

THE ROOT CAUSE ANALYSIS OF LATE DELIVERY RATE IN E-COMMERCE SHIPMENTS THROUGH SERVICE LEVEL AGREEMENT, FIRST ATTEMPT DELIVERY, AND TRANSACTION CHARACTERISTICS EVALUATION

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ABSTRACT

The rapid growth of the e-commerce industry has increased distribution complexity and required logistics companies to maintain delivery timeliness in accordance with service standards. However, the increasing shipment volume is often accompanied by a higher Late Delivery Rate (LDR), which may reduce service quality, increase customer complaints, and expose companies to marketplace penalties. This study aims to analyze delivery performance based on Service Level Agreement (SLA) and LDR indicators, evaluate the influence of First Attempt Delivery (FAD) and transaction characteristics on delivery timeliness, and identify the root causes of increasing LDR in e-commerce shipments at PT Pos Indonesia. A descriptive qualitative approach based on Root Cause Analysis (RCA) was employed using operational e-commerce shipment data from January to March 2026. The analysis was conducted through operational performance evaluation, Pareto Analysis, Fishbone Diagram, and 5 Whys Analysis. The results indicate that LDR increased from 4.69% in January to 16.40% in March 2026, while SLA delivery performance declined from 96.72% to 91.29%. Pareto Analysis identified four dominant factors contributing to 70% of the increase in LDR, namely the rise in LDR itself, declining SLA performance, discrepancies between Shopee's SLA and PT Pos Indonesia's SLA calculations, and marketplace penalty risks. RCA findings reveal that the primary root cause is the lack of optimal real-time and integrated operational control, particularly in shipment monitoring, SLA management, data synchronization, and inter-unit coordination. This study contributes to logistics research by integrating SLA, FAD, transaction characteristics, and RCA within a unified operational evaluation framework. Furthermore, it provides a foundation for developing real-time monitoring systems and early warning mechanisms to improve e-commerce logistics service performance.

Keywords: Late Delivery Rate, Service Level Agreement, First Attempt Delivery, Root Cause Analysis, E-Commerce Logistics

1. INTRODUCTION

Despite the growing body of literature on delivery performance and logistics operations, limited studies have comprehensively examined the relationship between Service Level Agreement (SLA), First Attempt Delivery (FAD), transaction characteristics, and Late Delivery Rate (LDR) within a single analytical framework. Most previous studies have focused on operational performance measurement and service quality assessment, while only a few have investigated the underlying causes of delivery delays using a systematic root-cause approach. As a result, the operational factors contributing to increasing delivery delays in e-commerce distribution remain insufficiently understood.

Based on the identified research gap and the operational challenges faced by PT Pos Indonesia, this study seeks to answer several important questions. First, how is the delivery performance of e-commerce shipments reflected through SLA and LDR indicators? Second, how do First Attempt Delivery (FAD) and transaction characteristics influence delivery timeliness? Third, what are the dominant factors and root causes contributing to the increase in Late Delivery Rate within e-commerce delivery operations? Addressing these questions is essential for developing a deeper understanding of the factors affecting delivery performance and operational reliability.

Therefore, this study aims to analyze the delivery performance of PT Pos Indonesia's e-commerce shipments, evaluate the role of FAD and transaction characteristics in delivery timeliness, and identify the root causes of increasing delivery delays using a Root Cause Analysis (RCA) approach. The novelty of this research lies in the integration of SLA, FAD, and transaction characteristics within a comprehensive RCA framework supported by real operational data from PT Pos Indonesia. The findings are expected to contribute to the advancement of logistics and operations management research while providing practical recommendations for improving delivery performance, reducing delays, and enhancing service quality in e-commerce logistics operations.

2. LITERATURE REVIEW

Logistics plays a crucial role in supply chain management by coordinating the flow of goods, information, and resources from the point of origin to the final customer efficiently and effectively. In the e-commerce industry, logistics performance has become increasingly important due to growing customer expectations regarding delivery speed, reliability, and service quality (Christopher, 2016). Among the logistics activities, last-mile delivery is considered one of the most challenging stages because it directly affects customer satisfaction and is often associated with delivery delays. Factors such as traffic congestion, delivery capacity, geographical conditions, and operational inefficiencies may significantly affect delivery performance (Gevaers et al., 2014; Hübner et al., 2016).

Delivery performance is commonly evaluated using several operational indicators, including Service Level Agreement (SLA), First Attempt Delivery (FAD), and Late Delivery

Rate (LDR). SLA represents the agreed performance standard between service providers and customers, while FAD measures the success rate of deliveries completed on the first delivery attempt. Meanwhile, LDR indicates the percentage of shipments delivered later than the promised delivery time. High LDR values may negatively affect customer satisfaction, increase operational costs, and result in penalties from e-commerce platforms or business partners (Heizer et al., 2020; Esper et al., 2020).

Several previous studies have investigated delivery delays and operational performance in logistics systems. Dama Yuninata and Dian Nur Ikayan (2025) applied Six Sigma, Root Cause Analysis (RCA), and Fishbone Diagram to identify the causes of export delivery delays in the furniture industry. Their findings demonstrated that operational and distribution process issues were the primary contributors to delivery delays. Similarly, Haris (2023) examined delivery delays at PT Seryu Cargo using RCA and operational analysis and successfully identified dominant operational barriers affecting delivery performance. Tarigan (2024) integrated Statistical Process Control (SPC), Pareto Analysis, and Fishbone Diagram to analyze delivery delays and found that quality control tools effectively identified critical factors contributing to delayed deliveries.

In addition, Sakdiyah et al. (2022) emphasized the effectiveness of Fishbone Diagram and Root Cause Analysis in identifying operational problems and supporting managerial decision-making. Furthermore, Li et al. (2024) introduced a data-driven root cause attribution approach using causal discovery and reinforcement learning techniques to identify delivery risks and their causal relationships. These studies demonstrate the importance of root cause identification in improving logistics performance and reducing delivery delays.

Despite their valuable contributions, previous studies exhibit several limitations. Most studies focus on operational issues, quality control, or distribution processes separately and do not comprehensively integrate Service Level Agreement (SLA), First Attempt Delivery (FAD), and transaction characteristics within a single analytical framework. In addition, existing studies mainly concentrate on identifying operational problems without explicitly examining how SLA achievement and FAD performance contribute to the occurrence of Late Delivery Rate in e-commerce logistics operations. Consequently, the relationship among these operational indicators remains insufficiently explored.

To address these limitations, this study adopts a Root Cause Analysis (RCA) approach supported by Fishbone Diagram, Pareto Analysis, and the Plan-Do-Check-Act (PDCA) improvement cycle. According to Ishikawa (1985), RCA is a systematic method used to identify the underlying causes of operational problems, while PDCA provides a structured framework for continuous improvement (Deming, 1986). These methods are considered appropriate for identifying dominant factors contributing to delivery delays and developing targeted operational improvement strategies.

The novelty of this study lies in the integration of Service Level Agreement (SLA), First Attempt Delivery (FAD), and transaction characteristics within a comprehensive Root Cause

Analysis framework using real operational data from PT Pos Indonesia. Unlike previous studies that primarily focused on performance measurement or isolated operational factors, this research investigates the causal relationship between operational indicators and delivery delays to identify the dominant root causes of increasing Late Delivery Rate in e-commerce logistics operations.

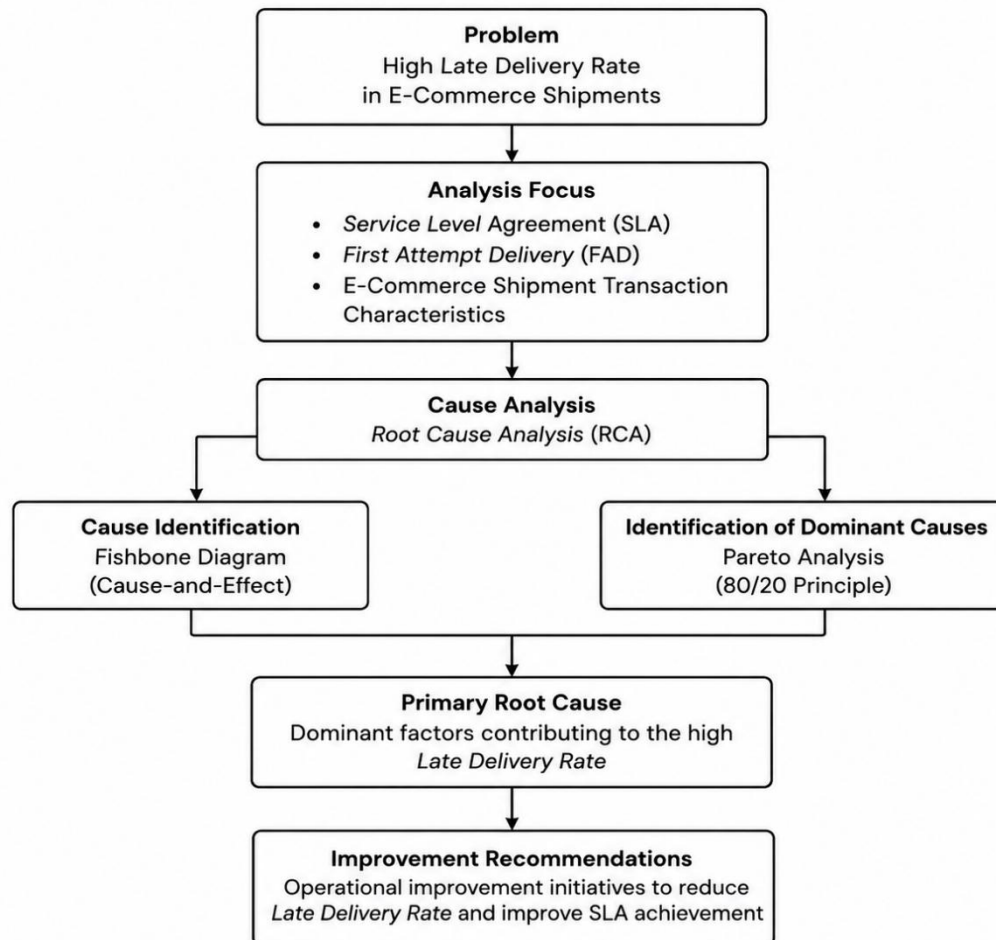


Figure 1 Research Framework for Root Cause Analysis of Late Delivery Rate in E-Commerce Shipments

Figure 1 illustrates the research framework. The framework proposes that Late Delivery Rate is influenced by Service Level Agreement achievement, First Attempt Delivery performance, and transaction characteristics. These factors are analyzed through Root Cause Analysis using Fishbone Diagram and Pareto Analysis to identify dominant causes and determine improvement priorities. The identified root causes subsequently become the basis for operational improvement recommendations aimed at reducing delivery delays and improving logistics service performance.

3. METHODS

This study employed a descriptive analytical approach using Root Cause Analysis (RCA) to identify the factors contributing to the high Late Delivery Rate (LDR) in PT Pos Indonesia's e-commerce shipments. The study focused on evaluating Service Level Agreement (SLA), First

Attempt Delivery (FAD), and shipment transaction characteristics as the primary variables influencing delivery performance. The research object was the operational performance of e-commerce shipments handled by PT Pos Indonesia, particularly Shopee (EC3) deliveries during the January–March 2026 period.

The study utilized both primary and secondary data sources. Primary data were collected through operational observations and semi-structured interviews with operational supervisors, monitoring officers, dispatchers, and service performance control units. Secondary data were obtained from PT Pos Indonesia's operational dashboards and internal reports, including SLA achievement, Late Delivery Rate (LDR), First Attempt Delivery (FAD), shipment volume, delivery irregularities, and shipment tracking records. The population of this study consisted of all e-commerce shipment transactions processed during the observation period, while the analytical unit focused on delayed shipments and operational performance indicators associated with delivery timeliness.

The research procedure began with problem identification based on the increasing Late Delivery Rate. Subsequently, operational data were collected, validated, and analyzed descriptively to evaluate shipment performance. Pareto Analysis was then applied to determine the dominant factors contributing to delivery delays. Following the Pareto analysis, Root Cause Analysis was conducted using Fishbone Diagram to systematically identify causal relationships among operational factors. The final stage involved determining the primary root causes and developing operational improvement recommendations using the Plan-Do-Check-Act (PDCA) framework.

Data analysis was performed in several stages. Descriptive analysis was used to evaluate shipment performance based on SLA, LDR, FAD, and transaction characteristics. Pareto Analysis was employed to prioritize operational issues according to their contribution to delivery delays. Fishbone Diagram was used to classify and analyze causal factors into five main categories: Service Level Agreement Control, First Attempt Delivery Execution, Shipment Data and Transaction Characteristics, Operational Capacity and Human Resources, and Monitoring System and Inter-Unit Coordination. The identified root causes were subsequently evaluated to formulate improvement recommendations aimed at reducing Late Delivery Rate and improving operational performance.

The proposed improvement initiatives were structured using the PDCA cycle to support continuous improvement in service quality, SLA achievement, delivery success rates, and overall e-commerce logistics performance.

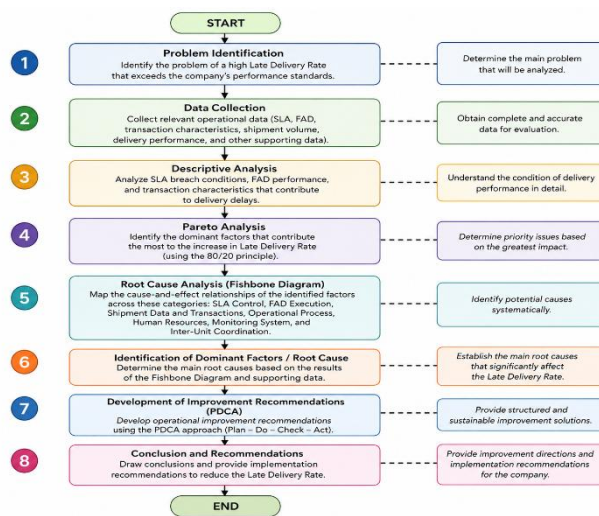


Figure 2 Research Methodology Flowchart.

Figure 2 illustrates the research procedure adopted in this study. The process begins with problem identification related to the increasing Late Delivery Rate (LDR) in e-commerce shipments. Relevant operational data are then collected and analyzed descriptively to evaluate shipment performance. Pareto Analysis is subsequently applied to determine dominant factors contributing to delivery delays, followed by Root Cause Analysis using Fishbone Diagram to identify the underlying causes. The identified root causes are then used as the basis for developing improvement recommendations through the Plan-Do-Check-Act (PDCA) approach. Finally, conclusions and recommendations are formulated to support continuous improvement in logistics operations.

4. RESULTS AND DISCUSSION

The delivery performance of PT Pos Indonesia's e-commerce shipments during the January–March 2026 period showed a decline in service performance, as indicated by the increasing Late Delivery Rate (LDR) and decreasing Service Level Agreement (SLA) achievement. The results revealed that the LDR increased from 4.69% in January to 5.86% in February and reached 16.40% in March 2026. During the same period, SLA achievement decreased from 96.72% to 91.29%.

Table 1 SLA Delivery and Late Delivery Rate Performance (January–March 2026).

No	Month	LDR (%)	Target
1	January	4.69%	5%
2	February	5.86%	5%
3	March	16,4 %	5%

No	Month	SLA (%)	Target
1	January	96.72%	95%
2	February	96.68%	95%
3	March	91.29 %	95%

The increasing shipment volume imposed additional pressure on sorting, transportation, and delivery processes. However, the findings indicate that delivery delays were not solely caused by volume growth. Transaction characteristics and operational irregularities also contributed significantly to delivery performance degradation. Major transaction categories included Home & Living, Muslim Fashion, Women Clothes, and Food & Beverages. Several operational irregularities were identified, including returned shipments, failed X-ray inspections, misrouted shipments, postal code mismatches, and delayed operational data updates.

These findings suggest that delivery delays are influenced not only by operational capacity constraints but also by data quality and operational control effectiveness.

Operational monitoring identified ten major issues affecting the performance of Shopee e-commerce shipments, including increasing Late Delivery Rate, declining SLA achievement, SLA discrepancies between Shopee and PT Pos Indonesia, marketplace penalty risks, increasing shipment volume, postal code mismatches, open shipments, operational complaints, delayed shipment updates, and misrouted shipments.

Table 2 Summary of Operational Issues Affecting E-Commerce Delivery Performance

No	Operational Issue	Condition
1	<i>Late Delivery Rate (LDR)</i>	The average LDR increased from 2.92% during October–December 2025 to 5.28% during January–March 2026.
2	SLA Achievement	SLA achievement declined from 96.9% during October–December 2025 to 94.8% during January–March 2026.
3	SLA Discrepancy	Based on March 2026 sampling data, a discrepancy in delivery SLA calculations was identified between Shopee's system and PT Pos Indonesia's system, with a difference of 63.8%.
4	Shopee Penalty Risk	Marketplace penalties increased from 0% to 5% of the item value in accordance with marketplace regulations.
5	Shipment Volume Growth	Average shipment volume increased by 64%.
6	Postal Code Mismatch	An average of 100 postal code mismatch cases per day were identified during January–March 2026.
7	Open Shipments	Operational monitoring identified 3,274 open shipments in March 2026, despite the company's target of zero unresolved shipments.
8	Internal Operational Complaints	Some delivery-related complaints were still reported through WhatsApp and Telegram, resulting in incomplete recording within the internal monitoring system.
9	Delayed Shipment Data Updates	The increasing number of delivery-related complaints reported through Telegram limited accurate shipment issue monitoring because some operational data were not centrally documented.
10	Misrouted Shipments	The percentage of misrouted shipments increased from 26.5% in January to 28.54% in February and rose significantly to 44% in March 2026.

The identified issues indicate that delivery delays are associated not only with physical distribution processes but also with operational monitoring, data quality, and inter-unit coordination. Therefore, a comprehensive operational improvement approach is required.

To determine the most influential operational issues contributing to delivery delays, all identified issues were quantified using Pareto Analysis. The results show that four major issues contributed approximately 70% of the total operational impact, namely increasing LDR, declining SLA achievement, SLA discrepancies between Shopee and PT Pos Indonesia, and marketplace penalty risks.

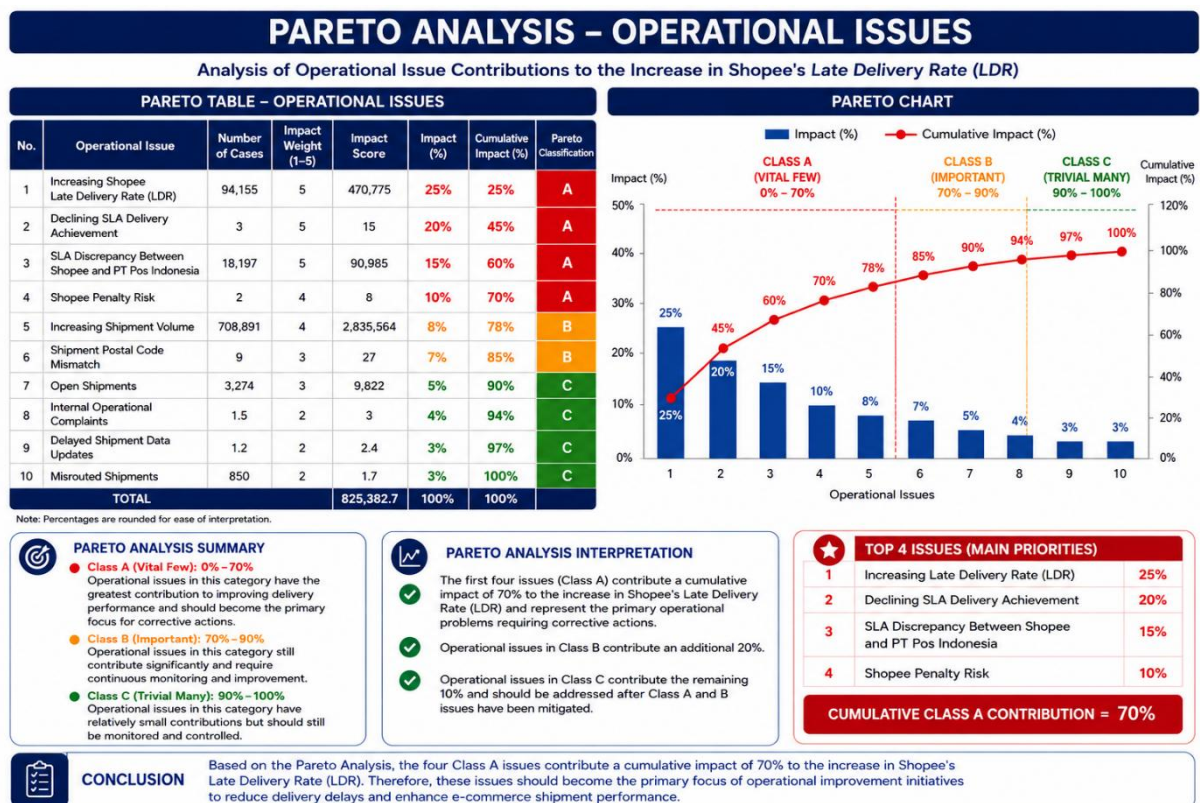


Figure 3 Pareto Analysis of Operational Issues Affecting Late Delivery Rate

The Pareto results indicate that the majority of operational problems originate from a limited number of critical factors. Therefore, these issues were categorized as vital few and became the primary focus of the Root Cause Analysis process.

Further analysis was conducted using Fishbone Diagram to identify the causal relationships underlying delivery delays. The results indicate that the causes of increasing LDR can be classified into five major categories: Service Level Agreement Control, First Attempt Delivery Execution, Shipment Data and Transaction Characteristics, Operational Capacity and Human Resources, and Monitoring System and Inter-Unit Coordination.

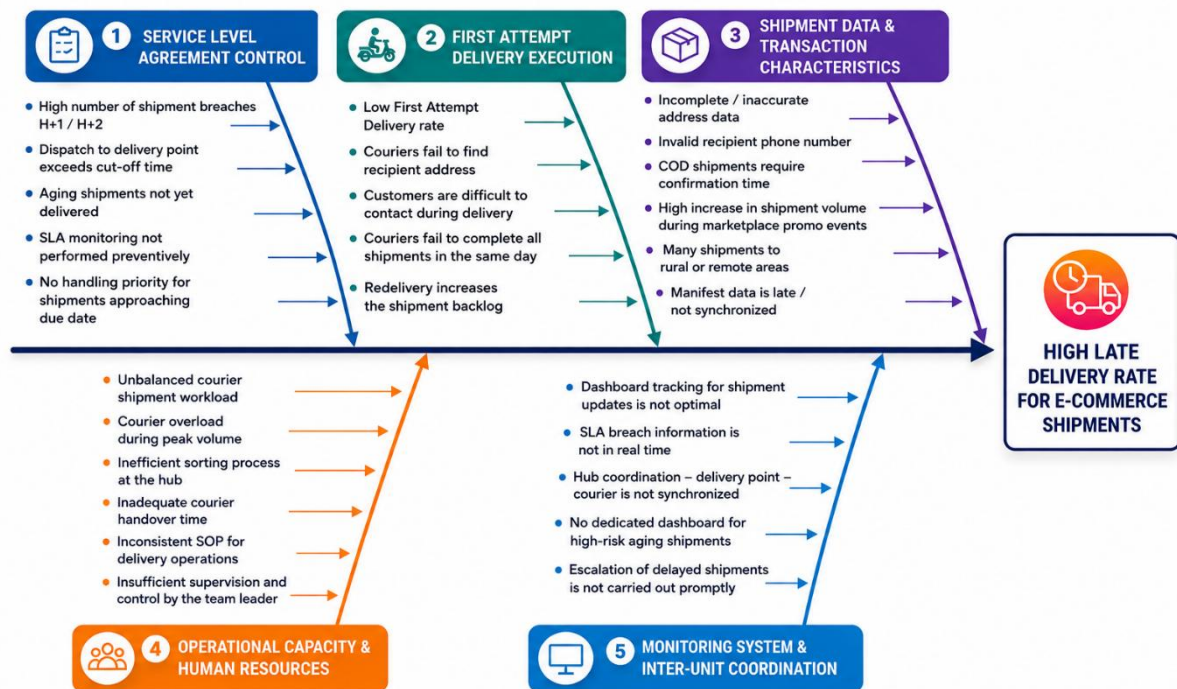


Figure 4 Fishbone Diagram of the Causes of High Late Delivery Rate

Subsequent analysis using the 5 Whys technique revealed that most contributing factors were associated with ineffective shipment monitoring, inadequate SLA control, poor shipment data quality, insufficient distribution control, and fragmented irregularity handling processes. The root causes were primarily related to the lack of real-time operational control, shipment visibility, SLA monitoring, operational data synchronization, and inter-unit coordination.

These findings support the Root Cause Analysis concept, which emphasizes identifying underlying causes rather than addressing only observable symptoms.

Based on the identified root causes, an improvement program was developed using the Plan-Do-Check-Act (PDCA) framework. The program focused on SLA synchronization between Shopee and PT Pos Indonesia, implementation of a real-time monitoring dashboard, development of an early warning system, shipment aging monitoring, data quality improvement, and stronger inter-unit coordination.

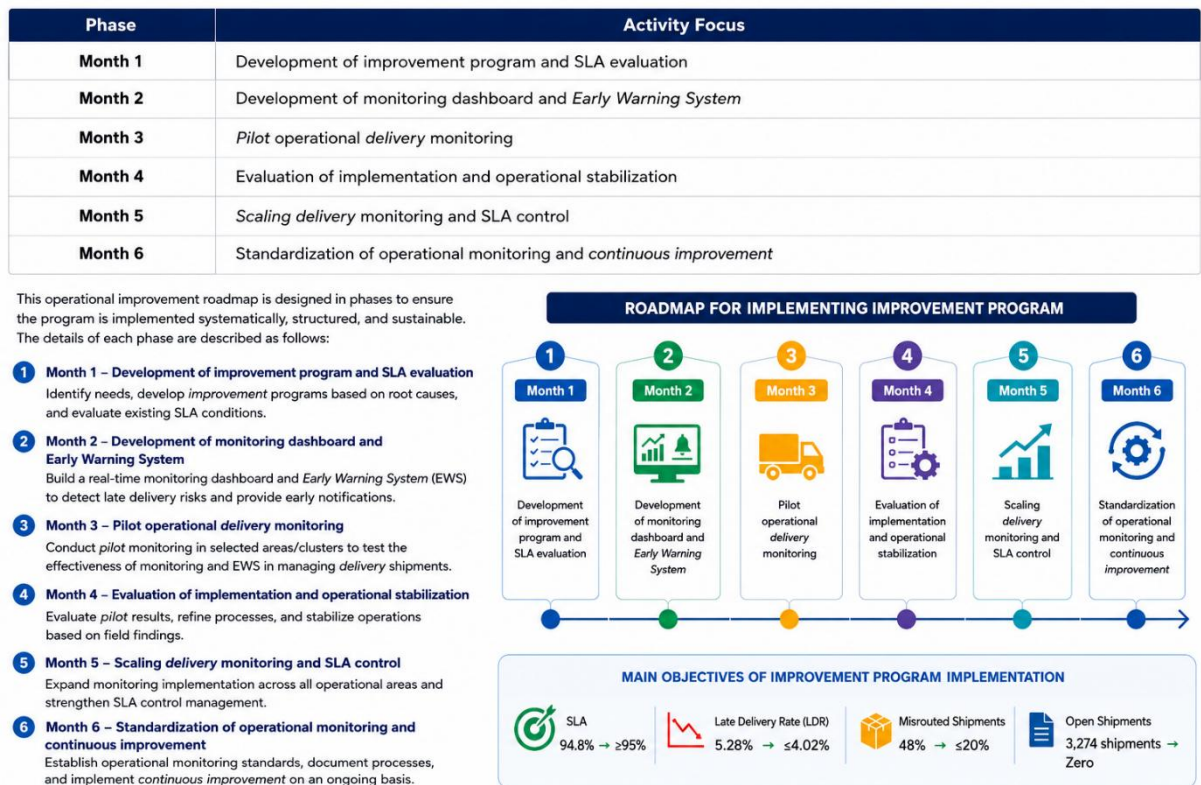


Figure 5 Roadmap for the Implementation of the Improvement Program

The proposed initiatives were designed to strengthen operational control mechanisms and improve the organization's ability to identify high-risk shipments before SLA violations occur.

Following implementation, an evaluation was conducted to assess the effectiveness of the proposed improvement initiatives.

Table 3 Implementation Evaluation of SLA Delivery and Late Delivery Rate

KPI	March	April	May
SLA Delivery	94,8%	95,48%	96,16%
LDR	5,28%	4,52%	3,84%

The evaluation results demonstrate a positive impact on operational performance. SLA achievement increased from 94.8% in March to 95.48% in April and 96.16% in May 2026. Simultaneously, LDR decreased from 5.28% to 4.52% and further declined to 3.84%.

The results indicate that the improvement initiatives successfully addressed the dominant causes of delivery delays. The implementation of real-time monitoring dashboards improved shipment visibility, while the early warning system enabled proactive corrective actions before SLA violations occurred. Furthermore, SLA synchronization and improved data quality reduced operational inconsistencies that previously contributed to delivery delays.

The findings indicate that increasing Late Delivery Rate is not solely driven by shipment volume growth but is primarily influenced by operational monitoring effectiveness, SLA control mechanisms, data quality, and inter-unit coordination. The study confirms the applicability of Root Cause Analysis as a systematic approach for identifying operational problems in e-commerce logistics.

From a practical perspective, organizations should adopt data-driven operational control mechanisms supported by real-time monitoring systems, early warning capabilities, and continuous improvement programs. The successful implementation of the PDCA framework demonstrates its effectiveness in translating Root Cause Analysis findings into measurable operational improvements. Therefore, integrating SLA management, shipment monitoring, and continuous improvement practices is essential for reducing delivery delays and enhancing service quality in e-commerce logistics operations.

5. CONCLUSION AND LIMITATION

This study examined the delivery performance of PT Pos Indonesia's e-commerce shipments by evaluating Service Level Agreement (SLA), First Attempt Delivery (FAD), transaction characteristics, and Late Delivery Rate (LDR) using a Root Cause Analysis (RCA) approach. The findings indicate that delivery delays were primarily influenced by weaknesses in operational monitoring, SLA control mechanisms, operational data synchronization, and inter-unit coordination rather than shipment volume alone. Through the application of Pareto Analysis, Fishbone Diagram, and 5 Whys Analysis, the study successfully identified the dominant root causes contributing to delivery delays and developed targeted improvement initiatives using the Plan-Do-Check-Act (PDCA) framework. The implementation of these initiatives improved operational control, enhanced shipment visibility, strengthened SLA management, and contributed to better delivery performance. The study contributes to logistics and operations management literature by integrating SLA, FAD, transaction characteristics, and RCA within a comprehensive framework for evaluating e-commerce delivery performance, while also providing practical guidance for logistics organizations seeking to reduce delivery delays through data-driven operational control and continuous improvement practices.

This study has several limitations. The analysis was limited to Shopee e-commerce shipments handled by PT Pos Indonesia during a specific observation period and did not incorporate external factors such as weather conditions, traffic congestion, or customer behavior. Future studies are recommended to utilize broader datasets, longer observation periods, and advanced analytical techniques such as statistical modeling, predictive analytics, or machine learning to develop more comprehensive and accurate delivery delay prediction models.

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