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# WASTE ANALYSIS OF THE INTERNATIONAL DELIVERY SERVICE PROCESS USING LEAN SIX SIGMA IN LOGISTICS SERVICE PROVIDER COMPANIES

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***ABSTRACT***
*International shipping poses challenges such as customs clearance delays, slow delivery speeds, and process bottlenecks, leading to time wasstage, increased costs, and potential profit losses. These issues impact specific processes and customer satisfaction. Lean Six Sigma offers a robust framework for identifying and eliminating waste in international shipping processes. Applying the lean service approach, we identified four key waste types in international shipping: delay, duplication, unnecessary movement, and error. However, a Pareto diagram highlighted delay and error as critical culprits, with sigma values of 1.85 for delay and 2.92, 3.46, 3.77 for the three error types, respectively. These low sigma values indicate significant room for improvement After conducting an impact analysis and failure mode analysis (FMEA), four improvement recommendations were proposed: the implementation of an online shipping form filling system, providing customs training to all counter employees, and creating SOPs for inspection processes at the warehouse. These recommendations form a roadmap for international shipping companies to embrace Lean Six Sigma, enhancing efficiency, reducing costs, and improving customer satisfaction.*
***Keywords:*** *FMEA, Lean Six Sigma, Pareto Chart, 5 Whys Analysis.*

## 1. Introduction

Global trade is evolving dynamically, marked by the cross-border movement of goods (Gani, 2017). The logistics sector has an important role to play in the challenges of globalization. Given the escalating trends of globalization and the rigorous demands of international competition, the performance of the logistics sector is assuming heightened significance (Ejaz & Naz, 2023). The logistics sector is an integral component of supply chain management, encompassing the planning, execution, and control of the flow and storage of goods, services, and strategic information to fulfill customer needs (Islam et al., 2023). Logistics management bears diverse responsibilities, including overseeing inbound and outbound transportation, fleet management, inventory management, supply/demand planning, order fulfillment, warehousing, material handling, logistics network design, and the management of third-party logistics service providers (Gomes et al., 2023). These aspects are crucial for an international delivery service. International delivery service is a shipping service that offers both domestic and international delivery of goods, focusing on ensuring customer satisfaction. Common issues encountered in international shipping encompass customs clearance, shipping velocity, and logistical bottlenecks (Gordy et al., 2019). These challenges can lead to time delays, additional costs, and operational profit losses, contingent on the specific processes and customer satisfaction levels (Ghoumrassi & Țigu, 2017). To sustain competitiveness and meet customer's escalating demands for speed and precision, companies providing international shipping services must innovate and enhance efficiency (Song & Lee, 2022). Improved efficiency can result in the reduction and elimination of wasteful processes.

Numerous studies aimed at identifying and eliminating waste in the logistic service process suggest that employing Lean Six Sigma (Song & Lee, 2022) represents an effective solution. Lean Six Sigma is a method that seamlessly integrates data-driven Six Sigma methodology with lean principles, focusing on simplifying processes, eliminating waste, and enhancing efficiency within the main components of Lean and Six Sigma. Emphasizing customer satisfaction and continuous improvement is also integral (Ishak et al., 2020). Implementing Lean Six Sigma can potentially boost process cycle efficiency by up to 70% (Guleria et al., 2022). Lean Six Sigma is adopted across various industrial sectors to establish sustainable performance. In warehousing, it is to enhance process cycle efficiency and minimize waste. Lean Six Sigma has demonstrated the capability to increase warehouse productivity by 76.9%, reduce lead time by 43.5%, and diminish non-value-added activities by 72.1% lean tools (Gutierrez-Gutierrez et al., 2016). Within the energy service sector, Lean Six Sigma achieved a notable 20% efficiency improvement and a 10% increase in targets within three-month time. It identifies vital problems and enhances overall processes (Bloj et al., 2020). In the railcar industry, implementing of Lean Six Sigma resulted in a 66.7% increase in productivity with the incorporation of kaizen. Additionally, it led to a 27.9% reduction in lead time, a 59.3% increase in value-added time, and a 71.9% reduction in non-value-added time (Madhani, 2020). Within the manufacturing industry, implementation of lean tools, notably 5S, in plant layout management contributed to a 3.2% rejection rate, a 400% reduction in material travel distance, and a waiting time reduced to just 11 days (Guleria et al., 2022).

According to (Gutierrez-Gutierrez et al., 2016), Lean Six Sigma significantly enhances the effectiveness and quality of logistic service processes. Organizational aspects experience notable improvements with Lean Six Sigma implementation (Anh et al., 2023). However, it is essential to note that this research has limitations regarding the generalizability of conclusions, and one of the two Continuous Improvement Projects (CIPs) did not undergo the DMAIC cycle (Anh et al., 2023). Given previous research's limitations, the research focuses on improving efficiency in several sectors with a lean six sigma approach. Only a few studies have addressed the problems in the international freight forwarding service process. Further analysis is needed to ascertain the underlying factors of inefficiency in the logistics sector and develop efficient solutions to eliminate inefficiency and waste. This is where the Lean Six Sigma approach and failure mode effect analysis (FMEA) become new and necessary. The FMEA approach detects problems before they arise and prioritizes issues based on severity, frequency, and detectability. These two methods have yet to be widely used in addressing issues in global supply chains, especially in international shipping. This research aims to analyze and classify waste in the international freight forwarding process by utilizing the current service blueprint, assess international freight forwarding performance through sigma levels, identify the root causes of waste, and propose improvement alternatives for logistic service providers in the international freight forwarding process. The expected results of this research will increase the understanding of the application of Lean Six Sigma in global shipping procedures. In addition, this research will provide valuable suggestions for international shipping process companies to improve service quality and efficiency, optimize overall international shipping, and fill in limitations that have yet to exist before

## 2. Literature Review

Services are intangible economic activities provided by one party to another party, which do not involve the production of physical goods but instead provide benefits to the users. Customers anticipate benefits and advantages when they pay for access to facilities, goods, competencies, professionals, and systems (Wirtz & Lovelock, 2016). The perceived quality of a service is determined by customers who assess the service delivery based on their expectations (Gronroos, 2015). Service quality dimensions are utilized to compare perceptions and expectations of service quality (Parasuraman et al., 1985). Five dimensions of service quality are utilized to compare perceptions and expectations of service quality: tangible, reliability, responsiveness, assurance, and empathy. Service blueprints are highly effective for delineating the complexities of international delivery processes, offering a detailed visualization of the customer journey, which helps identify inefficiencies and pain points (Kazemzadeh et al., 2015). By integrating service blueprints with Lean Six Sigma methodologies, this research aims to map and analyze the delivery process at a granular level, enabling the identification of waste and variations that impact service quality. This combination is essential for enhancing process performance in global logistics, aligning with the research objective of improving efficiency and customer satisfaction in international delivery services.

Lean service refers to the application of lean manufacturing principles to service companies. The goal is to minimize waste, enhance quality, increase process efficiency, and foster a culture prioritizing customer satisfaction and continuous improvement (Suárez-Barraza et al., 2012). Despite the positive outcomes associated with Lean Six Sigma, the literature reveals inconsistencies in its application across different logistics contexts. For example, a comparative analysis by (Kumar et al., 2016) identified variations in implementation of Lean Six Sigma across various sectors, suggesting that logistics service providers may face unique challenges that necessitate tailored approaches. This indicates a potential gap in understanding how Lean Six Sigma can be effectively adapted to the specific nuances of international delivery services. Several studies have explored the implementation of Lean Six Sigma within logistics operations, yet few have concentrated specifically on international delivery services. For example, a case study by (Adeodu et al., 2023) demonstrated the successful application of Lean Six Sigma in a domestic logistics company, resulting in significant improvements in delivery times and customer satisfaction. However, the complexities associated with international logistics, such as cross-border regulations and varying service standards, necessitate further investigation.

Moreover, research by (Alexander et al., 2019) pointed out that while Lean Six Sigma has been widely adopted in manufacturing, its application in service industries, particularly in logistics, remains underexplored. This observation underscores the need for more comprehensive studies that delve into how Lean Six Sigma can be tailored to address the specific challenges faced by logistics service providers engaged in international deliveries. The literature also identifies several barriers to the successful implementation of Lean Six Sigma in logistics. A study by (Knapp, 2015) highlighted organizational culture, lack of training, and resistance to change as significant obstacles that logistics companies encounter when adopting Lean Six Sigma methodologies. Additionally, research by (Sweeney et al., 2018) indicated that the dynamic nature of international logistics, characterized by fluctuating demand and regulatory complexities, further complicates the implementation process.

Despite these insights, there remains a paucity of research that specifically addresses the barriers to Lean Six Sigma implementation in the context of international delivery services. This gap suggests a critical area for future research, as understanding these barriers could facilitate the development of strategies to overcome them, ultimately leading to more effective waste reduction and process improvement. The application of Lean and Six Sigma has varied significantly across different sectors such as manufacturing, healthcare, and services. In international logistics, these methodologies focus on minimizing delays, reducing transportation costs, and improving the accuracy of deliveries (Antony & Sony, 2020). This research builds on previous approaches by specifically targeting inefficiencies within cross-border processes, adapting Lean Six Sigma to account for regulatory differences and cultural variations, which are less frequently addressed in other sectors.

## 3. Research Methods

Implementing Lean Six Sigma is crucial for improving international shipping service as it effectively minimizes waste and maximizes efficiency and service quality (Sundram Kaliani et al., 2023). The acceptance of the lean six-sigma technique is attributed to its capacity to comprehend complex organizational dynamics and tackle issues using quantitative and qualitative methods (Monday, 2022). These objectives are achieved through the DMAIC (Define, Measure, Analyze, Improve, and Control) technique, which offers a structured framework (Rodriguez Delgadillo et al., 2022). This research applies the lean Six Sigma approach through the DMAIC technique and failure and mode analysis (FMEA). The application of the DMAIC approach is limited to the improvement steps in this research framework. This research used two main data collection methods: primary data and secondary data. Primary data was collected by direct observation of the delivery service system of the object under study and conducting interviews with the company to gather the required information. Interviews and direct observations help understand the international shipping process flow and provide insight into possible waste. The data needed for direct observation include the pace of the international shipping service process, the duration of each activity in the service process flow, and the labor capacity in the office responsible for handling the international shipping process. Secondary data is obtained through historical data owned by the company from 2019 to 2020. The required information consists of complaint records related to international shipping services, international shipping volume statistics, summary data related to returned goods, standard operating procedures for international shipping, and additional relevant data. The observations, interviews, and secondary data collection results are carried out as initial data input that can help analyze more deeply such as determining root cause analysis, calculating DPMO, making Pareto charts, and FMEA analysis. This research combines qualitative (Observation and Interview) and quantitative (DPMO, Pareto Chart, and FMEA) methods. Qualitative methods aid in gaining a deep understanding of the root causes of problems and uncover obstacles that are not visible through numerical data. Quantitative methods provide a clear measurement of the problem's magnitude and assist in prioritizing corrective actions. Combining qualitative and quantitative methods is highly effective in implementing Lean Six Sigma.

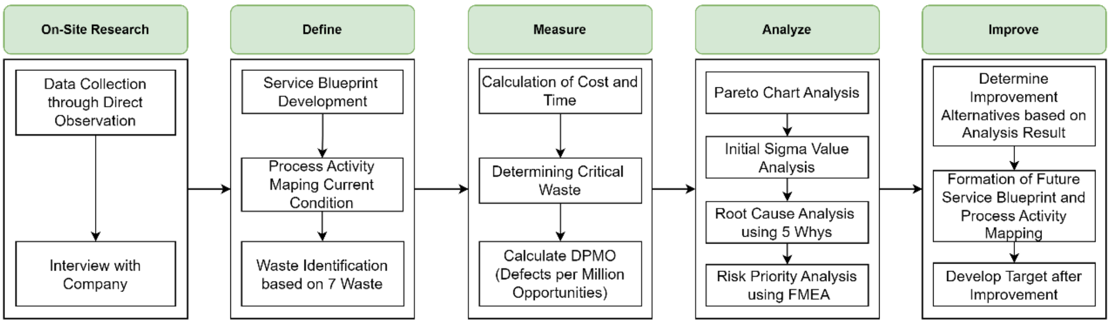



Fig. 1. Research Framework

2.1 Stage 1: On-Site Research

On-site research is a stage to find out the flow of processes and constraints in international shipping services and the condition of the work environment of the object of observation. On-site research is used in identifying waste in the process, both in terms of time, labor, and other resources, in accordance with lean principles.

2.2 Stage 2: Define

The define stage consists of several activities which include:

1. Service Blueprint Development: Used to describe the current system and process flow of international shipping services at the company.
2. Process Activity Mapping Curent Condition: Used to find out the details of activities in the international shipping process and group activities in the categories of value-added activity, non-value-added activity, and necessary but non-value-added activity. Process activity mapping current conditions was created to help identify waste in the international shipping process flow.
3. Waste Identification based on 7 service waste: Identify the waste contained in the international shipping process with the 7 waste approach which includes delay, duplication, unnecessary movement, unclear communication, unnecessary movement, incorrect inventory, lost opportunity, and error. The results of this identification are used as input in the next stage.

2.3 Stage3: Measure

The measurement phase consists of:

1. Calculation of Cost and Time due to Waste: Calculating the costs incurred due to waste and using data on labor costs, tool usage, transportation costs, and other costs that may result

from existing waste. The time of non-value-added activities based on the process activity mapping stage is also calculated.
2. Determining Critical Waste: The results of the time and cost calculations were recapitulated and analyzed using a Pareto chart to show critical waste.
3. Calculate DPMO (Defects Per Million Opportunities) and the Initial Sigma Value: Used to determine the capability of the Company's international shipping process.

2.4 Stage 4: Analyze
The analysis phase consists of:
1. Pareto Chart Analysis: Analyze the critical waste that has been determined through the previously created pareto chart.
2. Initial Sigma Value Analysis: Analyzing the initial sigma value by analyzing the results of the DPMO calculation and the initial sigma value of the waste contained in the international shipping process.
3. Root Cause of Analysis of Critical Waste with RCA (Root Cause Analysis): Used to determine the root cause of waste in the international shipping process.
4. Risk priority analysis using FMEA: Used to find the root cause of the problem that is most influential and has the greatest risk for immediate improvement. Analysis is carried out based on severity, occurrence, and detection. Furthermore, rating is done on these three factors to get the RPN (Risk Priority Number) value. The RPN value is obtained by multiplying the ratings of severity, occurrence, and detection.

2.5 Stage 5: Improve
The improvement phase consists of:
1. Determine Improvement Alternatives based on the Analysis Result: Develop recommendations and alternative improvements based on the results of root cause analysis and FMEA. Rekomendasi yang diberikan berdasarkan nilai RPN tertinggi pada analisis FMEA
2. Formation of Future Service Blueprint and Process Activity Mapping: Build Service Blueprint and Process activity mapping based on alternative recommendations that have been compiled previously.
3. Develop Targets after Improvement: The improvement recommendations that have been developed are weighted using the AHP method, which is filled in by the company's parties who are responsible for and know firsthand the international shipping service process. The improvement recommendations can minimize critical waste

## 4. Results and Discussions

4.1 Define

*4.1.1 Current Service Blueprint and Current Process Activity Mapping*

Service blueprint delineates the sequential stage of the international delivery service process, commencing with customer's order placement and conducting upon their receipt of the order. Process activity mapping is a tool used to identify and classify activities in the production process. Table 1 describes the classification of activities in the international shipping service process. These activities are categorized as value-added activity (VA), necessary but non-value-Added activity (NNVA), and non-value-Added activity (NVA). Each activity is classified into five types: operation (O), transportation (T), inspection (I), storage (S), and delay (D).

Table 1 - Activity Code Classification

| Code | Flow Process | Code | Flow Process |
|---|---|---|---|
| | *Entrance* | | *Inspection Counter* |
| E1 | Customers arrive at the office | P1 | Customer queue |
| E2 | Temperature Check | P2 | Inspection of goods |
| E3 | Retrieval number queue | P3 | The officer prepares the shipping form |
| E4 | Customers go to the waiting room | P4 | Submission form filling |
| E5 | Queue customer | P5 | Repackaging the goods to be shipped |
| E6 | Officer call queue | P6 | Recapitulate shipments manually into a book |
| E7 | The customer goes to the transaction counter | P7 | The officer hands back the goods to be delivered |

| | | | |
|---|---|---|---|
| | *Transaction Counter* | P8 | The customer goes to the transaction counter |
| | | | *Warehouse* |
| T1 | Hands over the goods to the clerk | | |
| T2 | Weighing and measuring goods | W1 | Delivery of goods and receipt documents to the warehouse |
| T3 | Checking price information based on weight and shipping destination | W2 | Inspection of conformity and goods receipt |
| T4 | The officer provides shipping cost information | W3 | Separation of goods that are not accompanied by a receipt |
| T5 | Officers submit back goods that are to be delivered to customers | W4 | Scan barcode |
| T6 | Customer to the inspection counter | W5 | Sorting according to the destination |
| T7 | Customer queue | W6 | Sorting according to the destination address |
| T8 | The customer hands over the goods to the clerk | W7 | Preparing the packaging of goods |
| T9 | Weighing and measuring goods | W8 | Scanning the barcode again |
| T10 | Form filling into the system by the clerk | W9 | Recap the shipment manually into the book |
| T11 | The officer provides information on shipping costs | W10 | Printing package handover documents |
| T12 | Payment of shipping cost | W11 | Closing the package |
| T13 | Print the tracking number | W12 | Inputting the package data code |
| T14 | Attaching the tracking number and form to the goods | W13 | Attaching the tag to the package |
| T15 | The clerk gives a copy of the tracking number to the customer | W14 | Scanning the barcode on the package |
| T17 | The clerk prints the delivery receipt | W15 | Moving the goods to the trolley |
| | *Loading Goods* | | |
| L1 | Moving all parcels to the loading area | L3 | Delivering the goods to Customs and Excise |
| L2 | Load the goods onto the transport truck | | |

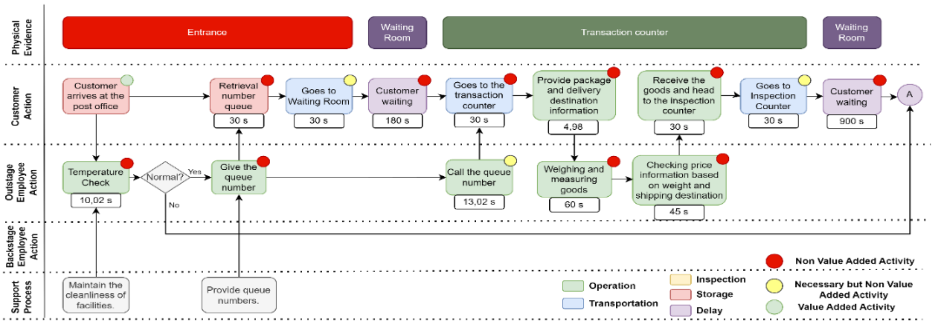



Fig. 2. Current Service Blueprint

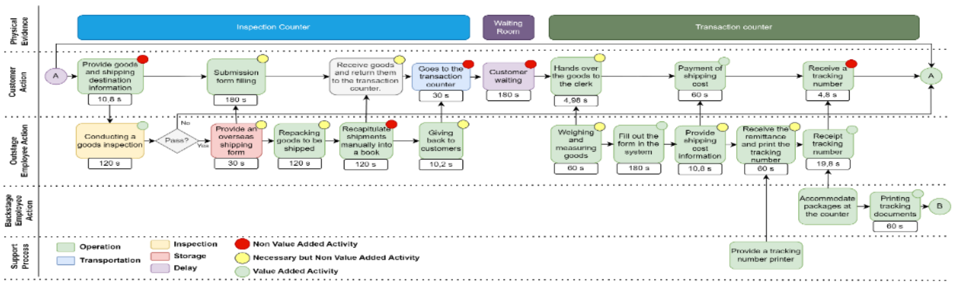



Fig. 3. Current Service Blueprint (continued)

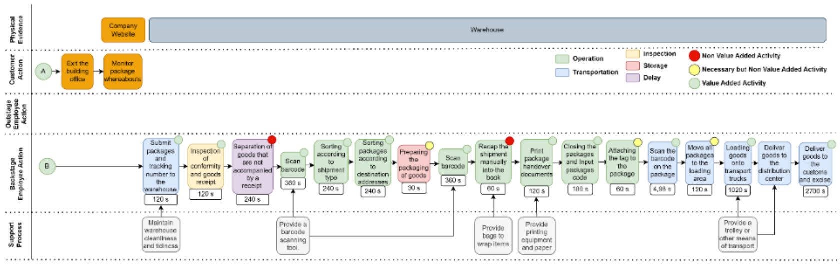



Fig. 4. Current Service Blueprint (continued)

Table 2 - Category based on Activity Code Classification

| Category | Activity Code Classification | Total Activity |
|---|---|---|
| Value Added Activity | E1, P2, T10, T12, T16, W1, W2, W4, W5, W6, W8, W10, W11, W12, W14, L2, L3 | 17 |
| Non-Value-Added Activity | E2, E3, E5, E7, T1, T2, T3, T4, T5, T7, T14, T15, P1, P6, P8, W3, W9 | 15 |
| Necessary but non-value-added activity | E4, E6, P3, P4, P5, P7, T6, T8, T9, T11, T13, W7, W13, W15, L1 | 17 |

Figure 2 and Table 2 depict the international shipping service process using a service blueprint. The data shows that the value-added activity category accounts for 34,7% of the total. This indicates that 17 out of the 49 activities in the international shipping process add value to customers. The non-value-added activity category is 34,7%, signifying that 17 out of the 49 shipping activities are classified as activities that do not provide added value to customers. Furthermore, the necessary but non-value-added activity category is 30,6%, implying that 15 out of the total 49 activities in the international shipping process are necessary but do not contribute any additional value. The process of international service delivery commences with customers obtaining a queue number and undergoing a temperature screening. The customer subsequently waits to proceed to the transaction counter. At the transaction counter, the customer's goods undergo inspection and are weighed, allowing the customer to obtain the estimated delivery time. Following the transaction counter, customers proceed to the inspection counter to complete the shipping form. After completing the delivery form, the customer receives a tracking number, and the goods are dispatched to the warehouse. Figure 2 demonstrates the presence of numerous repetitive activities performed by customers and as the identification of non-value-added activities.

### *4.1.2 Waste Identification*

Waste identification in the delivery process is accomplished by directly observing and engaging in brainstorming sessions with the company. At this stage, secondary data is also used to identify waste.

Table 3 – Data on the Number of Delays in International Shipments

| No | Period | Number of Shipments (Units) | Number of Goods delayed Shipment (Unit) |
|---|---|---|---|
| 1 | June 2020 | 616 | 173 |
| 2 | July 2020 | 817 | 221 |
| 3 | August 2020 | 960 | 336 |
| 4 | September 2020 | 886 | 302 |
| 5 | October 2020 | 760 | 213 |
| 6 | November 2020 | 797 | 287 |
| 7 | Desember 2020 | 872 | 323 |
| 8 | January 2021 | 599 | 228 |
| 9 | February 2021 | 515 | 199 |
| 10 | March 2021 | 801 | 321 |
| 11 | April 2021 | 695 | 286 |
| 12 | May 2021 | 571 | 240 |
| | **Total** | 8889 | 3129 |

Table 4 - International Returned Goods Data

| No | Period | Product (Unit) | Form Contents are not complete and or invalid (Unit) | Items that experienced delay Shipment (Unit |
|---|---|---|---|---|
| 1 | June 2020 | 616 | 112 | 173 |
| 2 | July 2020 | 817 | 151 | 221 |
| 3 | August 2020 | 960 | 235 | 336 |
| 4 | September 2020 | 886 | 207 | 318 |
| 5 | October 2020 | 760 | 154 | 213 |
| 6 | November 2020 | 797 | 203 | 287 |
| 7 | Desember 2020 | 872 | 223 | 323 |
| 8 | January 2021 | 599 | 154 | 228 |
| 9 | February 2021 | 515 | 135 | 199 |
| 10 | March 2021 | 801 | 210 | 321 |
| 11 | April 2021 | 695 | 185 | 286 |
| 12 | May 2021 | 571 | 160 | 240 |
| | **Total** | 8889 | 2129 | 3145 |

Table 5 - Waste Identification

| Waste | Description |
|---|---|
| Delay | Occurred due to customers queuing three times during the delivery process, resulting in delays of up to 10 days in the delivery of goods. In one year, 9386 units were delivered, with 3229 encountering delays |
| Duplication | It occurs when there is a lack of activity and flow of information or services, particularly during the service process at the inspection counter. The manual filling of the delivery form is one of the causes of the longest total time |
| Unnecessary Movement | This occurs when customers queue at one location and then must join another queue or proceed to another building, causing a waste of customer time and sorting activities based on the type of shipment, namely domestic or international |
| Unclear Communication | This occurs when the flow of information delivery is not clear. However, this waste is not found in the international shipping process because there is a complete procedure at the branch office or company website, and security is available to help provide information. |
| Incorrect Inventory | This waste was not found because the company consistently provides the services needed to meet customer requirements |
| Lost Opportunity | This occurs when the company loses the opportunity to earn revenue. However, this waste is not found in international shipping companies |
| Error | This occurs due to errors in data entry, receipt printing, detailed inspection of goods, being allowed prohibited items to pass inspection, and document requirements that do not comply with those set by customs. These errors result in goods being returned and causing delivery delays. According to available data, out of the 8889 units shipped, 2129 units experienced data input errors, and 3145 units experienced delays in delivery |

Table 3 and Table 4 are the company's secondary data for analyzing the number of delays in shipping goods and the number of returned goods on national shipments. Table 5 shows the identification process employs the seven wastes in the service approach: delay, duplication, unnecessary movement, unclear communication, incorrect inventory, lost opportunity, and error.

## 4.2 Measure

### 4.2.1 Critical Non-Value-Added Activity

Table 6 - Current Process Activity Mapping

| Code | Flow Process | Time (s) | Percentage |
|---|---|---|---|
| P1 | Customer queue | 900 | 49% |
| W3 | Separation of goods that are not accompanied by a receipt | 240 | 13% |
| E5 | Customer queue | 180 | 10% |
| T7 | Customer queue | 180 | 10% |
| P6 | Recapitulate shipments manually into a book | 120 | 7% |
| W9 | Recap the shipment manually into the book | 60 | 3% |
| T2 | Weighing and measuring goods | 60 | 3% |
| T3 | Checking price information based on weight and shipping destination | 40 | 2% |
| E7 | The customer goes to the transaction counter | 30 | 2% |
| T4 | The officer provides shipping cost information | 11 | 1% |
| T1 | The customer hands over the goods to the clerk | 5 | 0% |
| T5 | Officers submit back goods that are to be delivered to customers | 5 | 0% |

According to Table 6, the activities involved in the international shipping service process do not contribute any additional value. The duration of each activity will be computed as a proportion of time and utilized in a pareto chart for subsequent analysis. Pareto charts facilitate the identification of non-value added activities that contribute to the most significant time increases.

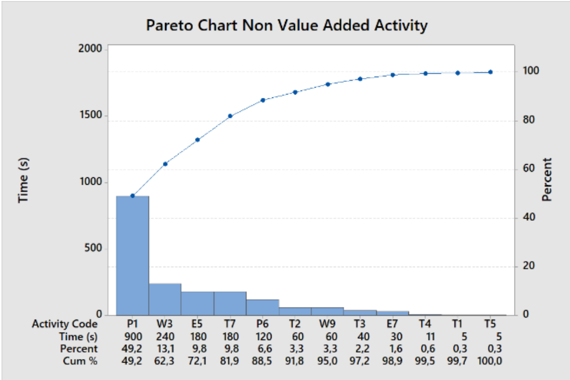



Fig. 5. Pareto Chart Non-Value-Added Activity

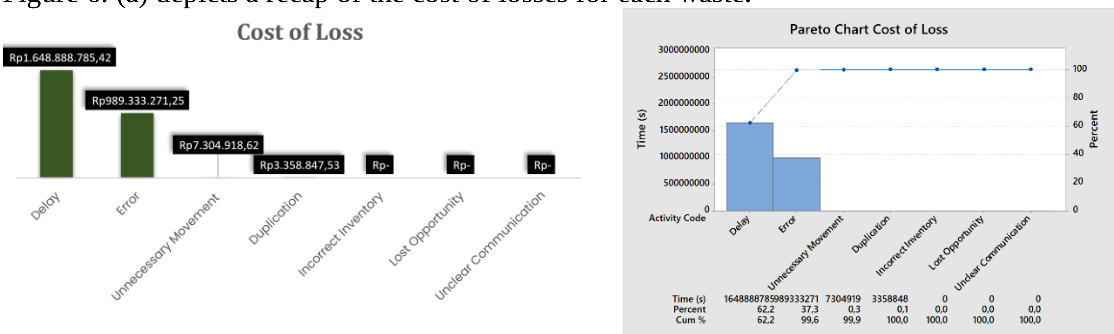
According to the data presented in Figure 5, it has been determined that three non-value-added activities are mainly with the highest total time. These activities include P1, W3, and E5 (queuing customers at the inspection counter, sorting out goods that do not meet shipping requirements, and arranging customers in a queue before they process to the transaction counter). Based on Figure 5, the customer queuing activity at the inspection counter is identified as a non-value-added activity with the longest total activity time, making it the most critical. When waste is connected to these three activities, they are considered the most critical non-value-added activities and are classified as delay waste.

4.2.2 Calculation of Waste Cost

Waste measurement is then carried out by calculating the cost of losses due to the occurrence of waste. During this stage, critical waste will be determined. Waste has the most significant influence on the financial losses experienced by the company.

1. Delay: Delays occur when the recipient still needs to receive the goods by the time set by the company, namely the earliest arrival within three days and the latest arrival within four days. However the goods are delayed on average up to 10 days.
2. Duplication: Repetitive activities such as filling out forms twice on paper forms and the system. In addition, duplication occurs in data entry, which is done manually into the book, causing additional processing time. Waste duplication makes the process inefficient because it performs unnecessary activities that can cause extra time.
3. Error: Errors in the input of shipping and inspection forms and the completeness of the requirements that cause the goods to be returned by customs. This return results in the company handling the goods sent (rework) with an average time for handling return goods, which is one week or six working days.

Figure 6. (a) depicts a recap of the cost of losses for each waste.




(a) (b)

Fig. 6. Cost of Loss: (a) Waste and (b) Pareto Chart

Based on Figure 6.b, it is determined that there are two categories of waste: delay and error. The cost of loss due to delay is Rp1,648,888,785.42, while the cost of loss due to error is Rp989,333,271.25. Both types of waste should be reduced or eliminated as much as possible. Minimizing this reduction is crucial to mitigate the losses suffered by the company and improve overall operational efficiency.

4.2.3 Sigma Value Calculation

Table 7 - Sigma Value Calculation

| No | Error | Total | Failure Rate | CTQ | DPO | DPMO | Sigma Value |
|---|---|---|---|---|---|---|---|
| | *Delay* | | | | | | |
| 1 | Delay | 3230 | 0,3634 | 1 | 0,3634 | 3634 | 1,85 |
| | *Error* | | | | | | |
| 1 | Incomplete and/or invalid form contents | 2129 | 0,307 | 3 | 0,080 | 77.881,95 | 2,92 |
| 2 | Incomplete documents | 697 | 0,078 | 3 | 0,026 | 25.037,29 | 3,46 |
| 3 | Prohibited items | 319 | 0,036 | 3 | 0,012 | 11.755,1 | 3,77 |

The calculation results in the Table 7 indicate that the DPMO (Defects Per Million Opportunities) and sigma value of waste delay are 363,370.4579 and 1.85, respectively. Regarding waste errors, specifically those related to incomplete and/or invalid form content errors, the DPMO and sigma values are 77,881.95184 and 2.95, respectively. The incomplete document error is characterized by DPMO and sigma values of 25,037.29 and 3.46. The DPMO and sigma values obtained for the type of prohibited goods error are 11,755.096 and 3.77.

4.3 Analyze

*4.3.1 Critical Waste Identification Result Analysis*

Pareto charts are graphical representations that demonstrate that 20% of causes are responsible 80% of the effects. These diagrams pinpoint the most crucial issues that necessitate immediate enhancement, thereby enhancing processes and service quality. Figure 5 indicates that the critical value-added activities include the customer queuing activity at the inspection counter, separating goods without a delivery receipt, and the queue at the entrance to access the international shipping counter. These three essential activities that do not add value contribute to the inefficiency of the international shipping service process.

Figure 6 illustrates the calculation of the lost opportunity cost for each identified waste. Based on Figure 5, waste delay and error are identified as critical wastes due to their significant impact on lost opportunity cost. Hence promptly identify the underlying cause for each significant waste and implementing enhancements to improve the process and quality of international shipping services is crucial.

4.3.2 Initial Sigma Value Analysis

As defined by (Von Rosing et al., 2015) quantifies process capability, indicating the extent to which a process aligns with company standards and customer requirements. Higher sigma values indicate superior processes, characterized by outputs closely aligned with customer expectations and computed sigma values for two critical waste categories: delay and error. We assessed three categories of error that caused product returns as a result of unmet delivery requirements. The sigma value for errors with incomplete or invalid form contents was only 2.92, indicating a significant deviation from the ideal 6 sigma level. The low value corresponds to the high Defect per Million Opportunity (DPMO) for this specific error type, highlighting a frequent occurrence of returning goods due to inaccurate forms. Although it is still below the 6-sigma target, other error categories showed higher sigma values: 3.46 for incomplete required documents and 3.77 for prohibited goods. This indicates a reduced occurrence of these errors compared to those related to inaccuracies. The calculated sigma value for delivery delays, based on the number of late deliveries, is a concerning 1.85. This value significantly deviates from the 6-sigma benchmark, suggesting a high frequency of delays. To further emphasize this point, the DPMO reaches a staggering 363,370 delays per million opportunities.

4.3.3 Critical Waste Analysis

Critical waste cause analysis is conducted using the 5 Whys root cause analysis approach. The 5 Whys approach is chosen for its effectiveness in uncovering root causes, leading to defect improvement and reduction, operational efficiency, and better management.

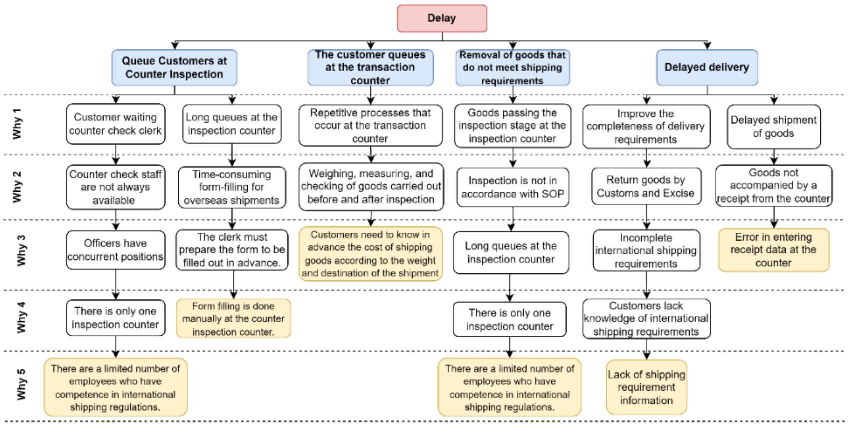


Fig. 7. 5 Whys Analysis Waste Delay

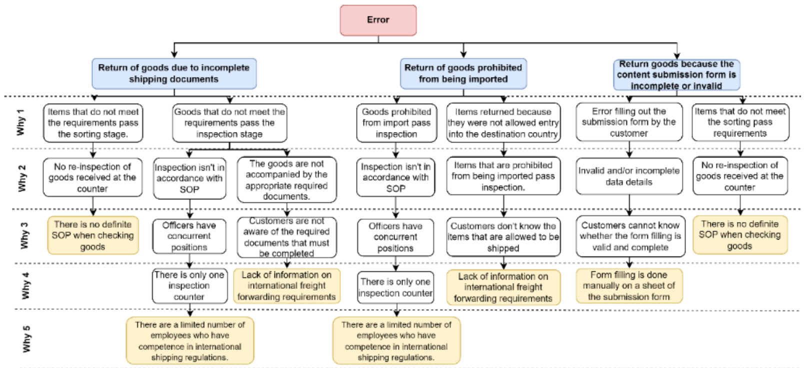


Fig. 8. 5 Whys Analysis Waste Error

Figures 7 and 8 illustrates the underlying factor responsible for significant inefficiencies in the global shipping service procedure. The root causes include the limited number of employees with competence in international shipping regulations, manual form filling at the inspection counter, lack of information on shipping requirements, and the absence of a definite SOP for checking the completeness of goods before the sorting process.

### 4.3.4 Failure Mode and Effect Analysis (FMEA)

FMEA (Failure Modes and Effects Analysis) is a method employed to identify and examine potential failure modes of a system and their effects on system performance. This analysis assists in prioritizing design issues, incorporating additional safety features, and minimizing the potential impact of failures on system operations (Nasrallah et al., 2023). FMEA is crucial in facilitating sustainable manufacturing by mitigating risks linked to the shift toward more environmental rocess. In this research, FMEA helps identify, evaluate, and minimize the risk of waste failure. It also provides preventive solutions to reduce risks and corrective actions if failures occur. The FMEA analysis was mapped based on the root causes of the two critical wastes.

Table 8 - FMEA scores of Occurrences, Severity, and Detection

| Occurrence | | Severity | | Detection | |
|---|---|---|---|---|---|
| Score | Description | Score | Description | Score | Description |
| 1 | Never happens in 1 year | 1 | None | 1 | Almost certain |
| 2 | Very Low: once a year. | 2 | Very Minor | 2 | Very High |
| 3 | Low: once in 6 months | 3 | Minor | 3 | High |
| 4 | Moderate: once in 3 months | 4 | Very Low | 4 | Moderate |
| 5 | Moderate: once in 2 months | 5 | Low | 5 | Moderate |
| 6 | Moderate: once a month | 6 | Moderate | 6 | Low |
| 7 | High: once in 2 weeks | 7 | High | 7 | Very Low |
| 8 | High: once a week | 8 | Very High | 8 | Remote |
| 9 | Very High: every three days | 9 | Hazardous with Warning | 9 | Very Remote |
| 10 | Very High: every day | 10 | Hazardous without | 10 | Impossible to |

| Occurrence | | Severity | | Detection | |
|---|---|---|---|---|---|
| Score | Description | Score | Description | Score | Description |
| | | | Warning | | detect |

Table 9 - FMEA scores of Occurrences, Severity, and Detection

| Failure Mode | Potential Effect | S | Potential Cause | O | Control | D | RPN | Recommended Action |
|---|---|---|---|---|---|---|---|---|
| | | | | *Delay* | | | | |
| The customer queues at the inspection counter | Long customer waiting time | 5 | There are a limited number of employees who have competence in international shipping regulations | 10 | Staff supervision | 1 | 50 | Provision of training to all employees at Counter |
| | | | Manual submission form filling | 10 | Supervision by counter staff | 1 | 50 | Create an online international submission form-filling system. |
| The customer queues at the transaction counter | Long customer waiting time | 5 | Customers need to know in advance the cost of shipping goods according to the weight and destination of the shipment | 10 | Staff supervision | 1 | 50 | Create a system form filling submission system form filling system online that will calculate shipping costs. |
| Delayed delivery | Goods arrive later than the set time | 8 | Inspection of goods at the inspection counter is not detailed according to SOP | 9 | Inspection of goods after arrival at customs and excise | 2 | 144 | Provision of training to all employees at Counter |
| Transfer goods that do not meet the requirements for shipping | Delaying the sorting process | 5 | The receipt does not match the number of items to be shipped | 3 | Inspection of goods and receipt of goods before processing sorting | 1 | 15 | Create an SOP to conduct a re-inspection before delivery of goods to the warehouse |
| | | | | *Error* | | | | |
| Return goods due to document requirements shipping incomplete | Delivery is delayed because we need to adjust meet the requirements | 8 | Lack of information on international freight forwarding requirements | 7 | Inspection of goods at the inspection counter | 2 | 112 | Develop an online global shipping form with tailored information on shipping prerequisites based on the type of goods and destination country |
| | | | Inspection isn't in accordance with SOP | 10 | Inspection of goods after arrival at customs and excise | 2 | 160 | Create an SOP for rechecking shipping requirement documents before sorting goods |
| | | | There are a limited number of employees who have competence in international shipping | 10 | Staff supervision | 1 | 80 | Provision of training to all employees at Counter |

| Failure Mode | Potential Effect | S | Potential Cause | O | Control | D | RPN | Recommended Action |
|---|---|---|---|---|---|---|---|---|
| | | | regulations | | | | | |
| Return of goods prohibited from being imported | Delivery is delayed because we need to adjust meet the requirements | 8 | Lack of information on international freight forwarding requirements | 6 | Inspection of goods at the inspection counter | 2 | 96 | Develop an online global shipping form with tailored information on shipping prerequisites based on the type of goods and destination country |
| | | | There are a limited number of employees who have competence in international shipping regulations | 10 | Staff supervision | 1 | 80 | Provision of training to all employees at Counter |
| Return goods because the content submission form is incomplete or invalid | Delivery is delayed because we need to adjust meet the requirements | 8 | Form filling is done manually on a sheet of the submission form | 10 | Inspection completeness requirements before process sorting | 2 | 160 | Develop an online global shipping form |

From Table 9, shows that the failure modes with the highest RPN on waste delay are delayed delivery, the customer queues at the inspection counter, and the customer queues at the transaction counter. In waste error, the failure modes with the highest RPN are return goods due to incomplete document requirements shipping and return goods because the content submission form is incomplete or invalid. Failure modes must be improved with the highest RPN before they affect other activities.

## 4.4 Improve

### 4.4.1 Improvement Recommendation

Table 10 - Improvement Recommendation

| Critical Waste | Root Cause | Recommended Action |
|---|---|---|
| Delay | There are a limited number of employees who have competence in international shipping | Provision of training to all employees at Counter |
| | Manual submission form filling | Create an online international submission form-filling system. |
| | Customers need to know in advance the cost of shipping goods according to the weight and destination of the shipment | Create a system form filling submission system form filling system online that will calculate shipping costs. |
| | Inspection of goods at the inspection counter is not detailed according to SOP | Provision of training to all employees at Counter |
| Error | Lack of information on international freight forwarding requirements | Develop an online global shipping form with tailored information on shipping prerequisites based on the type of goods and destination country |
| | Inspection isn't in accordance with SOP | Create an SOP for rechecking shipping requirement documents before sorting goods |
| | Form filling is done manually on a sheet of the submission form | Create an online international submission form-filling system. |

Table 10 displays the improvement recommendations based on the root causes of each critical waste in the international shipping service process. There are three improvement recommendations given, namely:

1. Create an online international shipping form-filling system through the company's Website or application. The online form aims to reduce the possibility of errors in filling out the form due to incomplete or invalid form contents.

2. Customs training should be provided to all international shipping counter employees so that goods can be inspected directly at the global shipping counter without going to the inspection and delivery counter.
3. Create an SOP regarding re-examining the completeness of the requirements for shipping goods in the warehouse process before sorting the goods according to the delivery destination.

### 4.4.2 Future Service Blueprint and Process Activity Mapping

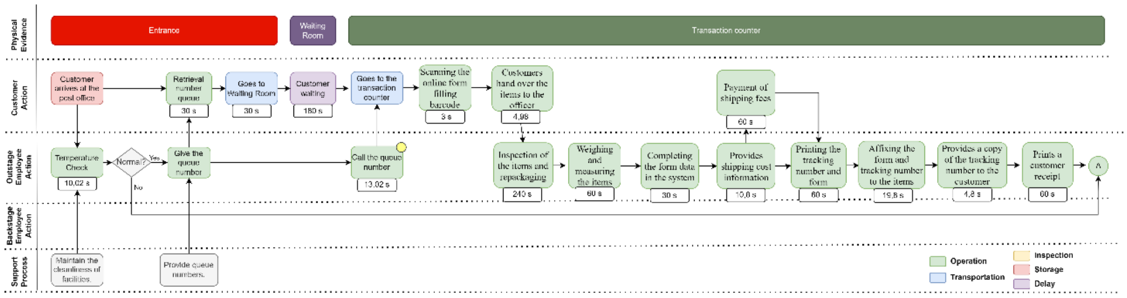



Fig. 9. Future Service Blueprint

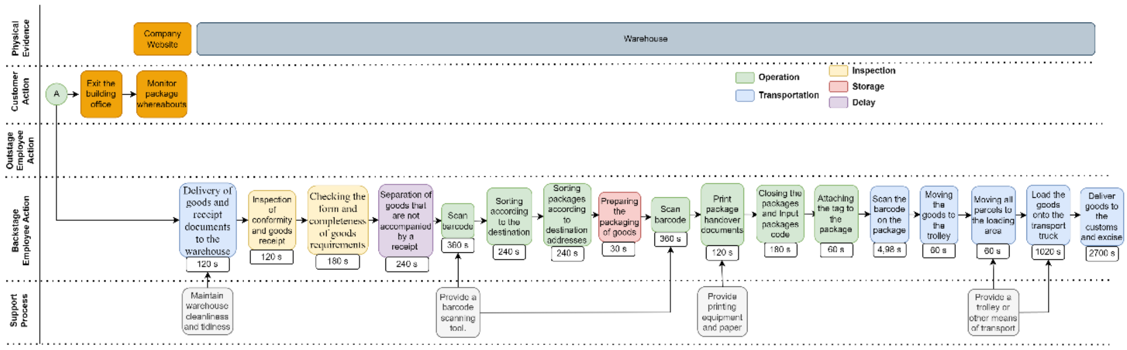



Fig. 10. Future Service Blueprint (continued)

Based on Figure 9 shows that changes to the future service blueprint include that customers no longer need to fill out forms manually because they can do so online through the company's website or application. Customers also do not need to queue three times to go to the shipping counter, the inspection counter, and back to the shipping counter. Still, customers now only go directly to the international shipping counter. So, the service process time at the counter is reduced by 10.25 minutes.

Table 11 - Future Process Activity Mapping

| Code | Flow Process | Machine/ Tools | Time (s) | Activity | | | | | Number of Operator | Category |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | O | T | I | S | D | | |
| | | | Entrance | | | | | | | |
| E1 | Customers arrive at the office | | | O | T | I | S | D | | VA |
| E2 | Temperature Check | Tools checker temperature | 10,02 | O | T | I | S | D | 1 | NVA |
| E3 | Retrieval number queue | | 30 | O | T | I | S | D | 1 | NVA |
| E4 | Customers go to the waiting room | | 30 | O | T | I | S | D | | NNVA |
| E5 | Queue customer | | 180 | O | T | I | S | D | | NVA |
| E6 | Officer call queue | | 13,02 | O | T | I | S | D | 1 | NNVA |
| | | | Transaction Counter | | | | | | | |
| T8 | Scanning the online form filling barcode | | 3 | O | T | I | S | D | | VA |

| Code | Flow Process | Machine/ Tools | Time (s) | Activity | | | | | Number of Operator | Category |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | O | T | I | S | D | | |
| T9 | Customers hand over the items to the officer | | 4,98 | **O** | T | I | S | D | 3 | NNVA |
| T10 | Inspection of the items and repackaging | | 240 | **O** | T | I | S | D | 3 | VA |
| T11 | Weighing and measuring the items | | 60 | **O** | T | I | S | D | 3 | NNVA |
| T12 | Completing the form data in the system | Computer | 30 | **O** | T | I | S | D | 3 | VA |
| T13 | The officer provides shipping cost information | | 10,8 | **O** | T | I | S | D | 3 | NNVA |
| T14 | Payment of shipping fees | | 60 | **O** | T | I | S | D | 3 | VA |
| T15 | Printing the tracking number and form | Computer and printer | 60 | **O** | T | I | S | D | 3 | NNVA |
| T16 | Affixing the form and tracking number to the items | | 19,8 | **O** | T | I | S | D | 3 | VA |
| T17 | The officer provides a copy of the tracking number to the customer | | 4,8 | **O** | T | I | S | D | 3 | NNVA |
| T18 | The officer prints a customer receipt | Printer | 60 | **O** | T | I | S | D | 3 | VA |
| | | | Warehouse | | | | | | | |
| W1 | Delivery of goods and receipt documents to the warehouse | Trolley | 120 | O | **T** | I | S | D | 1 | VA |
| W2 | Inspection of conformity and goods receipt | | 120 | O | T | **I** | S | D | 1 | VA |
| W3 | Checking the form and completeness of goods requirements | | 180 | O | T | **I** | S | D | 1 | VA |
| W4 | Separation of goods that are not accompanied by a receipt | | 240 | **O** | T | I | S | D | 1 | NVA |
| W5 | Scan Barcode | Scanner | 360 | **O** | T | I | S | D | 1 | VA |
| W6 | Sorting according to the destination | | 240 | **O** | T | I | S | D | 1 | VA |
| W7 | Sorting according to the destination address | | 240 | **O** | T | I | S | D | 1 | VA |
| W8 | Preparing the packaging of goods | | 30 | O | T | I | **S** | D | 1 | NNVA |
| W9 | Scanning the barcode again | Scanner | 360 | **O** | T | I | S | D | 1 | VA |
| W10 | Printing package handover documents | Printer | 120 | **O** | T | I | S | D | 1 | VA |
| W11 | Closing the package | | 60 | **O** | T | I | S | D | 1 | NN VA |
| W12 | Inputting the package data code | Computer | 120 | **O** | T | I | S | D | 1 | VA |
| W13 | Attaching the tag to the package | | 60 | **O** | T | I | S | D | 1 | NNVA |
| W14 | Scanning the barcode on the package | Scanner | 4,98 | O | **T** | I | S | D | 1 | VA |

| Code | Flow Process | Machine/ Tools | Time (s) | Activity | | | | | Number of Operator | Category |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | O | T | I | S | D | | |
| W15 | Moving the goods to the trolley | | 60 | O | T | I | S | D | 1 | NNVA |
| | | | Loading Goods | | | | | | | |
| L1 | Moving all parcels to the loading area | Trolley | 60 | O | T | I | S | D | 2 | NNVA |
| L2 | Load the goods onto the transport truck | Trolley | 1020 | O | T | I | S | D | 5 | VA |
| L3 | Delivering the goods to Customs and Excise | Transport Trucks | 2700 | O | T | I | S | D | 2 | VA |
| Total | | | 6448,2 | | | | | | | |
| | Operation | 2213,4 | | | Value Added | | | | 20 | 56% |
| | Transportation | 3994,98 | | | Necessary but Non-Value Added | | | | 4 | 11% |
| | Inspection | 30 | | | Non-Value Added | | | | 12 | 33% |
| | Storage | 30 | | | | | | | | |
| | Delay | 180 | | | | | | | | |

According to Table 11, the proposed improvement recommendations aim to eradicate non-essential activities at the shipping counter and the activity of filling out shipping forms at the inspection counter. Upon completion of the post improvement process activity mapping, the proportions of the three activity categories were determined and compared to the current process activity mapping. These improvements aim to enhance efficiency and eliminate non-value-added activities in the shipping process. These changes are in line with the principles of Lean Six Sigma, which aim to achieve more optimal operational results.

Upon analyzing the tables before and after the improvement, there is a total decrease of 13 activities. Before improvement, the proportion of value-added activities was 37%. After improvement, this proportion increased to 56%, indicating a 19% increase in value-added activities. Concurrently, the percentage of non-value-added activities decreased from 29% to 11%, indicating an 18% reduction in the proportion of these activities. The Necessary but non-value-added category saw a 2% reduction in its proportion, from 35% to 33%. This data illustrates the shift in the proportion of each activity category following the improvement, showing a substantial rise in value-added activities and a reduction in non-value-added activities.

### 4.4.3 Target After Improvement

The company addressed each defect by implementing targeted recommendations for specific changes. This is a strategic step to enhance the process and ensure a reduction in defects in the shipping process, simultaneously enhancing the overall performance of international shipping services. The company's objective is to bring about changes by implementing these improvement recommendations, which include reducing the number of items returned for each issue and a 50% reduction in the number of delayed items each month.

Table 12 - Future Sigma Value Calculation

| No | Error | Total | Failure Rate | CTQ | DPO | DPMO | Sigma Value |
|---|---|---|---|---|---|---|---|
| | | | | Delay | | | |
| 1 | Delay | 1576 | 0,177 | 1 | 0,177 | 177297,8 | 3,06 |
| | | | | Error | | | |
| 1 | Incomplete and/or invalid form contents | 1068 | 0,120 | 3 | 0,040 | 13.162,34 | 3,25 |
| 2 | Incomplete documents | 351 | 0,039 | 3 | 0,013 | 6.149,923 | 3,72 |
| 3 | Prohibited items | 164 | 0,018 | 3 | 0,006 | 11.755,096 | 4 |

Table 13 - Comparison of Existing and Target Waste Sigma Values

| No | Error | Initial Sigma Value | Target sigma value | Difference |
|---|---|---|---|---|
| | | Delay | | |
| 1 | Delay | 1,85 | 3,06 | 1,21 |
| | | Error | | |
| 1 | Incomplete and/or invalid form contents | 2,92 | 3,25 | 0,33 |
| 2 | Incomplete documents | 3,46 | 3,72 | 0,26 |
| 3 | Prohibited items | 3,77 | 4 | 0,23 |

Based on Table 12 and Table 13, there is an increase in the sigma values for all categories of errors that occur during the international shipping process. The error category with the most significant increase is "incomplete and invalid form content", with a rise of 0.33. This is followed by "incomplete documents" with an increase of 0.26, and "prohibited item shipping" with an increase of 0.23. The significant increase in sigma values, especially for form content errors, suggests that the implemented improvement recommendations can effectively resolve the commonly encountered error issues in international shipping.

Regarding the waste delay, the sigma value has increased by 1.21. The effectiveness of the implemented improvement recommendations in addressing the root causes of delivery delays, specifically related to item returns caused by errors or mistakes in the item inspection process reason for this attribution. The improvements in this process have a favourable influence on diminishing waste delay and enhancing the overall efficiency of international shipping services.

One notable case is the implementation of Lean Six Sigma at a global logistics provider, courier company. According to a case study by (Lemke et al., 2021) the company adopted Lean Six Sigma principles to streamline its warehousing operations. Through value stream mapping and root cause analysis, courier company identified key bottlenecks and implemented targeted improvements, resulting in a 25% reduction in order processing time and a 15% increase in overall productivity. Similarly, a study by (Navarro, 2021) examined the impact of Lean Six Sigma on a regional freight transportation company. The authors reported a significant decrease in transportation costs and delivery times after the company adopted Lean Six Sigma methodologies. By focusing on continuous improvement and employee engagement, the company fostered a culture of quality and accountability, leading to enhanced service delivery and customer satisfaction. In conclusion, the literature on industry benchmarks in logistics using Lean Six Sigma demonstrates the significant impact of these methodologies on operational performance. By integrating Lean principles of waste reduction with Six Sigma's focus on quality improvement, logistics firms can enhance efficiency, reduce costs, and improve customer satisfaction.

## 5. Conclusion

Waste identified in the international shipping service process is based on seven service wastes: delays, duplication, unnecessary transfers, and errors. Based on the Pareto diagram, from the seven wastes, it is known that delay and error are critical wastes in the international shipping service process. Two types of waste are identified as critical waste, namely delay waste and error waste. Based on the sigma level calculation for the two critical wastes, the sigma waste delay value is 1.85. The sigma value is very far from the 6-sigma level, which means the ability of the delivery process to produce deliveries on time according to customer wishes is still poor. Meanwhile, in waste errors, there are three types of errors, namely incomplete and/or invalid form contents, goods with incomplete and/or invalid required documents, and prohibited goods, with sigma values of 2.92, 3.46, respectively, and 3.77. The recommendations given include creating a system for filling out online international shipping forms that displays shipping costs and requirements, creating a standard operating procedure for checking completeness before the sorting process, and providing training to all counter employees for the inspection process at international shipping counters. Future service blueprint changes mean customers no longer need to fill out forms manually; they fill it out online via the company's website or application. Customers also no longer need to queue three times, starting from the delivery counter to the inspection counter and vice versa. Now, customers go directly to the international shipping counter, reducing the service processing time at the counter by 10.25 minutes. However, there are limitations in this study, including the lack of expert validation of the improvement recommendations due to limited time and research costs. Furthermore, the implementation of improvement recommendations within the company's process necessitates a significant investment of time and financial resources. Therefore, the agreement with the company limits this study to the improvement proposal. Therefore, validation of the recommendation purposed, and a more detailed cost-benefit analysis can be carried out in further research.

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