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Enhancing Operational Efficiency In Cross-docking Warehouses Through Value Stream Mapping

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value stream mapping,
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ABSTRACT

This study aims to identify waste and analyze process improvements in the sorting area of a cross-docking warehouse at PT X, a logistics service company. The research applies the Value Stream Mapping (VSM) method as a tool within lean management to evaluate operational processes and identify activities that do not provide added value. Data were collected through direct observation of sorting activities, documentation of operational processes, and analysis of process duration within the warehouse. The results show that several operational activities still contain waste, particularly waiting time caused by delays in goods arrival and inefficiencies in sorting operations due to limited sorting space. The current state map indicates that the average sorting duration reaches 199 minutes per sorting code. After implementing improvements such as sorting area reorganization, establishing Key Performance Indicators (KPI), and optimizing labor allocation, the proposed future state map reduces the average sorting duration to 85.25 minutes per sorting code. The findings indicate that implementing Value Stream Mapping can significantly improve operational efficiency in cross-docking warehouse processes by reducing non-value-added activities and optimizing workflow.

Kata Kunci:

value stream mapping,
cross docking warehouse,
lean management,
sorting process,
waste

ABSTRAK

Penelitian ini bertujuan untuk mengidentifikasi pemborosan (waste) serta merancang perbaikan proses operasional pada area sortir gudang cross docking di PT X, sebuah perusahaan jasa logistik. Penelitian ini menggunakan metode Value Stream Mapping (VSM) sebagai salah satu alat dalam pendekatan lean management untuk menganalisis alur proses operasional dan mengidentifikasi aktivitas yang tidak memberikan nilai tambah. Data penelitian diperoleh melalui observasi langsung terhadap aktivitas sortir, dokumentasi proses operasional, serta analisis durasi proses pada gudang. Hasil penelitian menunjukkan bahwa masih terdapat beberapa aktivitas yang mengandung pemborosan, terutama waste berupa waktu menunggu yang disebabkan oleh keterlambatan kedatangan barang serta keterbatasan luas area sortir yang menyebabkan proses tidak dapat dilakukan secara paralel. Berdasarkan analisis current state map, rata-rata durasi proses sortir mencapai 199 menit per kode sortir. Setelah dilakukan perancangan perbaikan melalui future state map dengan penataan ulang area sortir, penetapan Key Performance Indicators (KPI), serta optimalisasi penggunaan tenaga kerja, durasi proses sortir dapat dikurangi menjadi 85,25 menit per kode sortir. Hasil penelitian ini menunjukkan bahwa penerapan Value Stream Mapping mampu meningkatkan efisiensi operasional gudang cross docking dengan mengurangi aktivitas non-value-added serta mengoptimalkan alur kerja operasional.

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1. INTRODUCTION

The rapid expansion of global trade and e-commerce has significantly increased the demand for efficient logistics and distribution systems. Within supply chain operations, warehouses play a critical role in facilitating the

movement of goods from suppliers to customers through activities such as receiving, sorting, consolidation, and dispatch. As customer expectations regarding delivery speed and service reliability continue to increase, logistics organizations are required to improve operational efficiency and minimize process delays in order to maintain competitiveness within supply chain networks(Duc, Huu and Nananukul, 2020; Rachman et al., 2022). One logistics strategy that has gained considerable attention for improving distribution efficiency is cross-docking. Cross-docking is a warehouse management approach in which incoming goods are directly transferred to outbound transportation with little or no intermediate storage.

This system reduces inventory holding costs, shortens order fulfillment time, and improves distribution responsiveness. However, because cross-docking operations rely heavily on synchronization between inbound and outbound flows, any inefficiencies within operational processes—such as waiting time, unnecessary movement, redundant handling, or transportation delays—can significantly disrupt material flow and reduce overall operational performance (Abideen and Mohamad, 2020; Robaaiy, Rahima and Alghazali, 2023; Fitriasari, 2025). In order to address these operational inefficiencies, many organizations have adopted Lean management principles to improve process performance and eliminate waste. One of the most widely used analytical tools within Lean management is Value Stream Mapping (VSM). VSM provides a systematic visualization of material and information flows across operational processes, enabling organizations to identify value-added and non-value-added activities within complex operational systems. Through the development of current-state and future-state maps, VSM helps managers analyze operational bottlenecks, redesign workflows, and implement process improvements aimed at increasing efficiency and reducing operational waste (Baby, Prasanth and Jebadurai, 2018; Salhieh, Altarazi and Abushaikha, 2019; Aghda and Siswanto, 2021; Poere, Nurnabila and Oktarina, 2025; Rahmawati, 2026).

Previous studies consistently demonstrate that the application of VSM contributes to the identification and elimination of waste across warehouse and logistics operations. By mapping the entire operational flow, organizations can detect inefficiencies such as waiting, excessive transportation, unnecessary motion, and redundant processing activities that do not add value to the overall process. Future-state mapping derived from VSM analysis provides a structured framework for process improvement, including the implementation of standardized workflows, FIFO-based material flows, and pull-based systems inspired by Kanban principles (Abdoli, Kara and Kornfeld, 2016; Baby, Prasanth and Jebadurai, 2018; Fitriasari, 2025; Rusadi, 2025). Furthermore, empirical evidence indicates that VSM-based improvements can significantly reduce operational lead time and enhance service performance within logistics systems. Several studies report that eliminating non-value-added activities through VSM can improve process cycle time, increase operational throughput, and strengthen order fulfillment reliability. In cross-docking environments, where operational speed and synchronization are essential, reductions in waiting time and process delays directly contribute to improved service levels and on-time delivery performance (Abideen and Mohamad, 2020; P.G. and Pratap, 2020; Nhu et al., 2023; Robaaiy, Rahima and Alghazali, 2023; Fitriasari, 2025; Rusadi, 2025).

In addition to its role in waste identification, VSM also supports managerial decision-making when integrated with quantitative analysis and simulation tools. Several studies highlight that combining VSM with discrete-event simulation (DES) enables organizations to evaluate proposed operational improvements dynamically before implementation. Through simulation-based analysis, managers can assess the potential impact of process redesign, layout changes, and resource allocation decisions using measurable performance indicators such as lead time, process cycle time, throughput, value-added percentage, and Process Cycle Efficiency (PCE) (Abideen and Mohamad, 2020; Nhu et al., 2023; Rahmawati, 2026). Moreover, VSM has been widely used to support warehouse layout optimization and operational flow redesign. In cross-docking facilities where both time and space constraints are critical, effective layout design can significantly influence operational efficiency. Studies show that VSM-driven improvements can enhance space utilization, reduce material handling distance, streamline sorting and dispatch processes, and support standardized operational procedures within warehouse systems (Baby, Prasanth and Jebadurai, 2018; Raghuram and Arjunan, 2021; Robaaiy, Rahima and Alghazali, 2023; Fitriasari, 2025). Despite the growing body of literature demonstrating the effectiveness of VSM in warehouse and logistics operations, many studies focus primarily on general warehouse environments rather than specifically addressing operational processes within cross-docking systems. Given the unique characteristics of cross-docking operations—particularly their dependence on rapid flow and minimal storage—further empirical analysis is needed to understand how VSM can be applied to identify operational inefficiencies and improve process performance within such environments.

Therefore, this study aims to analyze operational processes within a cross-docking warehouse using the Value Stream Mapping approach in order to identify non-value-added activities and propose improvements that enhance operational efficiency and process performance.

2. RESEARCH METHOD

2.1 Research Design

This study employs a quantitative descriptive approach with a case study conducted in a cross-docking warehouse at PT X, a logistics service company. The research focuses on analyzing the operational activities in the sorting process to identify inefficiencies and non-value-added activities. The Value Stream Mapping (VSM) method is applied as the primary analytical tool within a lean management framework to visualize the flow of materials and information, evaluate process performance, and identify operational waste.

2.2 Data Collection

The data used in this study consist of primary data obtained through the following methods:

1). Direct Observation
Observations were conducted on the sorting process to understand the sequence of operational activities, workflow conditions, and actual practices in the warehouse.

2). Process Documentation
Documentation was carried out to record operational flows, layout conditions, and sorting line configurations within the warehouse.

3). Time Measurement (Time Study)
Measurement of processing time for each activity in the sorting process to determine total process duration and identify delays.

2.3 Research Procedure

The research was conducted through the following stages:

1). Identifying the overall operational flow in the cross-docking warehouse, particularly the sorting process.
2). Collecting data and measuring the processing time of each activity.
3). Developing the current state map using Value Stream Mapping to represent existing operational conditions.
4). Classifying activities into Value-Added (VA), Non-Value-Added (NVA), and Necessary but Non-Value-Added (NNVA).
5). Identifying sources of waste, such as waiting time, unnecessary movement, and process delays. Designing the future state map to propose process improvements.
6). Comparing current and proposed conditions to evaluate efficiency improvements.

2.4 Data Analysis

Data analysis was conducted using the Value Stream Mapping (VSM) approach, which includes:

1). Analysis of material and information flow
2). Identification of value-added and non-value-added activities
3). Calculation of total process duration (lead time)
4). Evaluation of inefficiencies and operational bottlenecks

The main performance indicator used in this study is the average sorting process duration (minutes per sorting code) to measure the level of operational efficiency.

2.5 Improvement Strategy

Based on the results of the VSM analysis, several improvement strategies were proposed, including:

1). Reorganizing the sorting area based on delivery destinations
2). Optimizing labor allocation across sorting lines
3). Establishing Key Performance Indicators (KPI) for operational monitoring
4). Streamlining workflow to reduce waiting time and process delays

3. RESULTS AND DISCUSSION

3.1 Results

The analysis of operational activities in the cross-docking warehouse focuses on the sorting process, which represents one of the most critical stages in the distribution flow. The sorting operation begins after goods arrive from suppliers and are unloaded at the receiving dock. The items are then sorted according to delivery destinations and order codes before being consolidated and loaded into outbound transportation. This process is designed to minimize storage time and accelerate the distribution flow.

Based on field observations and operational data analysis, the sorting process was organized into several operational lines, each responsible for handling specific sorting codes and delivery routes. However, the analysis of the operational workflow revealed that the existing process contained several inefficiencies that affected the overall performance of the warehouse system. The Value Stream Mapping (VSM) analysis began with the development of the current state map, which visualizes the flow of materials and information across the entire sorting process. Through

this mapping process, each operational activity was classified into three categories: value-added (VA), non-value-added (NVA), and necessary but non-value-added (NNVA) activities.

The results of the current-state analysis identified several operational inefficiencies, particularly in the form of waiting time and process delays. One of the main sources of inefficiency was the delay in the arrival of goods from suppliers, which caused temporary interruptions in sorting operations. When goods did not arrive on schedule, workers were unable to proceed with sorting tasks, resulting in idle time and reduced operational productivity. Another issue identified in the analysis was the limitation of sorting area space. Certain sorting lines operated within relatively restricted working areas, which prevented simultaneous sorting operations. As a result, sorting activities in those lines had to be conducted sequentially rather than in parallel. This operational constraint created process bottlenecks and increased the total time required to complete sorting activities. Operational data indicated that each sorting line handled different volumes of goods and sorting codes. In the current operational system, the average duration required to complete the sorting process reached approximately 199 minutes per sorting code. This duration included both value-added activities such as sorting and consolidation, as well as non-value-added activities such as waiting and unnecessary movement within the sorting area.

To address these inefficiencies, several improvement strategies were proposed based on the VSM analysis. These improvements included reorganizing the sorting area based on delivery destinations, optimizing the allocation of workers within sorting lines, and implementing operational performance indicators to monitor sorting activities. The proposed improvements were incorporated into the future state map, which represents the redesigned operational workflow aimed at reducing waste and improving process efficiency. The analysis of the future-state map demonstrated that the proposed improvements could significantly reduce the duration of sorting operations. After the redesign of the operational workflow, the average sorting time decreased from 199 minutes to 85.25 minutes per sorting code, indicating a substantial improvement in operational efficiency.

3.1 Discussion

The findings of this study demonstrate that the application of Value Stream Mapping provides a comprehensive understanding of operational inefficiencies within cross-docking warehouse processes. By visualizing both material and information flows, VSM enables organizations to identify operational bottlenecks and sources of waste that may not be easily detected through conventional process analysis. One of the most significant forms of waste identified in the analysis was waiting time, which occurred when sorting activities were interrupted due to delayed inbound deliveries. In cross-docking systems, where operational performance relies heavily on continuous material flow, such delays can significantly disrupt process efficiency. Waiting waste not only increases operational lead time but also reduces labor productivity and overall warehouse throughput. Another important factor influencing operational performance was the physical layout of the sorting area. Limited workspace prevented certain sorting lines from performing parallel sorting activities, forcing them to adopt a sequential workflow.

This condition increased process congestion and created operational bottlenecks, ultimately extending the total duration of sorting activities. The findings highlight the importance of warehouse layout design in supporting efficient cross-docking operations. The implementation of the proposed improvements addressed these issues by reorganizing the sorting workflow and optimizing the use of available space and labor resources. By restructuring the sorting area according to delivery destinations and improving the allocation of workers across sorting lines, the redesigned workflow allowed sorting activities to proceed more efficiently. These improvements reduced unnecessary movement and minimized waiting time within the operational process. The significant reduction in sorting duration—from 199 minutes to 85.25 minutes—demonstrates the effectiveness of VSM as a process improvement tool in cross-docking environments. The results confirm that identifying and eliminating non-value-added activities can substantially improve operational performance without requiring major technological investments.

These findings are consistent with previous studies that emphasize the role of VSM in reducing operational waste and improving logistics performance. Several studies have reported that VSM can effectively identify inefficiencies within warehouse systems and support the redesign of operational workflows to reduce lead time and improve service performance. In cross-docking operations, where rapid material flow is essential, improvements in sorting efficiency directly contribute to better delivery reliability and customer service levels. Furthermore, the results highlight the importance of adopting a Lean-based operational approach within warehouse management. By continuously identifying and eliminating waste, organizations can improve process efficiency while maintaining operational flexibility in dynamic logistics environments. Overall, the study demonstrates that Value Stream Mapping is a valuable analytical tool for evaluating and improving cross-docking warehouse operations. Through systematic analysis of operational processes and targeted improvement strategies, VSM enables organizations to achieve more efficient workflows and enhanced operational performance.

4. CONCLUSION

This study analyzed operational processes in a cross-docking warehouse using the Value Stream Mapping (VSM) approach to identify inefficiencies and propose process improvements. The analysis revealed that several operational activities contained non-value-added components, particularly waiting time and inefficient workflow arrangements within the sorting process. These inefficiencies were mainly caused by delays in inbound goods arrival and limitations in sorting area layout, which forced certain sorting activities to be performed sequentially rather than simultaneously. The current-state analysis showed that the average sorting duration reached approximately 199 minutes per sorting code. Through the application of VSM and the development of a future-state map, several improvement strategies were proposed, including the reorganization of the sorting area based on delivery destinations, optimization of workforce allocation, and the establishment of operational performance indicators. The implementation of these improvements significantly reduced the sorting duration to approximately 85.25 minutes per sorting code, indicating a substantial improvement in operational efficiency. These findings demonstrate that Value Stream Mapping is an effective analytical tool for identifying operational waste and improving workflow efficiency in cross-docking warehouse environments. By providing a systematic visualization of both material and information flows, VSM enables organizations to redesign operational processes, reduce non-value-added activities, and enhance overall process performance. For future research, further studies are recommended to integrate VSM with advanced analytical approaches such as simulation modeling or digital warehouse management systems in order to evaluate process improvements under dynamic operational conditions and support more comprehensive decision-making in warehouse operations.

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