

# Evaluation of the Procurement Process Regarding Delays in Goods Delivery After the Purchase Order (PO) Document is Released in Systems Applications and Products (SAP)

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## ARTICLE INFO

### Article history

Received 2025-06-20

Revised 2025-07-16

Accepted

### Keywords

Procurement

Delayed Delivery

DMAIC

Purchase Order

SAP

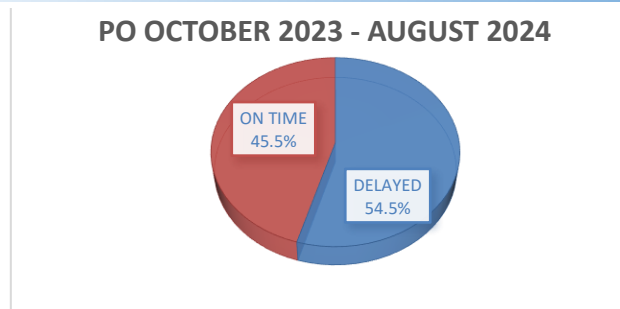
## ABSTRACT

Delays in the delivery of goods in the procurement process are a serious challenge for manufacturing industries, including PT X which is engaged in metal stamping and electronic component assembly. This study aims to identify the causes of delays and design improvement strategies to minimize their impact on the production process. Data was obtained through interviews and documentation from the SAP system with a mixed approach (quantitative and qualitative) with a mixed method type of sequential explanatory design, and analyzed using the DMAIC method. The results showed that delays in the delivery of goods after the issuance of a Purchase Order (PO) document in the SAP system were caused by a number of internal factors in the procurement process, such as the length of time for automatic Purchase Requisition (PR) generation, time-consuming approval processes, and external factors such as the readiness of vendor companies to produce goods and the obstruction of the goods distribution process due to natural factors. These delays have a negative impact on both parties. Delays in the delivery of goods in the procurement process are a serious challenge for manufacturing industries, including PT X which is engaged in metal stamping and electronic component assembly. This study aims to identify the causes of delays and design improvement strategies to minimize their impact on the production process. Data was obtained through interviews and documentation from the SAP system with a mixed approach (quantitative and qualitative) with a mixed method type of sequential explanatory design, and analyzed using the DMAIC method. The results showed that delays in the delivery of goods after the issuance of a Purchase Order (PO) document in the SAP system were caused by a number of internal factors in the procurement process, such as the length of time for automatic Purchase Requisition (PR) generation, time-consuming approval processes, and external factors such as the readiness of vendor companies to produce goods and the obstruction of the goods distribution process due to natural factors. These delays have a negative impact on both parties.

## 1. Introduction

In the competitive manufacturing industry, procurement plays a crucial role in ensuring the smooth operation of the company. Procurement teams are responsible for ensuring quality goods and services are available on time and in quantity. However, the delay of goods after ordering remains a major challenge, which can disrupt production, increase costs, and decrease customer satisfaction (Arief & Gunawan, 2023; Riswandi & Yudoko, 2023). PT X, which is engaged in metal stamping and electronic component assembly, faces similar constraints, particularly in the procurement of materials such as Brass Strip from India used in the production of electric toothbrushes. During the period October 2023 to August 2024, the order value of this material ranged from USD 21,396.6 to USD 83,385.5 per transaction. Analyzing the causes of delays, both from suppliers and internal factors, is an important step to maintain the stability of the company's production and service quality.





**Figure 1.** Percentage of PO documents delivered on time and delayed

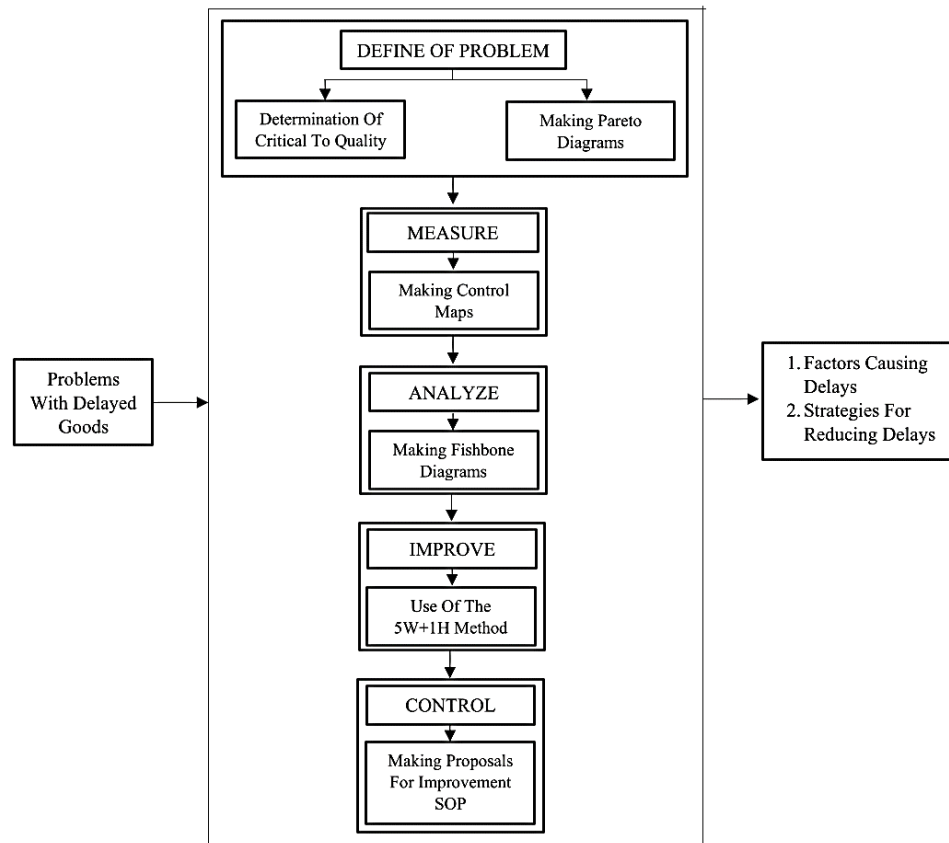
Figure 1 shows the percentage data obtained from October 2023 to August 2024 shows that the Purchase Order (PO) documents that are on time are 45.5% with an actual number of 5 Purchase Order (PO) documents and those that are late in coming are 54.5% with an actual number of 6 Purchase Orders (PO) out of a total of 11 Purchase Order (PO) documents that have come out. For Purchase Order (PO) documents that are delayed have the number of each item which, if totaled, can reach 23 boxes with a total of 20,889 units with a net order value of around USD 174,931.50, if converted into IDR 2,834,257,656. This problem needs to be resolved because delays can have a long-term impact on business value, including customer satisfaction (including trust and loyalty) and the company's brand reputation. Low customer satisfaction and brand reputation can reduce product sales, which in turn will affect the company's revenue (Riswandi & Yudoko, 2023).

**Table 1.** PO document data from October 2023 to August 2024

PO DATE	TOTAL PO	%	DELAYED PO	ON TIME PO	DELAYED PO (%)	ON TIME PO (%)
August 2024	2	18.18%	1	1	50%	50%
April 2024	2	18.18%	0	2	0%	100%
March 2024	2	18.18%	2	0	100%	0%
December 2023	2	18.18%	2	0	100%	0%
October 2023	3	27.27%	1	2	33.33%	66.67%
<b>Total</b>	<b>11</b>	<b>100%</b>	<b>6</b>	<b>5</b>		

Table 1 shows the number of Purchase Orders (POs) each month that were delayed, with the highest number of delayed Purchase Orders (POs) occurring in March with 2 and December 2023 with 2 documents each. To address delivery delays, an effective procurement strategy is needed, as previously studied by Somadi (2020) and Ramadhan et al. (2022) using the DMAIC method to identify the causes of delays, though their focus was limited to the number of delayed items. Tirtaningrum and Ernawati (2023) used process mapping to analyze delay factors, while Riswandi and Yudoko (2023) proposed handling strategies, but with a less comprehensive analytical approach. This study aims to address these shortcomings by taking Purchase Order (PO) documents as the research subject and PT. X as the object. The objective is to identify the types and factors causing delivery delays and design effective improvement strategies to minimize their impact on the company's production process.

## 2. Method



**Figure 2.** Framework of Thought

Figure 2 shows the framework of this research process, which uses a mixed-method approach, combining quantitative and qualitative approaches. This mixed-method research approach employs a sequential explanatory design, where qualitative data collection and analysis are used to explain and deepen findings from quantitative data, thereby enabling the research to produce more accurate data and relevant solutions. The analysis technique used is the DMAIC method, which consists of five stages: define (identifying the problem and objectives), measure (measuring current performance), analyze (analyzing the root causes of the problem), improve (proposing process improvements), and control (monitoring and ensuring the sustainability of improvements). Each stage in DMAIC uses different analytical tools according to its purpose, as shown in the research framework in Figure 2. Regarding the type of methodological approach, quantitative methods are used in the define and measure stages, while qualitative methods are used in the analyze, improve, and control stages.

Regarding data collection, the researcher collected data through interviews and documentation from the System Application and Product (SAP). The data sources consisted of primary and secondary data. Primary data was obtained through interviews using non-probability sampling, employing purposive sampling techniques involving purchasing staff, purchasing assistant managers, and store personnel at PT.X. Meanwhile, secondary data was derived from SAP documentation related to Purchase Orders (POs) issued from October 2023 to August 2024, including the quantity of goods per PO and their delivery status (on time or delayed). The research analysis process was conducted as follows.

### 2.1. Define

This stage aims to identify and determine the main problems, research objectives, and relevant limitations in the process. In addition to collecting data on goods delays, this stage also collects other problems related to purchase orders (POs) that experience delays after being released in the SAP system. Therefore, there is data that needs to be collected at PT X, including:

- a. The procurement process and the time required from the release of the Purchase Order (PO) document to the delivery of goods from the vendor
- b. Number of orders in Purchase Orders (POs) from October 2023 to August 2024
- c. Purchase Order (PO) documents that have been delayed and the total number of items that have been delayed and items that do not match the order (shortage)
- d. Verification and approval process for Purchase Order (PO) documents in SAP.

Once the data has been collected, it can be seen that the problem is not only the delay in delivery but also the discrepancy in the quantity of goods received. Therefore, the most suitable method to help researchers focus their research is the Critical To Quality (CTQ) method. The following are the results of the data (Somadi, 2024).

**Table 2.** Goods Delivery Issues

Data	Total Delivery	Problem	Type of Problem	
			Delayed Delivery of Goods	Shortage of Goods
August 2024	5,631	4,111	2,742	1,369
April 2024	16,997	0	0	0
March 2024	12,333	6,473	6,368	105
December 2023	10,927	10,927	10,927	0
October 2023	11,593	958	852	106
<b>Total</b>	<b>57,270</b>	<b>22,469</b>	<b>20,889</b>	<b>1,580</b>

Table 2 shows data on the number of items per Purchase Order (PO) taken directly from the SAP system, with the most problems occurring in Purchase Orders (PO) in December 2023 with a total of 10,927 units and March 2024 with 6,473 units.

#### 1) Critical To Quality (CTQ)

Focus on determining the most crucial quality aspects to be improved, which will then be followed by further improvement efforts. The CTQ process consists of two main steps, namely.

- a. Calculating Critical To Quality (CTQ)

**Table 3.** Check sheet Type of problem

Data	Type of Problem		Total
	Delayed Delivery of Goods	Shortage of Goods	
Time Issue 1	(Delayed Delivery of Goods Time Issue 1)	(Shortage of Goods Quantity Time Problem 1)	(Total Overall Time of Problem 1)
Time Issue 2	(Delayed Delivery of Goods Time Issue 2)	(Shortage of Goods Quantity Time Problem 2)	(Total Overall Time of Problem 2)
Time Issue 3	(Delayed Delivery of Goods Time Issue 3)	(Shortage of Goods Quantity Time Problem 3)	(Total Overall Time of Problem 3)
<b>Total</b>	(Total Delay in Delivery of Goods)	(Total Shortage of Quantity of Goods)	(Grand Total)

(Source : Somadi., Tahun 2020)

Table 3 above is a summary of the data obtained to facilitate analysis in the next stage. In the next stage, cumulative percentages are calculated for each type of problem, such as delays in delivery, to understand how much impact they have on overall quality (Somadi., 2020).

a) Delays in the delivery of goods

$$percentage \% = \frac{unit\ count}{frequency\ count} \times 100$$

b) Shortage of goods

$$percentage \% = \frac{unit\ count}{frequency\ count} \times 100$$

**Table 4.** Percentage of Delivery Delay Based on CTQ

No	Problem Identification	Frequency	Accumulated Frequency	Percentage of Total	Percentage of Total
1	Delayed Delivery of Goods	(Total Delays in Goods Delivery)	(Total Delay in Delivery of Goods)	(Result of Percentage of Shipments)	(Total Percentage of Late Deliveries)
2	Shortage of Goods	(Total Shortages in Goods Quantity)	(Total Delay in Delivery of Goods + Shortage in Quantity of Goods)	(Result of Total Shortage in Quantity of Goods)	(Total Percentage of Late Deliveries + Shortages)
<b>Total</b>		(Total Frekuensi)		(Total persentase)	

(Source: Somadi., Tahun 2020)

Table 4 shows data used to determine the percentage of problems encountered, taking into account that the results must correspond to a frequency of 100%.

b. Establishing Critical To Quality (CTQ)

That is, researchers determine which problems occur most frequently and have the greatest impact on process quality. In other words, researchers identify existing problems in the company that need to be improved, so that the improvements made focus on the things that have the greatest effect on quality (Ramadan dkk., 2022)

**Table 5.** CTQ Characteristics

No	CTQ	Types of losses
1	Delayed Delivery of Goods	(Impact of delayed goods)
2	Shortage of Goods	(Impact of insufficient quantity of goods)

(Source: Somadi., Tahun 2020)

Table 5 shows the results of the study when creating a table of losses incurred due to delays based on the data obtained.

**2) Pareto Chart**

Meanwhile, Pareto charts are used to help map out key issues based on Critical To Quality (CTQ) analysis, enabling companies to focus on improvements that will have the greatest impact (Somadi, 2020).



**Figure 3.** Lines on the Fishbone Diagram

(Source : Somadi, Tahun 2020)

Figure 3 above shows the fishbone diagram that will be created in the define stage, with data referring to the results of Critical To Quality (CTQ).

**2.2.Measure**

The Measure stage aims to follow up on the Define stage by validating the identified problems. According to this stage, to measure the severity of a problem in this study, a Control map is created. After calculating the Critical To Quality (CTQ), the next step is to perform an analysis using a control chart to determine whether the results of the Critical To Quality (CTQ) are still within the statistical control limits or have exceeded the established tolerance (Ramadan dkk., 2022).

One type of control chart is the *P* control chart. There are several steps in compiling this control chart, as follows (Rollandiaz & Iskandar, 2024).

- a. Perform a calculation to obtain the percentage of delay for each PO, using the following formula:

$$p1 = \frac{x1}{n1}$$

Explanation:

*p* = Proportion of delays

*x* = Count of delays per month

*n* = Count of shipments per month

- b. Calculate the average percentage of delay or center (CL) on the control chart as the center line using the following formula :

$$CL = \frac{\sum x}{\sum n}$$

Explanation:

$\sum x$  = Total count of delays

$\sum n$  = Total count of shipments

- c. Calculate the Upper Control Limit (UCL) and Lower Control Limit (LCL) using the following formula:

$$UCL = CL + 3 \frac{\sqrt{CL(1 - CL)}}{ni}$$

$$LCL = CL - 3 \frac{\sqrt{CL(1 - CL)}}{ni}$$

Explanation:

*CL* = Total count of average percentage results of delays

*ni* = Total count of delays

- d. Create a control limit calculation table

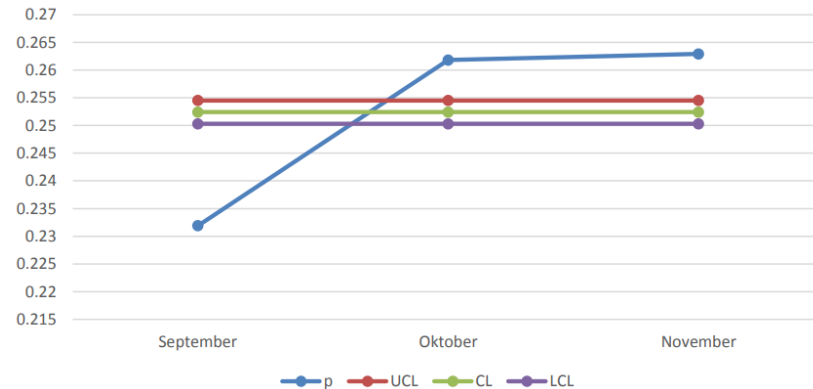
**Table 6.** Delay *P* Control Limit Calculation

Purchase Order	Total Of Shipment	Total Of Delays	<i>P</i>	<i>CL</i>	<i>UCL</i>	<i>LCL</i>
August 2024	Total	Delayed/PO	Result	Result	Result	Result
	goods/PO	Goods	<i>PI</i>	<i>CL</i>	<i>UCL</i>	<i>LCL</i>
April 2024	Total	Delayed/PO	Result	Result	Result	Result
	goods/PO	Goods	<i>PI</i>	<i>CL</i>	<i>UCL</i>	<i>LCL</i>
December 2023	Total	Delayed/PO	Result	Result	Result	Result
	goods/PO	Goods	<i>PI</i>	<i>CL</i>	<i>UCL</i>	<i>LCL</i>

(Source: Somadi., Tahun 2020)

Table 6 above is a table created to determine the control limits of the results of previous calculations.

- e. Once the control limits have been obtained, the next step is to create a control chart.



**Figure 4.** Delay P Control Map

(Source : Somadi., Tahun 2020).

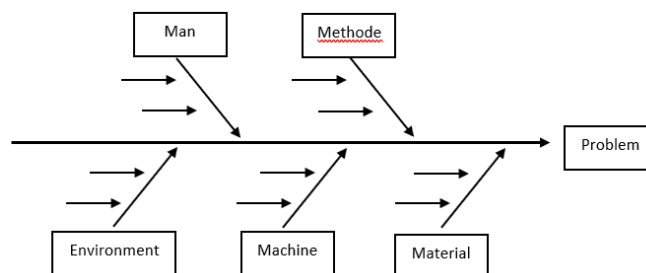
Figure 4 above is a reference image of the analysis results from the data in Table 6, which was created earlier.

### 2.3. Analyze

In the Analyze stage, a cause-and-effect analysis is conducted to identify the factors that influence the problem by studying various related variables. The results of the highest Critical To Quality (CTQ) value as the main problem to be discussed in the fishbone diagram and the results of the Control map will be used as considerations for the causes of delays in that month to determine the focus of the analysis branches in the fishbone diagram (Somadi, 2020).

In its development, techniques such as surveys (data collection through interviews) and exploring previous research were used to identify these causes. The following are the steps in creating a fishbone diagram (Malabay, 2016).

- 1) Develop a fishbone diagram framework.
- 2) Formulate the main problems that need to be solved.
- 3) Identify the main factors contributing to the problem.
- 4) Find specific causes in each category of factors causing the problem.
- 5) Once the problems and their causes are known, the next step is to illustrate them in the form of a fishbone diagram..



**Figure 4.** Fishbone Diagram

Figure 4 above shows the form of the fishbone diagram that will be created, containing the factors listed, including.

- 1) Human factors, which are the workforce or human resources, are the most important assets for a company. Therefore, managers must strive to create positive behavior within the organization to support the company's goals.

- 2) Work methods, which are the application of effective and efficient ways or procedures to meet the technical needs of the company's operations.
- 3) Materials, which are the main components needed to ensure a smooth production process. Therefore, it is important to ensure the availability of raw materials so that production can continue seamlessly.
- 4) Machinery, which is the main tool in the production process used to produce goods or services according to the company's needs.
- 5) Environment, which includes the use of natural resources while considering the capacity and carrying capacity of the surrounding environment, so that the company's activities remain sustainable and do not disrupt the balance of nature.

After creating the fishbone diagram, the next step is to create a cause-and-effect table (Tirtaningrum & Ernawati, 2023).

#### **2.4. Improve**

In the Improve stage, researchers focus on implementing improvements based on the analysis conducted in the previous stage. At this stage, the method used is the 5W + 1H approach, which consists of the following (Ramadhan dkk., 2022).

- 1) What, meaning what needs to be improved?
- 2) Who, meaning who is responsible for the improvement?
- 3) Where, meaning where can the improvement be made?
- 4) When, meaning when can the improvement be implemented?
- 5) Why, meaning why does the improvement need to be implemented?
- 6) How, meaning what is the strategy for addressing the issues that will be improved?

Researchers can explore the root causes of problems and design appropriate solutions based on the findings from the fishbone diagram that has been compiled. These proposed improvements aim to improve the procurement and delivery process after the Purchase Order (PO) document is issued in SAP (Somadi, 2020).

#### **2.5. Control**

The final stage in the DMAIC methodology is Control, which aims to control the results of the analysis that has been carried out. At this stage, the results of the breakdown in the 5W + 1H improvement table serve as a guide in creating a Standard Operating Procedure (SOP), which will be applied to all parties involved, particularly the Purchasing department responsible for the procurement or purchasing process. This is expected to reduce the likelihood of delays in goods delivery from suppliers based on the theoretical methods in procurement and Purchasing (Riswadi & Yudoko, 2023).

### **3. Results and Discussion**

Based on the results of interviews and direct analysis of the SAP system used, a problem of goods delays was found in 6 out of 11 Purchase Order (PO) documents, caused by internal and external factors within the company. Therefore, further data processing was carried out. The following are the results and discussion of the data processing that has been carried out.

#### **3.1. Define**

The define stage is a step to identify problems in research. In this study, the problems raised are related to delays in the procurement process, which include delays in delivery and discrepancies in the quantity of goods ordered. The following are the results of the analysis at the define stage.

The first step is to understand the SIPOC diagram. According to Yono Mulyono (2018), the SIPOC diagram is used to help everyone understand the entire workflow from start to finish without delving into technical details. To create this diagram, the researcher utilized research materials from interviews and data from informants, including information on the stages of goods ordering management at PT. X, as follows:

- 1) The Planner will enter production data (job), and Customer Service (CS) will enter forecast data (demand estimates).
- 2) The data from the Planner and Customer Service (CS) will trigger the SAP system to calculate material requirements.
- 3) If the requirements are approaching the lead time (the time required for purchasing/material arrival), the system will automatically create a Purchase Requisition (PR).
- 4) Next, the Buyer can convert the Purchase Requisition (PR) to a Purchase Order (PO) when the time is right.
- 5) Once the Purchase Order (PO) has been released in SAP, it awaits approval from relevant users such as Assistant Manager, Manager, General Manager, RVP/VP, DCEO/CEO, and board approval.
- 6) The system will then automatically send information to the vendor regarding the order.
- 7) The vendor will receive the order via email directly from SAP.
- 8) The supplier prepares the product.
- 9) Once the goods are ready, the vendor will inform via email that the goods will be shipped to the address specified in the PO.
- 10) Before entering Batam, the goods will first stop in Singapore for transit, then be shipped to Batam.
- 11) After being received by the Logistics department, the logistics team (store) will create a "DONE GR" (Good Receipt) in the SAP system based on the type and quantity of goods received..

Based on this information, a SIPOC diagram was created based on the procurement process flow at PT X, as shown in the image below.

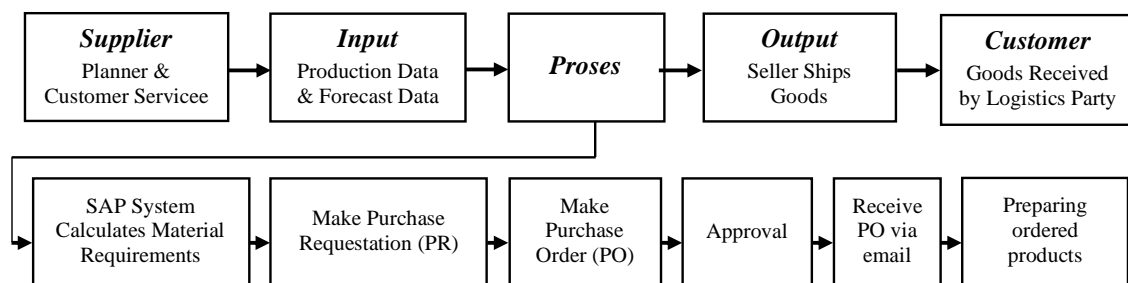


Figure 6. SIPOC Diagram of Goods Ordering at PT. X

The SIPOC diagram in Figure 6 is expected to produce the desired output, such as no delays in goods delivery from vendors beyond the specified deadline. However, it is often found in the field and recorded in SAP data that there are problems with goods deliveries from vendors experiencing delays and the quantity of goods received does not match the order. The following is data on problems received by PT X, specifically for the "Brass Strip" product.

Table 7. PO data and number of problematic items

Data	Count of PO	Total Order Quantity	Total Delivery	On Time	Problem
August 2024	2	7,000	7,000	2,889	4,111
April 2024	2	16,000	16,997	16,997	0
March 2024	2	12,000	12,228	5,860	6,368
December 2023	2	10,500	10,927	0	10,927
October 2023	3	11,387	11,487	10,635	852
<b>Total</b>	11	56,887	57,270	36,381	22,258

Table 7 above shows the data for Brass Strip items ordered each month per Purchase Order (PO). Purchase Order (PO) Opening Brass Strip orders are not placed every month but rather every two to four months, depending on the urgency of the goods. However, in April 2024, there was a surge in demand for the goods, prompting the company to immediately open a Purchase Order (PO). The next step will involve calculating the Critical To Quality (CTQ) related to delays in the delivery of goods and documents.

**1) Critical To Quality (CTQ)**

a. Calculating *Critical To Quality* (CTQ)

The Critical To Quality (CTQ) calculation at this stage is done using a check sheet. The check sheet is used to present information about the types of problems encountered, the number of problematic products, and the time of observation. The check sheet can be seen in the table below.

**Table 8.** Check sheet Delay of goods and Lack of quantity

Data	Type of Problem		Total
	Delayed Delivery of Goods	Shortage of Goods	
Agust 2024	2,742	1,369	4,111
April 2024	0	0	0
March 2024	6,368	0	6,368
December 2023	10,927	0	10,927
October 2023	852	0	852
<b>Total</b>	20,889	1,369	22,258

Table 8 shows that April did not have any problems compared to other months, because goods arrived and the quantity received was in accordance with the specifications due to smooth communication between the purchasing department and vendors and the absence of other disruptions such as bad weather or other issues. Next, calculations were performed to determine the cumulative percentage based on the type of delay. These calculations were performed as follows:

- a) Delays in the delivery of goods

$$Persentase \% = \frac{Jumlah\ Unit}{Jumlah\ Frekuensi} \times 100 = \frac{20,889}{58,639} \times 100 = 93,8\%$$

- b) Insufficient quantity of goods

$$Persentase \% = \frac{Jumlah\ Unit}{Jumlah\ Frekuensi} \times 100 = \frac{1,369}{58,639} \times 100 = 6,2\%$$

**Table 9.** Percentage of Brass Strip goods receipt problems based on CTQ

No	Problem Identification	Frequency	Accumulated Frequency	Percentage Total	Accumulated Percentage
1	Delayed Delivery of Goods	20,889	20,889	93.8%	93.8%
2	Shortage of Goods	1,369	22,258	6.2%	100%
	<b>Total</b>	22,258		100 %	

Table 9 shows the high rate of delivery delays, which is 20,889 with a percentage of 93.8%, compared to problems with insufficient quantities of goods.

b. Establishing *Critical To Quality* (CTQ)

To identify CTQ, development was carried out through specifications derived from check sheets and actual problems that have occurred or frequently occur in the company.

**Table 10.** CTQ Characteristics

No	Problem Identification	Type of Loss
1	Delayed Delivery of Goods	1. Production schedule changes 2. Production process halted 3. Delayed delivery of products to customers
2	Shortage of Goods	Tidak dapat menyelesaikan target produksi

Table 10 shows the potential losses that arise due to late delivery or insufficient quantity of goods. At this stage, CTQ is determined based on the type of problem with the Brass Strip product. These problems are classified into two categories, namely late delivery and insufficient quantity of goods upon receipt.

Based on the table above, the potential losses arising from delivery delays or insufficient quantities of goods can be seen. At this stage, the CTQ is determined based on the type of issues with the Brass Strip product. These issues are classified into two categories: delivery delays and insufficient quantities of goods upon receipt.

## 2) Pareto Diagram Based on CTQ

Pareto charts are used to identify the types of problems that have the greatest impact, thereby helping to determine priorities in improving work systems. In the define stage, CTQ calculations were performed to identify and determine the most dominant types of delays. The next step was to create a Pareto chart based on the CTQ calculation results. The following is a Pareto chart that illustrates the problems found during the goods receiving process for Brass Strip products.

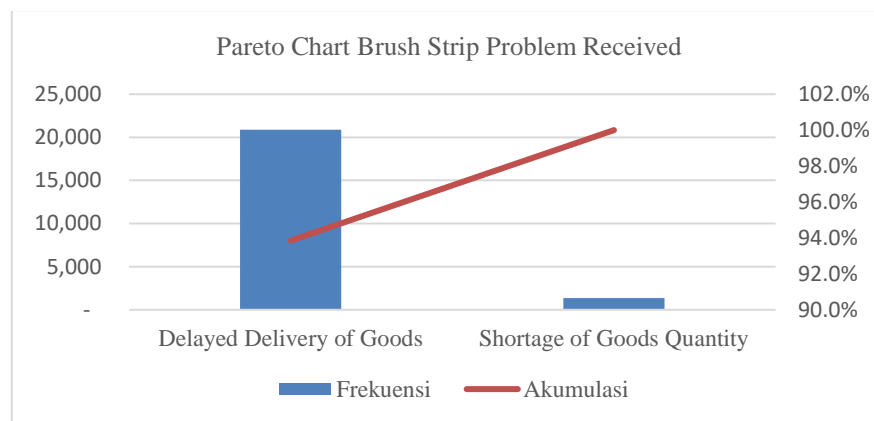


Figure 7. Pareto diagram of problem identification results

The results of the analysis shown in Figure 7 indicate that the frequency of delays in goods delivery is much higher than the problem of insufficient quantities of goods received, with percentages of 93.8% and 6.2%, respectively. Based on this comparison of frequencies, the focus of the analysis in the next stage will be directed at the problem of delays in goods delivery.

### 3.2. Measure

After calculating the CTQ, the researcher then used the control chart method at this stage. From the CTQ calculations, it was found that the type of delay with the highest percentage was delays in shipping goods. The next step was to calculate the control chart to determine whether the shipping delays were still within the statistical control limits. In this study, a *P* type control chart was used for the analysis. Based on the data listed in the following table, the *P* control chart calculation is presented;

- a. Percentage of delays based on the month of each PO

$$p \text{ October 2023} = \frac{852}{11,487} = 0,074$$

$$p \text{ April 2024} = \frac{0}{16,997} = 0$$

$$p \text{ December 2023} = \frac{10,927}{10,927} = 1$$

$$p \text{ August 2024} = \frac{2,742}{7,000} = 0,392$$

$$p \text{ March 2024} = \frac{6,368}{12,228} = 0,521$$

- b. Average delay percentage (CL), which is useful as a center line in a control chart

$$CL = \frac{20,889}{58,639} = 0,356$$

- c. Upper Control Limit (UCL) and Lower Control Limit (LCL)

$$UCL \text{ October 2023} = 0,365 + 3 \frac{\sqrt{0,365(1 - 0,365)}}{11,487} = 0,378$$

$$UCL \text{ December 2023} = 0,365 + 3 \frac{\sqrt{0,365(1 - 0,365)}}{10,927} = 0,379$$

$$UCL \text{ March 2024} = 0,365 + 3 \frac{\sqrt{0,365(1 - 0,365)}}{12,228} = 0,378$$

$$UCL \text{ April 2024} = 0,365 + 3 \frac{\sqrt{0,365(1 - 0,365)}}{16,997} = 0,376$$

$$UCL \text{ August 2024} = 0,365 + 3 \frac{\sqrt{0,365(1 - 0,365)}}{5,631} = 0,384$$

$$LCL \text{ October 2023} = 0,365 - 3 \frac{\sqrt{0,365(1 - 0,365)}}{11,487} = 0,351$$

$$LCL \text{ December 2023} = 0,365 - 3 \frac{\sqrt{0,365(1 - 0,365)}}{10,927} = 0,351$$

$$LCL \text{ March 2024} = 0,365 - 3 \frac{\sqrt{0,365(1 - 0,365)}}{12,228} = 0,352$$

$$LCL \text{ April 2024} = 0,365 - 3 \frac{\sqrt{0,365(1 - 0,365)}}{16,997} = 0,354$$

$$LCL \text{ August 2024} = 0,365 - 3 \frac{\sqrt{0,365(1 - 0,365)}}{5,631} = 0,346$$

From the calculations that have been carried out, the control limits for the number of shipments and the number of delays can be presented in the following table:

**Table 11.** Calculation of Delay *P* Control Limit

Purchase Order	Counts of Shipments	Counts of Delays	<i>P</i>	<i>CL</i>	<i>UCL</i>	<i>LCL</i>
October 2023	11,487	852	0.074	0.365	0.378	0.351
December 2023	10,927	10,927	1.000	0.365	0.379	0.351
March 2024	12,228	6,368	0.521	0.365	0.378	0.352
April 2024	16,997	0	0.000	0.365	0.376	0.354
August 2024	5,631	2,742	0.487	0.365	0.384	0.346
<b>Total</b>	57,270	20,889				

The results in Table 11 show that the Upper Control Limit (UCL) and Lower Control Limit (LCL) vary each month, due to the varying number of shipments each day. The highest Upper Control Limit (UCL) value is observed in August 2024 at 0.384, while the lowest value is in April 2024 at 0.376. Meanwhile, the highest Lower Control Limit (LCL) value is in April 2024 at 0.354, and the lowest value is in August 2024 at 0.346. Additionally, there is a high percentage of delays, represented by *P*, in December 2023 due to all ordered goods being delayed. This contrasts with the data shown in April, where no delays in goods occurred during that month. This data summary is based on Purchase Order (PO) orders for Brass Strip material, which are not placed continuously every month, except in urgent situations such as those that occurred in April 2024. Therefore, based on Table 11, a control chart can be constructed as shown below.

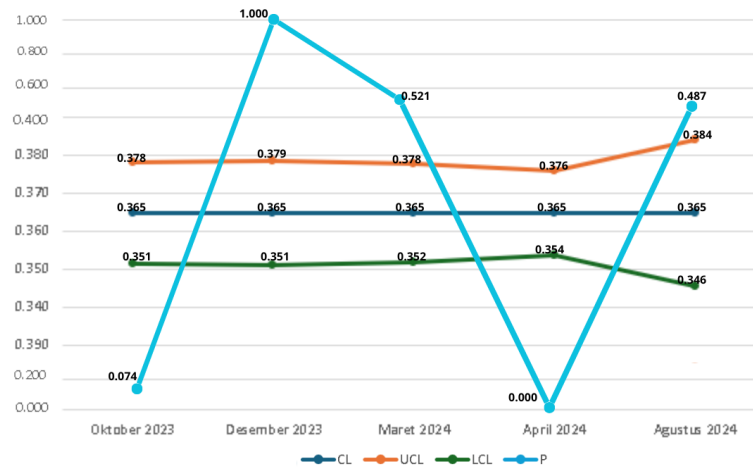


Figure 8. Delay P Control Map

Based on Figure 8, the results of the calculations performed earlier show that the Upper Control Limit (UCL) and Lower Control Limit (LCL) have different shapes due to the varying problem data each month. Therefore, all Purchase Order (PO) data for those months experienced delays because their positions were outside the control limits, such as in October 2023 with a value of 0.074, December 2023, with a value of 1, March 2024 with a value of 0.521, April 2024 with a value of 0 (where no delays occurred in that month), and August 2024 with a value of 0.487. This condition indicates that the control of delivery delays at PT X still faces various problems. Therefore, a more in-depth analysis is needed to identify the causes of the irregularities observed in the P control chart. These causal factors will be further analyzed using a fishbone diagram.

### 3.3. Analyze

At this stage, analysis using a fishbone diagram is used to identify the source of the problem. This diagram serves to trace the causes of a problem, both the main causes and the underlying factors. The following are the root causes from the fishbone diagram.

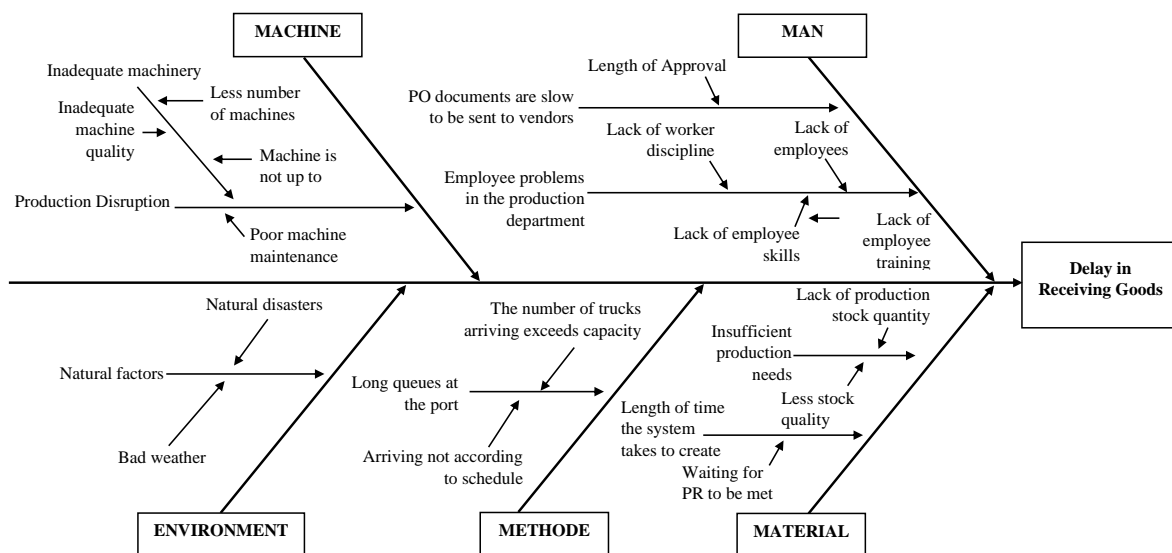


Figure 9. Fishbone Diagram Analysis

Figure 9 explains the breakdown of the root cause of the problem found. According to a senior buyer and staff member who created the Purchase Order (PO) document, based on data obtained directly through direct communication with the vendor, the issues arose due to three factors: bad weather, prolonged production processes, and lengthy queues at the port during that period, except in April 2024, when no delays occurred due to frequent communication with the vendor and the absence of issues beyond the three factors mentioned earlier. However, the most common factor was bad weather during shipping. Additionally, the researcher identified internal issues such as the lengthy process of automatically generating Purchase Requisitions (PRs) in the system and the prolonged

approval of Purchase Orders (POs), which further extended the procurement process. Therefore, the results of Figure 10 highlight five factors contributing to the delay in receiving goods: man, machine, material, method, and environment. Below is an explanation of the analysis findings.

**Table 12.** Cause-and-effect analysis fishbone diagram

Factor	Root of the problem			The impact of the root cause	Repair solutions
	Branch	Sub-branch	Sub-sub-branch		
Man	Employee issues in the production department	Lack of employees	-	A shortage of employees to work on a production, especially if it is urgent, can certainly cause the production process to take longer to complete	Recruit additional employees or implement an outsourcing program to meet the workload and ensure that the number of products ordered in advance is fulfilled
		Lack of worker discipline	-	The lack of discipline among employees in complying with operational standards can certainly cause production delays	Implement a reward and punishment system and conduct regular briefings to improve work discipline
		Lack of employee skills	Lack of employee training	Lack of training for employees, such as seminars or other types of training, which can lead to injuries or delays in the production process	Conduct regular training programs in accordance with production needs and output quality targets
	PO documents were sent to vendors late	Length of approval process	-	The length of the approval process from relevant users such as assistant managers, managers, and general managers also prolongs the process of sending POs to vendors. It is known that the approval process from assistant managers takes 2-3 days, managers take 3 days, and general managers take 7 days	Automate the approval system through digital workflow and set a maximum time for each approval stage
Mechine	Production disruption	Inadequate machinery	Insufficient number of machines	Insufficient number of machines An insufficient number of machines can certainly disrupt the production process, especially for urgent items	Gradually add production units based on production capacity needs analysis
			The quality of the machine is inadequate	Inadequate machine quality is a significant issue in production, as good quality will result in products that meet expectations	Replace or upgrade machines with more stable and precise technology
			The machine is not up to date.	Companies that still use old machines will certainly experience a decline in production speed and quality	Conduct regular technology audits to develop a roadmap for the procurement of modern machinery
		Poor machine maintenance	-	The length of the repair and maintenance process or repair schedule that is not on time can cause damage to the machine,	Susun jadwal <i>preventive maintenance</i> dan monitoring mesin secara digital

				which can disrupt the production process	
Material	Production needs are inadequate	Insufficient Production Stock Quantity	-	Inadequate stock levels will certainly become a problem that will affect the production of the goods themselves, therefore adequate materials are needed	Plan material requirements based on accurate forecasting and safety stock
		Poor Stock Quality	-	The quality of supplies needs to be considered because production results are influenced by the quality of the raw materials used	Improve the QC (Quality Control) system and conduct regular supplier audits
	The length of the system creates homework	Waiting for Purchase Limits to be Met	-	The system will create a Purchase Requisition (PR) if the purchase limit has been met. Of course, this can cause the ordered goods to take longer to arrive, which will have a direct impact on urgent goods	Reevaluate the minimum purchase limit rule and optimize the system function so that PR can be created immediately when the threshold is reached
Methode	Long queues at the port	The number of trucks arriving exceeds capacity	-	The number of trucks arriving exceeds the capacity of the dock, which will certainly cause congestion at the port and disrupt distribution	Implement a truck slot booking system and coordinate with ports to distribute arrival times.
		Arriving not according to schedule	-	The arrival of containers that are not on schedule will cause congestion at the port and prolong the loading and unloading process	Improve coordination with transporters using real-time monitoring and integrated scheduling systems.
Environment	Natural factors	Natural disasters	-	Natural disasters greatly affect the delay in the delivery of goods, which can result in potential damage to goods or delays in departure schedules	Create a contingency plan and diversify logistics channels or alternative suppliers.
		Bad weather	-	Bad weather is a situation that has a significant impact on delays in goods delivery, such as traffic jams on distribution routes due to rain, which can cause flooding at distribution points	Use weather forecast data in delivery planning and prepare a logistics time buffer.

Table 12 shows the roots consisting of branches, sub-branches, and sub-sub-branches of the problems that occurred due to delays in goods delivery, based on the analysis of the fishbone diagram. The large number of sub-branches of the root problems proves the need for a solution, so a solution was created for each root problem based on the analysis of the fishbone diagram. The problem roots and proposed solutions reveal similarities in issues arising from both internal and external company factors, such as internal issues caused by lengthy approval processes and the automatic generation of Purchase Requisitions (PR) in the system, as well as external issues stemming from unforeseen events, particularly during production and distribution processes. Therefore, further analysis of the root causes of the issues is necessary to address them more thoroughly.

### 3.4. Improve

At this stage, the 5W+1H analysis is used to answer several questions arising from the root causes mentioned in the previous stage, namely in Figure 9 and Table 12, using the 5W+1H analysis technique. This stage aims to formulate recommendations for improvement based on the root causes identified through the results of the fishbone diagram.

**Table 13.** 5W+1H Analysis

Factor	Description	Question	Explanation
Insufficient number of employees	<i>What</i>	What is the problem?	Production workload.
	<i>Why</i>	Why did it happen?	When production demand is high or large projects are running simultaneously.
	<i>When</i>	When did it happen?	In the production and logistics departments of the vendor company
	<i>Where</i>	Where did it happen?	Production operators and delivery teams
	<i>Who</i>	Who was affected?	The production process is hampered and the delivery of goods is delayed.
	<i>How</i>	What was the impact?	Workers are not disciplined in terms of time and work procedures.
Lack of employee discipline	<i>What</i>	What is the problem?	Lack of supervision and sanctions for disciplinary violations.
	<i>Why</i>	Why did it happen?	During working hours
	<i>When</i>	When did it happen?	In the production line of the vendor company
	<i>Where</i>	Where did it happen?	Production team and supervision team.
	<i>Who</i>	Who was affected?	Decreased productivity, delayed production completion.
	<i>How</i>	What was the impact?	Employees lack adequate skills.
Insufficient employee training	<i>What</i>	What is the problem?	There is no regular training program from the company.
	<i>Why</i>	Why did it happen?	When using new machinery or when production increases at the vendor company
	<i>When</i>	When was it noticed?	In the production and machinery operation department.
	<i>Where</i>	Where did it happen?	New operators
	<i>Who</i>	Who is affected?	Work errors increase, and process time becomes longer.
	<i>How</i>	How does it affect them?	Increased time for purchasing goods through PO documents to vendors
Lengthy approval process	<i>What</i>	What is the problem?	In accordance with previous standards, which meant that relevant users did not have to monitor SAP every day
	<i>Why</i>	Why did it happen?	PO documents can be approved depending on the purchase amount, starting from the lowest level, which is the Assistant Manager with an approval limit of once every 2-3 days, the Manager with a limit of once every 3 days, and the General Manager once every 7 days
	<i>When</i>	When was it approved?	At PT X
	<i>Where</i>	Where did it happen?	Vendor
	<i>Who</i>	Who is affected?	Vendors will take longer to start production
	<i>How</i>	How does it affect them?	Production capacity is limited due to insufficient machinery.
	<i>What</i>	What is the problem?	No additional machinery is added despite increased production volume.
Insufficient number of machines	<i>Why</i>	Why did it happen?	When demand increases or sudden requests arise.
	<i>When</i>	When did it happen?	In the main production area.
	<i>Where</i>	Where did it happen?	The entire production team.
	<i>Who</i>	Who is affected?	Processes become slow and cause delays in goods delivery.
	<i>How</i>	How does it affect them?	Machinery frequently breaks down or does not function optimally.
	Inadequate machine quality	<i>What</i>	What is the problem?
<i>Why</i>		Why did it happen?	When machines are used continuously without maintenance.
<i>When</i>		When did it happen?	In the vendor company's production line
<i>Where</i>		Where did it happen?	Technicians, operators, and QC.
<i>Who</i>		Who is affected?	Production is hindered and output decreases.
<i>How</i>		What is the impact?	Machine technology is outdated and inefficient.
Outdated machinery	<i>What</i>	What is the problem?	No investment in technology updates
	<i>Why</i>	Why did it happen?	production workload.
	<i>When</i>	When did it happen?	During intensive production processes.
	<i>Where</i>	Where did it happen?	In the vendor company's production department.
	<i>Who</i>	Who is affected?	Machine operators and production managers.

	How	What is the impact?	Production times are longer than expected and do not meet targets.
Insufficient production stock quantity	<i>What</i>	What is the problem?	There are insufficient raw materials for production.
	<i>Why</i>	Why did it happen?	Delays in procurement or planning errors.
	<i>When</i>	When did it happen?	When there is a surge in demand or sudden orders.
	<i>Where</i>	Where did it happen?	At the vendor company.
	<i>Who</i>	Who is affected?	Production department.
Insufficient stock quality	How	What is the impact?	Production cannot run according to schedule.
	<i>What</i>	What is the problem?	Available raw materials do not meet quality standards.
	<i>Why</i>	Why did it happen?	Suppliers fail to perform QC or make errors in receiving goods.
	<i>When</i>	When did it happen?	When conducting production planning
	<i>Where</i>	Where did it happen?	At the vendor company
	<i>Who</i>	Who is affected?	QC team, production team, and suppliers.
	<i>How</i>	What is the impact?	Production is hindered or finished products are defective.
Waiting for purchase limits to be met	<i>What</i>	What is the problem?	The system will automatically generate a Purchase Requisition (PR) if the purchase limit has been met
	<i>Why</i>	Why did it happen?	From the start, the system is set to order goods after all requests are fulfilled with the aim of purchasing in large quantities.
	<i>When</i>	When did it happen?	When the Planner and Customer Service have entered the job and forecast
	<i>Where</i>	Where did it happen?	At PT X
	<i>Who</i>	Who is affected?	Buyer and vendor
	<i>How</i>	What is the impact?	The buyer will take a long time to create the Purchase Order (PO) document, and the vendor will take even longer to start producing the goods.
	Number of trucks arriving exceeds capacity	<i>What</i>	What is the problem?
<i>Why</i>		Why did it happen?	There is no truck arrival scheduling system.
<i>When</i>		When did it happen?	During peak hours or on certain days.
<i>Where</i>		Where did it happen?	At the port or loading/unloading area of Batu Ampar Port
<i>Who</i>		Who is affected?	Truck drivers, logistics, and security.
<i>How</i>		What is the impact?	Delays in the loading/unloading process.
Arriving outside of schedule	<i>What</i>	What is the problem?	Goods arrive later or earlier than scheduled.
	<i>Why</i>	Why did it happen?	Poor coordination of schedules between parties.
	<i>When</i>	When did it happen?	When shipping from outside the region or overseas.
	<i>Where</i>	Where did it happen?	At the Batu Ampar port
	<i>Who</i>	Who is affected?	Goods recipients, logistics department, and production.
	<i>How</i>	How does it affect them?	Goods piling up or production disrupted due to stock shortages.
Natural disasters	<i>What</i>	What is the problem?	Operational disruptions caused by natural disasters such as floods or earthquakes.
	<i>Why</i>	Why did it happen?	Unpredictable external factors.
	<i>When</i>	When did it happen?	During extreme rainy seasons or unstable geological conditions.
	<i>Where</i>	Where did it happen?	Distribution route or port areas.
	<i>Who</i>	Who is affected?	All parties involved in distribution and production.
	<i>How</i>	How does it affect them?	Delayed shipments and damaged goods/materials.
Bad weather	<i>What</i>	What is the problem?	Shipments disrupted due to unfavorable weather conditions.
	<i>Why</i>	Why did it happen?	Heavy rain, high waves, or fog disrupting transportation.
	<i>When</i>	When did it happen?	Rainy season or storm season.
	<i>Where</i>	Where did it happen?	Sea, land routes, ports, and airports.
	<i>Who</i>	Who is affected?	Logistics parties and customers.
	<i>How</i>	How does it affect them?	Delays in goods shipments until an uncertain time.

Based on the results of the analysis in Table 13, this further reinforces the issues mentioned in the previous stage, with the discovery of internal and external root causes of the company's problems. Internally, issues were identified in the lengthy approval process and the waiting time for Purchase Requisitions (PRs) to be automatically generated in the system. This can hinder the timely issuance of Purchase Orders (POs) to vendors and delay suppliers' ability to produce the ordered goods. Additionally, external factors such as insufficient staff numbers, low worker discipline, inadequate employee training, limited machinery, subpar machinery quality, outdated machinery, and constraints in the quantity and quality of production stock directly impact the length of the production process.

On the other hand, factors such as the number of trucks arriving exceeding capacity, mismatched truck arrival schedules, natural disasters, and bad weather contribute to delays in the distribution process.

Both groups of issues, whether internal or external to the company, are interdependent, leading to delays in goods delivery. Ultimately, PT X will receive ordered goods later than expected, and the production process will be disrupted. Therefore, the primary focus of improvement efforts should be directed toward addressing the root causes related to the efficiency of the Purchase Order (PO) document creation process, production at the vendor company, and the smoothness of the distribution process. Improvements targeted at these three aspects are expected to reduce delivery delays and enhance the overall timeliness and quality of the company's services.

### 3.5. Control

The final stage in the DMAIC process is Control, which is the control stage to ensure that the improvements made can run consistently. At this stage, Standard Operating Procedures (SOPs) are implemented for all parties involved, especially the purchasing department responsible for procuring goods, particularly for urgent needs. The implementation of these SOPs aims to reduce the risk of delayed deliveries, especially those caused by issues in creating Purchase Orders (POs), slow production processes at vendor companies, and disruptions in the distribution process. Below are suggestions for improving the SOPs in the procurement of goods.

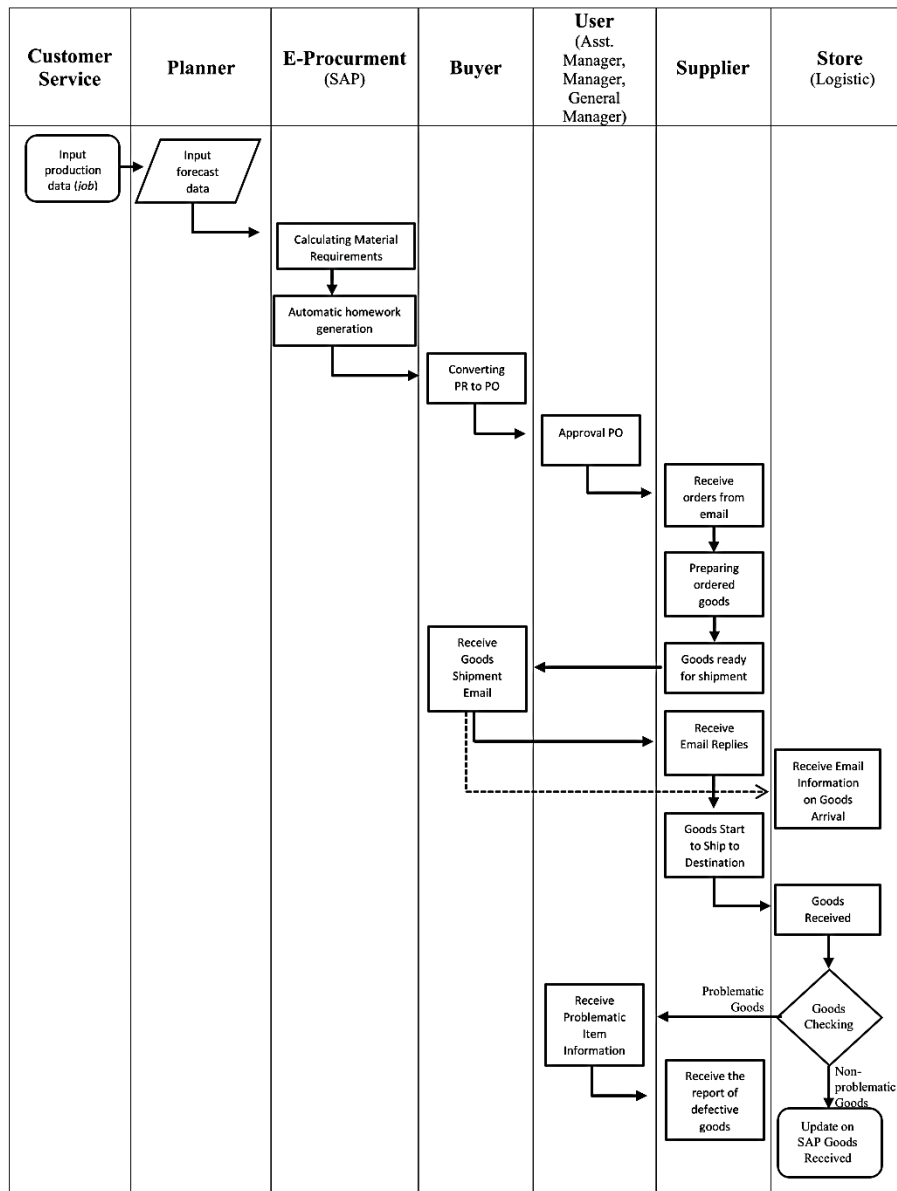


Figure 10. PT. X Procurement Improvement SOP

**Table 15.** Process lead time of the procurement SOP

Activity	Lead Time
System for creating Purchase Requisitions (PR) automatically	1-3 days
The vendor will contact its suppliers to check availability and production capacity for delivery on the agreed date.	1 day
Purchase Requisition (PR) is converted to Purchase Order (PO) by the Buyer.	1-2 days
Approval process by the assistant manager.	1-3 hours after PO release
Approval process by the manager.	1 day after PO release
Approval process by the general manager.	2 days after PO release
Production process at the supplier until ready for shipment	7–14 days
Shipping from the vendor's company location to the nearest cargo port in India	1-2 days
Shipping from India to Batam via Singapore	14 days
When the goods arrive at Batu Ampar port until they are transported to the company	1-2 days
Goods inspection process at the store and updating the SAP system or if any issues are found	1-2 hours
<b>Total Lead Time</b>	<b>16 - 25 days</b>

Based on Figure 10 and Table 15, it can be seen that lead time in the procurement process can be significantly reduced by cutting several activities that take a long time and are considered ineffective. One of the proposed changes is to eliminate the stage of waiting until requests are consolidated or stocks are depleted before the procurement process begins. This activity has been proven to prolong the overall process time. As an alternative, the SAP system is proposed to automatically generate a Purchase Requisition (PR) document just one day after the need is identified, so that the process can begin sooner without waiting for specific stock conditions.

Additionally, in the improved SOP shown in Figure 8.5, an important step has been added: direct confirmation from the purchasing department to the vendor before the Purchase Order (PO) document is issued. This confirmation process is limited to a short timeframe of one to three hours, thereby avoiding additional obstacles in decision-making. Furthermore, the use of Genext Logistics Pvt. Ltd.'s shipping services is also part of the strategy to accelerate the distribution process, as this logistics provider is considered to offer more reliable and efficient shipping services.

With the implementation of these changes, the estimated lead time can be reduced to a minimum of 31 days and a maximum of 64 days, and may even be shorter depending on operational conditions. Previously, the company applied the bulk buying method, which involved purchasing in large quantities without considering the continuity of production needs. However, in the updated SOP, the approach used is the Just In Time (JIT) method. This method allows procurement to be conducted only when there is a real need for the next production project, while still considering the quantity and timing of orders with precision.

This change aligns with the research conducted by Riswandi and Yudoko (2023), which emphasizes the importance of developing more responsive procurement SOPs. They recommend reducing approval process timelines, eliminating activities that do not add value, and enhancing vendor reliability in meeting delivery deadlines. Thus, this improvement strategy not only contributes to internal efficiency but also strengthens on-time delivery to customers.

#### 4. Discussion

Based on the results of the research conducted, several similarities were found with previous studies, such as those conducted by Riswandi and Yudoko (2023), which discussed delays in the delivery of goods through the subject of PO documents. However, the analysis process used in this study did not use critical to quality, Pareto diagrams, control charts, and 5W+1H analysis. However, the results of their research are the same, namely producing an SOP with the main focus on reducing certain processes and lead times in the SOP. Meanwhile, another similar study comes from research conducted by Somadi (2020) and Ramadhan et al. (2022), where the research subject involves the number of goods shipped by comparing on-time deliveries with late deliveries. The results of this research are also the same, namely an SOP. Therefore, this study was conducted by the researcher by combining the three studies using the DMAIC method, and the output of the study is an improved SOP. The difference from the three previous studies lies in the data on the number of items that

experienced higher delays and in certain months within the specified time frame, there were items that did not experience delays. This certainly requires a more in-depth data processing process.

## 5. Conclusion

The results of the study indicate that delays in shipping goods after the issuance of a PO in SAP are caused by internal factors such as slow automatic Purchase Requisition (PR) creation and approval processes, as well as external factors such as vendor readiness and distribution obstacles. The impact is detrimental to both parties. Therefore, the researchers suggest improvements through the development of more efficient procurement SOPs, including the removal of restrictions on the creation of automatic Purchase Requisitions (PRs), the acceleration of Purchase Order (PO) approvals for urgent goods, confirmation of vendor readiness, and the use of Genext Logistics Pvt. Ltd. services. The proposed purchasing method, Just In Time (JIT), is also suggested to ensure orders are placed according to production needs. These improvements are expected to create a more adaptive and responsive procurement system, thereby reducing delays and enhancing the company's competitiveness amid global supply chain challenges.

The researchers acknowledge several limitations and shortcomings in managing this study. The analysis only covers 11 PO documents over a one-year period based on data available in SAP, focusing on a single material type, and thus does not represent other material types. The causes of delays were analyzed based on actual occurrences, leaving room for unidentified external factors. Additionally, the proposed improvements through SOPs remain theoretical and have not been tested in practice. Therefore, further research is needed with a broader data scope, such as a longer data sample period, more material types, and other industries, as well as testing the implementation of these SOPs, to obtain more comprehensive and applicable results for future procurement process improvements.

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