store.

Primary data was collected through direct observation and work study principles, accurately recording the time required for each activity within the process. The direct time measurement method was employed, where each task with a duration of at least 2 minutes was timed five times, and the average was calculated to ensure reliability and consistency.

Additionally, secondary data was sourced from the retailer’s sales records and customer order histories, which were collected for 12 months from September 2022 to August 2023. This case study is directed at an online retailer that sells toppers through the platform. This retail location in Kalasin province's Thailand provides products, specifically toppers, in three different sizes: 3.5 feet, 5 feet, and 6 feet. The products are categorized based on their design.

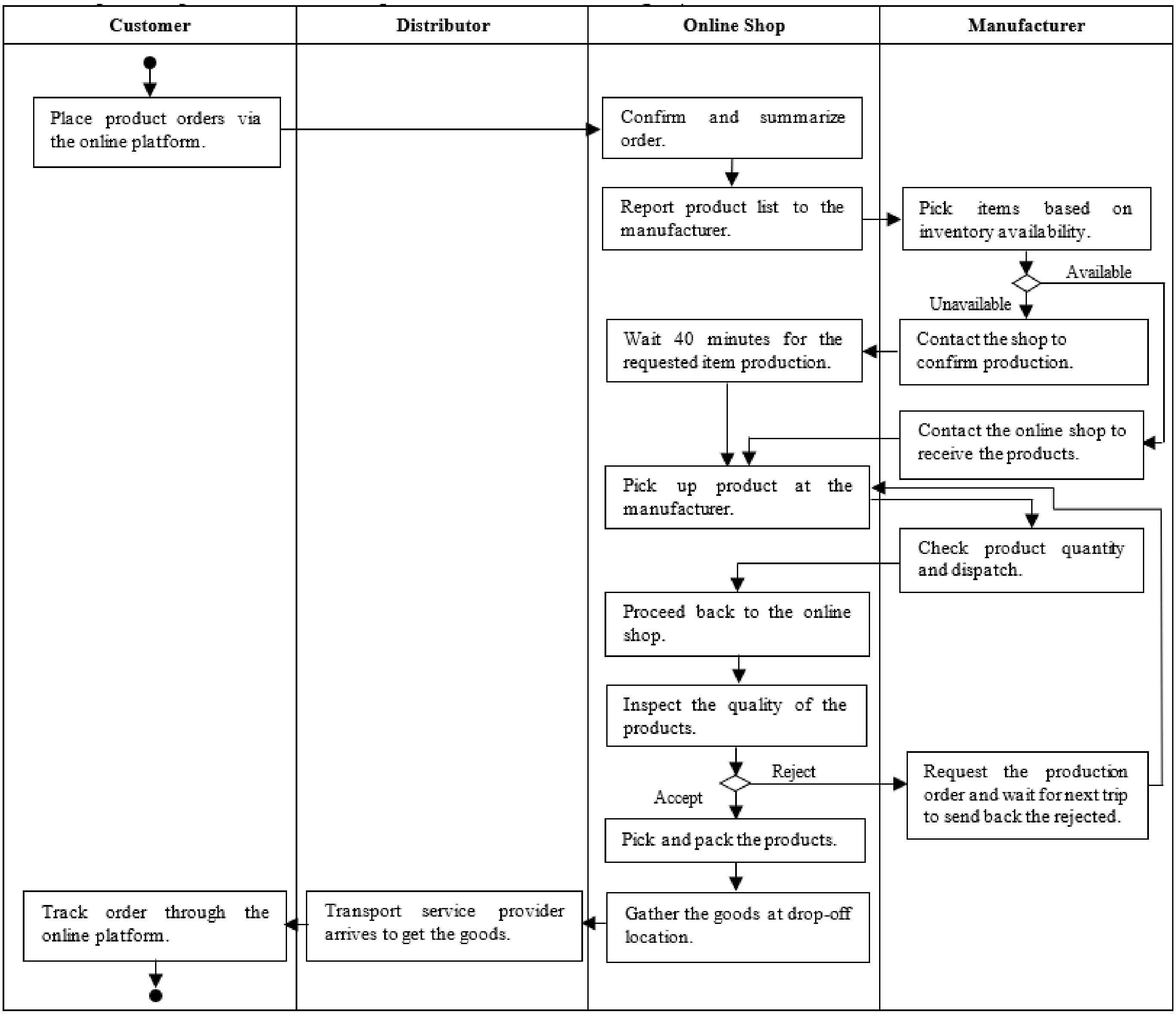

Figure 1. Process diagram of the online ordering process as a case study.

B. Process Workflow Analysis

Workflow process analysis involves evaluating the existing processes to pinpoint inefficiencies as well as possibilities for improvement. This study extensively defined the online mattress topper store's workflow process, methodically outlining each step from order placement to final delivery to visually represent the process.

Figure 1 demonstrated the process for responding to online product orders, as follows: Initiate the procedure for responding to orders from consumers who have chosen their preferred mattress through the online platform. Subsequently, the online shopping retailer awaits orders for 24 hours and then verifies them on a daily basis at 1:30 p.m. The online store gathers and summarizes all the orders made by customers. After that, the online retailer is required to contact the manufacturer to verify the availability of the products that the buyer has requested. If a product is available, the online store has the capability to retrieve it. If a product is unavailable, which happens often, the online store will promptly initiate a manufacturing request. Because the retailer follows a zero-stock policy, unavailability often triggers a 40-minute production wait. After picking the full quantity of the ordered products, the manufacturer will reach out to the store to coordinate their retrieval. The store confirms the quantity and dispatches the products, returning them to the online retailer for packaging. Prior to packaging, the products must pass a quality inspection. The online store will proceed with packaging the goods once they have undergone inspection and acceptance. However, if the store identifies a defective product, it will initiate a claim process with the manufacturer, which happens very rarely, and postpone the consumer's delivery until the next cycle. Once the packing process is complete, collect all the merchandise at the designated location and wait for the transportation operator to arrive to retrieve the products. Customers can track their shipment's progress when the carrier arrives from the distribution center and uploads the information into the system.

The online topper store operates as a trading business, acting as an intermediary between producers and consumers. It follows a zero-stock policy, meaning products are sourced from manufacturers only after receiving customer orders, effectively making it a partial make-to-order (MTO) system from the retailer's perspective. However, the manufacturers operate on a make-to-stock (MTS) model, producing inventory based on anticipated demand.

This mismatch can lead to stockouts, particularly for popular toppers. When a product is unavailable, the retailer must wait for the manufacturer to produce it, causing a 40-minute delay and adding non-value-added time to the order response process, reducing overall efficiency.

C. Activity Value Analysis

Understanding the activities that generate losses or present process-related challenges is an important stage in applying the lean principles to the classification of work, activities, processes, or information connections to minimize time and continually improve. The process of identifying actions is divided into 3 separate activities:

(1) Value-added activities (value added: VA) are tasks that directly contribute to transforming a product or service in a way that meets customer expectations and for which the customer is willing to pay. In the context of online retail operations, these include essential actions such as processing customer orders, inspecting product quality, and packaging goods for delivery.

(2) Activities that are required but do not contribute value (necessary but non-value-added: NNVA) are tasks that, while not directly adding value for the customer, are essential for maintaining the current process due to regulatory needs, quality assurance, or system limitations. In the context of online mattress topper retail, such activities include order verification, communication with the manufacturer, and product transportation between parties.

(3) Non-value-added activities (NVA) are actions that do not contribute to the overall value of a process or activity. These activities are considered pure waste from a Lean perspective, as they consume time, resources, or space without adding any benefit to the customer and should be eliminated or minimized whenever possible.

To improve the efficiency of the online ordering workflow, waste and non-value-added operations should be eliminated from the process. For identifying waste, activity value analysis is a procedure that involves identifying, quantifying, eliminating, and avoiding waste. This analysis provided actionable insights into how the store could streamline its order response process, reduce lead times, and enhance overall productivity.

Activity value analysis employs the value-added ratio (VAR) as a significant statistic. The VAR measures the ratio of time allocated to value-added activities compared to the overall process time [25]. The calculation is performed using the formula:

$$VAR = \frac{Value\ Added\ Time}{Total\ Process\ Time} \times 100 \quad (1)$$

By calculating the VAR, organizations can assess the efficiency of their processes and identify opportunities for improvement. A higher VAR indicates a greater proportion of time spent on activities that add value from the customer's perspective, while a lower VAR indicates that there is much potential for improvement by minimizing non-value-added activities and optimizing necessary non-value-added activities.

Furthermore, once these non-value-added (NVA) activities are identified through the value-added ratio (VAR) and activity value analysis, the next step is to devise targeted solutions that minimize or eliminate them. In particular, the retailer can proactively communicate with the manufacturer to prepare products in advance while maintaining a pull strategy, ensuring that top-selling items are readily available and reducing waiting time. Instead of real-time sales reports, the retailer utilizes daily updated sales insights from Power BI, which enables demand forecasting based on the most recent sales trends. By analyzing these daily sales data updates, the retailer can identify popular products early, anticipate fluctuations in demand, and adjust production planning accordingly.

D. Framework for Business Intelligence in Online Retail

This research applies business intelligence principles to address problems and enhance efficiency. The designed and presented business intelligence system framework is illustrated in Figure 2.

The initial phase, data source, involves acquiring data from a marketplace store. It is crucial to gather comprehensive and relevant data to ensure the subsequent steps are built on a solid foundation. The primary aim is to collect raw data that encapsulates various facets of online shopping activities, serving as the input for the entire BI process. Data can be sourced from various marketplace stores and includes customer transactions, product details, sales records, and potentially other auxiliary data that can influence shopping behavior.

In the data cleaning phase, the raw data acquired in the previous step is cleaned and transformed into a structured format. This step is essential to address any inconsistencies, inaccuracies, and missing values in the dataset. The goal is to ensure the data is accurate, complete, and ready for analysis, involving processes such as removing duplicates, correcting errors, and standardizing data formats. Various data preprocessing techniques and tools are utilized in this phase to ensure the dataset is reliable and suitable for analysis.

The data analysis and visualization steps involve applying business intelligence techniques to derive insights from the cleaned data. Power BI, a powerful data visualization tool, is highlighted for creating interactive dashboards and reports. The primary aim is to uncover patterns, trends, and relationships within the data that can provide valuable insights into online shopping behaviors.

The final step, decision-making, involves using the insights derived from the analysis and visualization phases to support strategic planning. These insights are translated into actionable strategies that enhance online shopping experiences, optimize operations, and drive business growth. A key component of this phase is the use of geographic map visualizations, which provide a clear, intuitive view of regional sales performance. By identifying high- and low-performing areas at a glance, managers can allocate marketing budgets more effectively, tailor regional promotions. This spatial awareness enhances the quality of decision-making by enabling data-driven, location-specific strategies that improve business outcomes, increase customer satisfaction, and reduce operational costs.

To ensure the effectiveness of business intelligence implementation, the data update frequency is set to daily (day-end update). This approach ensures that the BI system provides up-to-date insights based on the most recent sales and order data. By updating at the end of each business day, the system minimizes processing disruptions while maintaining accurate and relevant information for decision-making.

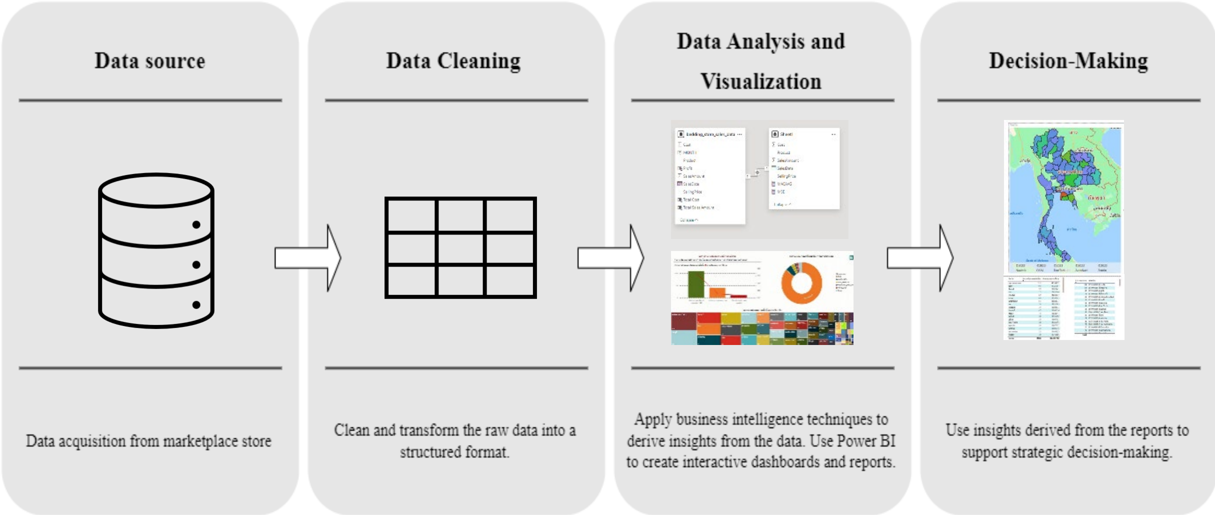

Figure 2. The business intelligence framework used in research.

Table 1 Analysis of the value, waste, and time of activities in fulfilling the online mattress topper order process

No.	Activity	Avg. Time (Min.)	Value of Activity	Type of Waste
1	The online store verifies and summarizes customer orders.	3	NNVA	Extra Processing
2	Transmit a product list to the manufacturer.	2	NNVA	Extra Processing
3	Wait for the manufacturer to pick items based on inventory availability.	10	NVA	Waiting
4	Wait for the production of unavailable items after receiving a request to confirm the production order (if out of stock).	40	NVA	Waiting
5	Receive a notification from the manufacturer to collect the products.	2	NNVA	Extra Processing
6	Pick up the products at the manufacturer.	15	NNVA	Transportation
7	Check the quantity of products and collects them.	5	NNVA	Extra Processing
8	Return to the store with the collected products.	15	NNVA	Transportation
9	Inspect the products and proceed with packaging.	65	VA	-
10	Gather goods for the transportation service provider at the delivery point.	5	NNVA	Transportation
	Value-Added Activities (VA) Time	65 min.	(40.12 %)	
	Non-Value-Added Activities (NVA) Time	50 min.	(30.87 %)	
	Necessary-Non-Value-Added Activities (NNVA) Time	47 min.	(29.01 %)	
	Total Time	**162 min.**		

4. Results and Discussion

A. Activity Value Analysis to Reduce Waste

In this case study, the business operation entails procuring products from mattress topper producers in community enterprises and distributing goods through internet-based platforms. However, the store in the case study employs a zero-stock inventory policy, whereby it acquires products directly from manufacturers for packs and delivers them to customers. This implies that the store applies a pull strategy to products based on client demand, instead of stockpiling large quantities in advance.

The analysis focuses on the current order procedure's fulfillment process. Researchers offered a comprehensive analysis from the perspective of the online retailer, focusing on identifying wasteful activities as well as actions that add value, operations that do not add value, and activities that are necessary but do not add value. In addition, the time required for each stage of completing an online order is represented in Table 1.

The waste analysis technique is applied to identify the waste produced through the process and evaluate the value produced by each activity. The results of the research classified three types of activities as follows (1) VAaccounted for 40.12%, with a total time of 65 minutes, (2)) accounted for 30.87%, totaling 50 minutes, and (3) NNVA made up 29.01%, with a total time of 47 minutes. This breakdown highlights that although VA activities contribute directly to customer value, a significant portion of the process time is still consumed by NVA and NNVA, indicating opportunities for improvement through waste elimination and process optimization.

An in-depth analysis of Necessary Non-Value-Added (NNVA) activities indicates that certain process stages, although not directly contributing value, are crucial for the fulfillment of orders. Especially, awaiting the manufacturer's order pick according to inventory availability (activity no. 3) requires a waiting period of 10 minutes. Although this step does not transform the product or enhance its value to the customer, it remains necessary to ensure accurate order-picking before fulfilling the order. Within the existing supply chain framework, this step cannot be entirely eliminated but can be optimized to minimize delays.

Similarly, activities such as quality checks, transportation between the manufacturer and retailer, and order verification fall under NNVA. While these steps do not contribute directly to product enhancement, they are required for operational efficiency, regulatory compliance, or ensuring order accuracy. Streamlining these processes through better coordination and data-driven insights from Power BI can reduce redundant handling and shorten lead times.

Conversely, waiting for the production of unavailable items (activity no. 4) represents a 40-minute delay when an item is out of stock and requires production. Unlike activity no. 3, this waiting period presents a clearer opportunity for waste reduction. By implementing Lean methodologies and BI-driven demand forecasting, this study aims to minimize or eliminate the 40-minute waiting period through improved production planning and proactive coordination between the retailer and manufacturer.

As a result, the researchers proposed methods for reducing inefficiencies by leveraging a business intelligence system to analyze sales data and identify top-selling products. By providing daily-updated sales insights, the system enables the retailer to anticipate demand fluctuations, communicate with manufacturers in advance, and encourage limited make-to-stock production for high-demand items. This approach optimizes inventory management, reduces waiting time, and fosters data-driven decision-making through BI-powered dashboards.

B. Data Analysis using Business Intelligence Tools

The implementation of Power BI, a business intelligence tool in this case study, supports online store owners through the development of business intelligence tools. The system processes sales transaction data collected from the retailer's order management system and updates insights at the end of each business day. This update frequency ensures that decisions are based on the most recent sales data without causing real-time system disruptions.

The inclusion of data tables, diagrams, or charts allows for a clear visualization of data comparisons, facilitating the identification of disparities. Business intelligence enables users to access and utilize structured business data in a visual and interactive format. The dashboard reports are designed to support sales forecasting, payment trend analysis, and regional sales distribution insights, allowing decision-makers to proactively adjust business strategies.

Figure 3 represents a dashboard that presents the results of the data collection analysis as a comprehensive overview of all the data. The report dashboard presents an overview of order numbers, payment methods, and ordering activities in each province. The analysis provides the following results:

- The bar graph indicates the sales volume of three product types: 6 feet, 5 feet, and 3.5 feet. It also displays the average price for each product type. For example, the 6-foot size has the highest sales, with a total of 1,098 units sold. The 5-foot size facilitates the sale of 406 units. The 3.5-foot size can sell 104 items.
- The pie chart displays the aggregate amount paid using six alternative payment methods: (1) COD; (2) Mixed Card; (3) TMN Express; (4) Kasikorn Bank Vasa; (5) Pay Later; and (6) Others. Clients most frequently choose cash on delivery (COD).
- The table dashboard displays the order results for each province, including the quantity of products sold in each province. Each channel's scale corresponds to the number of product orders. For instance, Bangkok shows a high volume of product sales, indicating that Bangkok's channels are more extensive compared to other provinces.
- A map of Thailand displays each province color-coded according to its respective sales volume. Warm colors indicate most sales, while coolly colored areas indicate low sales.

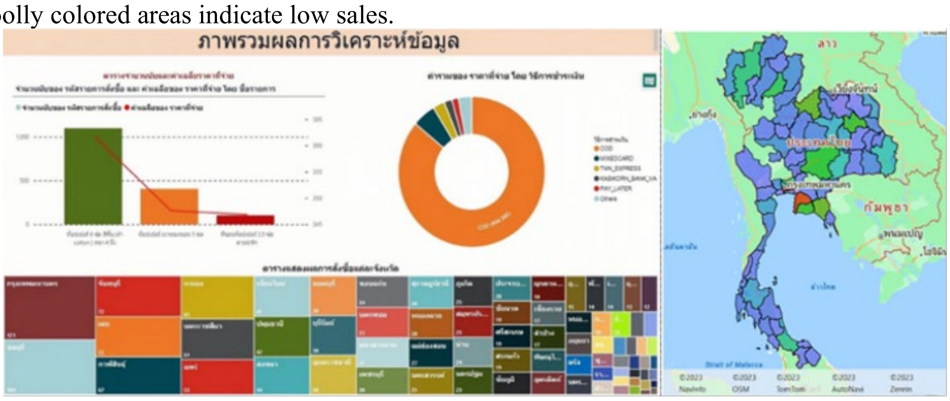

Figure 3. The system displays analytical reports in the form of a dashboard.

Other than providing a summary of data analysis outcomes as illustrated in the dashboard, a map-based dashboard is also developed to display the sales volume in different regions. Information influences advertising executives' decisions to enhance product promotion and boost market sales. To provide a brief and explicit representation of the state of sales in each province, we generate a dashboard report in the form of a color map, as shown in the right of Figure 3.

Data is analyzed by Power BI, such as product sales volume in different regions, the volume of each individual product, and the payment methods clients use through various channels. It presents an overview of the data in the form of a dashboard, which is simple to present and demonstrate comprehensive outcomes, thereby facilitating more informed decision-making for businesses.

C. Discussion

The analysis results indicate that waiting is a major source of waste in the operational process of the online store, primarily occurring when manufacturers fail to deliver requested products on time. As shown in Table 2, product manufacturing can take up to 40 minutes, accounting for approximately 24.19% of the total operational time. Performance was measured by comparing the time before and after the process improvement. Before the implementation of the dashboard, there was no historical sales data available, making it impossible to forecast best-selling products in advance. As a result, production orders had to wait until customer orders were received, causing NVA time. After implementing the dashboard, sales data became available, enabling the team to identify best-selling products in advance and send production orders to suppliers earlier. This significantly reduced the waiting time for production to 0 minutes. A comparison of the before and after scenarios clearly demonstrates that eliminating non-value-added (NVA) waiting time significantly reduced the total process time from 162 minutes to 122 minutes. Consequently, the Value-Added Ratio (VAR) increased from 40.12% to 53.28%.

Table 2 Summary of comparison

Index	Before	After	Change Summary
VA Time	65 min.	65 min.	—
NVA Time	50 min.	10 min.	- 40 min
NNVA Time	47 min.	47 min.	—
Total Process Time	162 min.	122 min.	- 40 min
Value Added Ratio (VAR)	40.12%	53.28%	+13.16%

This time reduction highlights the effectiveness of Lean principles in identifying and eliminating inefficiencies. The fact that VA time (65 minutes) remained unchanged suggests that the primary improvement stemmed from reducing waiting time within the process. These findings confirm that targeting wasteful activities, especially production-related waiting, can profoundly enhance operational efficiency, enabling retailers to respond to customer demands more rapidly.

Despite these improvements, a key operational challenge remains: the misalignment between the retailer's inventory policy and the manufacturer's production approach. The online store follows a zero-stock policy, a semi make-to-order model where products are manufactured based on customer orders. However, for high-demand items, the retailer encourages manufacturers to prepare stock in advance, adopting a limited make-to-stock strategy for top-selling products. This hybrid approach helps balance inventory efficiency while mitigating long lead times.

To improve process efficiency and support data-driven decision-making, a Business Intelligence (BI) system with day-end update was implemented using Power BI. Instead of real-time updates, the system consolidates and processes sales and order data at the end of each business day. This approach ensures that insights remain current while minimizing potential disruptions to system performance. By leveraging daily updated sales data, the retailer can monitor demand trends, proactively communicate with manufacturers, and mitigate stockout risks without the need for constant data streaming. However, one of the key challenges of using Power BI is its lack of real-time data processing, which may not be suitable for businesses requiring immediate insights. Additionally, the free version has limitations in handling large datasets, making it less ideal for large-scale enterprises.

Comparing these findings with related research highlights how the integration of Lean techniques and BI tools can significantly improve operational efficiency across various industries. Studies in healthcare [23], [24], education [17], and manufacturing [22], [25], [26] have shown that combining data-driven decision-making with Lean waste reduction strategies can substantially reduce process times. However, applying this approach to online mattress topper retail presents a unique challenge due to the retailer's Zero-Stock Policy, which follows a semi-make-to-order model, while the manufacturer adopts a make-to-stock approach for high-demand products. This inventory misalignment underscores the critical role of BI-driven demand forecasting, even with daily data updates, in preventing stockouts and improving order fulfillment efficiency.

In addition to decreasing waiting time, the integration of Lean and BI enabled the retailer to optimize inventory planning. Before BI implementation, frequent stockouts of top-selling mattress toppers caused delays and lost sales opportunities. With daily sales data analysis, the retailer could proactively coordinate with manufacturers, allowing for more accurate production scheduling and inventory replenishment, ensuring consistent product availability.

5. Conclusions

This study analyzed and improved the order fulfillment process of an online mattress topper retailer using Lean principles and Business Intelligence (BI) tools. By systematically identifying and eliminating non-value-added activities (NVA), the Value-Added Ratio (VAR) increased from 40.12% to 53.28%, reflecting a greater focus on value-adding activities. The elimination of 40 minutes of waiting time significantly improved process efficiency, reducing the total process time from 162 minutes to 122 minutes. This substantial enhancement in workflow is critical for meeting consumer demands in a competitive online retail environment.

To enhance operational decision-making, a business intelligence system was implemented using Power BI. The system provides structured insights through four key data dimensions: (1) sales volume per product, (2) payment methods across different channels, (3) sales distribution by province, and (4) overall sales performance. By leveraging daily sales data updates, the retailer can proactively identify top-selling products, communicate with manufacturers in advance, and mitigate potential stockout risks. This approach balances inventory efficiency while avoiding unnecessary overproduction.

The findings reinforce the synergistic benefits of combining Lean methodologies with BI-driven insights, demonstrating how structured data analytics can streamline operations, reduce process inefficiencies, and improve responsiveness to customer demand. Future research could explore the use of predictive analytics to enhance demand forecasting and optimize make-to-stock strategies for high-demand products. The integration of machine learning models could also refine stock-level recommendations and reduce dependency on manual inventory planning.

Overall, this research highlights the importance of continuous process improvement and data-driven decision-making in optimizing e-commerce operations. By adopting Lean principles and leveraging BI insights, online retailers can significantly enhance order response times, improve supply chain efficiency, and strengthen their competitive advantage in the rapidly evolving digital marketplace.

References

[1] "E-commerce remains robust, maintaining its top position in the Thai business arena," *Department of Business Development, Thailand*. Available: https://www.dbd.go.th/news/176161266. Accessed: Jan. 30, 2024.

[2] "Because we sleep well, the mattress and bedding market continues to grow," *Marketeer Online.* Available: https://marketeeronline.co/archives/338398. Accessed: Apr. 11, 2024.

[3] " Four types of mattress toppers," *Patexstore.com*. Available: https://patexstore.com/content/4 - type-topper/. Accessed: Mar. 20, 2025.

[4] P. Ugochukwu, J. Engström, and J. Langstrand, "Lean in the supply chain: a literature review," *Management and production engineering review* , vol. 3, no. 4, pp. 87-96, 2012.

[5] R. Čiarnienė, and M. Vienažindienė, "Lean manufacturing: theory and practice, " *Economics and management,* vol. 17, no. 2, pp. 726-732, Apr. 2012, doi: 10.5755/j01.em.17.2.2205

[6] J. K. Kavota, L. Cassivi, and P. M. Léger, "A systematic review of strategic supply chain challenges and teaching strategies," Logistics, vol. 8, no. 1, pp. 1-19, Feb. 2024, doi: 10.3390/logistics 8010019

[7] P. C. Hong, , D. D. Dobrzykowski, and M.A. Vonderembse, "Integration of supply chain IT and lean practices for mass customization: Benchmarking of product and service focused manufacturers," *Benchmarking: an international journal*, vol. 17, no. 4, pp. 561-592 , Jun. 2010, doi: 10.1108/14635771011060594

[8] C. D. Arconte, "Business intelligence applied in small size for profit companies," *Procedia computer science*, vol. 131, pp. 45-57, 2018, doi: 10.1016/j.procs.2018.04.184

[9] A. Ferrari and M. Russo, *Introducing Microsoft Power BI*. Redmond, WA, USA: Microsoft Press, 2016.

[10] G. Shaman, and S. K. Jain, "A literature review of lean manufacturing," *International Journal of Management Science and Engineering Management,* vol. 8, no .4, pp. 241-249. Nov. 2013, doi:10.1080/17509653.2013.825074

[11] M. Rossini, A. Ahmadi, A. P.Staudacher, "Integration of lean supply chain and industry 4.0," *Procedia Computer Science*, vol. 232, pp. 1673-1682, 2024, doi: 10.1016/j.procs. 2024.01.165

[12] P.M. Madhani, "Strategic supply chain management for enhancing competitive advantages: developing business value added framework," *International Journal of Value Chain Management*, 2019, vol. 10, no. 4, pp. 316–338, Oct. 2019, doi: 10.1504/IJVCM.2019.103270

[13] J. Reyes, J. Mula, and M. Diaz-Madroñero, "Quantitative insights into the integrated push and pull production problem for lean supply chain planning 4.0," *International Journal of Production Research*, pp. 1–25, Feb. 2024, doi: 10.1080/00207543.2024.23122 05

[14] P. Chaitien, and S. Ramingwong, "Enhancing warehouse management efficiency for precast concrete product business", *Science & Technology Asia*, vol. 29, no. 2, pp. 19–31, Jun. 2024.

[15] N. Sriputtha, "Improving overall equipment effectiveness of the plaster mold process using lean manufacturing principles," *Engineering Access*, vol. 9, no. 2, pp. 133–139, Nov. 2023, doi: 10.14456/mijet.2023.17

[16] G. Jirasirilerd, and N. Ponsri, "Application of lean manufacturing system to reduce production time: a case study of Khanom Jeen fermented flour rice noodles factory," *Thai Industrial Engineering Network Journa*l, vol. 9, no. 1, pp. 21–28, Jun. 2023.

[17] K. Sarawan, R. Khalwipat, W. Daengkasai, and P. Khumla, "Implementing lean principles for digital archiving of student projects: A case study in higher education", *Sustainable Engineering and Innovation*, vol. 7, no. 1, pp. 51-64, Feb. 2025.

[18] K. L Nada, , M. D. Idawicaksakti, and P. P. Suryadhini, "Application of the 5S method to minimize waiting waste at the yanti shop, brebes regency." *Jurnal Teknik Industri: Jurnal Hasil Penelitian dan Karya Ilmiah dalam Bidang Teknik Industri*, vol. 10, no. 1, 2024.

[19] R. M. Barnes, Motion and time study: design and measurement of work. *John Wiley & Sons*, 1991.

[20] W. Richirawanit. Work Study Principles and Case studies. Bangkok: *Chulalongkorn University Press*, 2002.

[21] P. Khumla, A. Kanloed, P, Panrasamee, and K. Sarawan, "Productivity improvement in production process of charcoal stove case study: charcoal stove manufacturing in Kalasin," *Journal of Engineering and Innovation,* vol. 14, no. 3, pp. 1-9, Dec. 2021, [Online]. Available: https://ph02.tci-thaijo.org/index.php/eng_ubu/article/view/240311

[22] P. Khumla and K. Sarawan, "Improving material requirements planning through web-based: a case study Thailand SMEs," *Applied Computer Science.*, vol. 19, no. 4, pp. 39–50, Dec. 2023, doi: 10.35784/acs-2023-34.

[23] R. Muhammad and N. N. Fahira. "Leveraging lean management to improve patient flow in the outpatient department: a case study in cancer healthcare Santosa Hospital Bandung Kopo (SHBK)." *Jurnal Ekonomi Manajemen Bisnis*, vol. 5, no . 1, Jan. 2024, pp. 99-112, doi: 10.37366/ekomabis.v5i01.1239

[24] K. Jitthananan, N. Kessomboon, N. Natsathaporn. "An application of value stream mapping for the improvement of pharmaceutical distributor process at Borabue Hospital, Mahasarakham Province," *Isan Journal of Pharmaceutical Sciences.* vol. 13, no. 4, pp. 50-62, Dec. 2017, doi: 10.14456/ijps.2017.26

[25] M. Ewnetu, and Y. Gzate, "Assembly operation productivity improvement for garment production industry through the integration of lean and work-study, a case study on Bahir Dar textile share company in garment, Bahir Dar, Ethiopia," *Heliyon*, vol. 9, no. 7, Jul. 2023, doi: 10.1016/j.heliyon.2023.e17917.

[26] Y. Buranasing, and J. Choomlucksana, “Lean and work-study: analysis & integration in an outbound logistics,” *Journal of Engineering and science research*, vol. 2, no. 2, pp. 17-25, 2018.

[27] T. Gunadham, “A Study of Business Intelligence Tools from Users’ Perspectives,” *Interdisciplinary Research Review*, vol. 18, no. 3, Jun. 2023.

[28] A. O. Adewusi, U. I. Okoli, E. Adaga, T. Olorunsogo, O. F. Asuzu, and D. O. Daraojimba. “Business intelligence in the era of big data: a review of analytical tools and competitive advantage,” *Computer Science & IT Research Journal*, vol. 5, no. 2, Feb. 2024, pp. 415-431, doi: 10.51594/csitrj.v5i2.791.

[29] O. B. Seyi-Lande, E. Johnson, G. S. Adeleke, C. P Amajuoyi, and, B. D. Simpson, “Enhancing business intelligence in e-commerce: Utilizing advanced data integration for real-time insights,” *International Journal of Management & Entrepreneurship Research*, vol. 6, no. 6, pp. 1936-1953, 2024, doi: 10.51594/ijmer.v6i6.1207

[30] N. Ashal, and A. Morshed. “Balancing data-driven insights and human judgment in supply chain management: The role of business intelligence, big data analytics, and artificial intelligence,” *Journal of infrastructure policy and development*, vol. 8, no. 6, pp. 1-17, Jun. 2024, doi: 10.24294/jipd.v8i6.3941

[31] P. S. Patil, S. S. Patil, S. M. Patil, and M. R. Dhanvijay, “Development of MS Excel and Power BI Integrated Production Scheduling System for an MSME,” *Engineering Access*, vol. 10, no. 2, pp. 124–142, Jun. 2024, doi: 10.14456/mijet.2024.15