Supply Chain Resilience Analysis at Electronic Manufacturing Company Work-In-Process Warehouse Using SCOR Method and Importance Performance Analysis

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***Abstract*—The warehouse has an important linking role in the supply chain and can enrich the competitive advantage for the company. In order to always be able to provide the best service, it is necessary to know the current condition of the warehouse through performance assessment and improvement on aspects that have low scores. This research is to measure the performance and provide recommendations for the Work-in-Process warehouse of an electronics manufacturing company in 2023 using the SCOR and AHP methods. There are 26 performance indicators that will be used as a reference to determine warehouse performance. The results obtained are that the warehouse performance is in the Average category according to the Traffic Light System with a value of 58.16%. Priority indicators are also identified using the Importance Performance Analysis method to identify indicators that have low scores but have high importance weights. Five prioritized indicators were obtained, namely Total Order Lead Time, Supplier Product Defect Rate, Raw Material Usage Accuracy, MTTR from Disruption, and Rate of Return. The recommendations given to improve the five performance indicators are Computer-aided Visual for Inspection, Vehicle Routing Problem, Digital Twin for Resilience, and Just in Time (JIT) System in Warehousing Process.**

Keywords — Supply Chain Operations Reference (SCOR), Key Performance Indicator (KPI), Electronic Manufacturing, Analytical Hierarchy Process (AHP), Importance Performance Analysis (IPA).

1. NOMENKLATUR

S_{norm}	$= \frac{S_{max} - S_i}{S_{max} - S_i} \times 100\%$. S_{norm} *lower is better*
S_{norm}	$= \frac{S_i - S_{min}}{S_{max} - S_{min}} \times 100\%$. S_{norm} *higher is better*
CI	$= \frac{t-n}{n-1}$. Inconsistency index
CR	$= \frac{CI}{RI_n}$. Consistency ratio
RI	$= \frac{\lambda max - n}{n-1}$. Random index

I. INTRODUCTION

According to Statista, Indonesia's consumer electronics sector in 2024 will be growing and promising, with a revenue of USD 21.410 million. Forecasts indicate a 2.53% annual growth rate (CAGR 2024–2028), highlighting the market's resilience and potential for growth. The telecommunications category is expected to lead the market, contributing USD 11.580 million in 2024, underscoring the importance of communication technologies in Indonesia's consumer electronics market. By 2028, the Indonesian consumer electronics market is projected to reach 267.2 million units, growing at an estimated annual rate of 2.0% through 2025 (Statista, 2024).

However, the growth data of the ILMATE (Industri Logam, Mesin, Alat Transportasi, dan Elektronika) sector from 2020 to 2024 indicates a significant decline in 2020, with a drastic drop to -9.21%. This decline, also notable in 2024, was primarily due to sudden disruptions, which highlighted the sector's lack of resilience in facing such challenges (Kemenperin, 2024). Major integrated device manufacturers (IDM) from the United States and Europe are increasing their investments in the Southeast Asian market due to geopolitics, technology improvements, and talent availability. OSAT (outsourced semiconductor assembly and test) firms are shifting their focus from Southeast Asia to China. Therefore, Southeast Asia is expected to play a significant role in the market for semiconductor assembly and testing (Titoma, 2024).

To support the high growth of the electronics industry and maintain resilience, a reliable and efficient supply chain is essential. Key aspects include companies in the sound and communications manufacturing sector. Five supply chain drivers—Production, Inventory, Facilities, Transportation, and Information—significantly impact performance. Businesses must balance responsiveness and efficiency, with stability and predictability being crucial for efficiency. This study focuses on the facility supply chain driver. Facilities, where inventory is stored, components are made, and final goods are assembled, significantly impact supply chain performance. Warehouses play a vital role in temporarily storing raw materials or finished goods during logistics processes. Proper warehouse management stabilizes prices by storing products when demand is low and distributing them when demand rises.

As an electronic manufacturer in Indonesia, PT XYZ Indonesia needs to improve its performance to support Indonesia's growth as a global leader in the electronics industry. PT XYZ Indonesia invests in a large-capacity warehouse as part of its primary supply chain strategies to enhance responsiveness. However, the company has not systematically evaluated its supply chain management. Traditional performance measurement methods do not provide structured insights into the current supply chain performance. Therefore, measuring the supply chain performance of PT XYZ Indonesia's warehouse is crucial. This research aims to identify weak or inadequate supply chain elements and provide strategic recommendations for improvement. The findings are expected to help businesses enhance their supply chain performance and competitiveness both locally and globally.

II. RESEARCH METHODOLOGY

The research methodology will be implemented through several stages, such as the initial research process, the research analysis process, and the final research process.

A. Problem Solving and Research Challenges

The main research problem focuses on the performance of PT XYZ Indonesia's Work-In-Process (WIP) warehouse, specifically regarding the systematic measurement of its supply chain performance during normal conditions and disruptions. The challenge lies in identifying risks that may cause process failures and proposing strategies to achieve supply chain resilience. The research aims to measure the warehouse performance using the Supply Chain Operations Reference (SCOR) method and Importance Performance Analysis (IPA) and provide strategic recommendations for performance improvement.

B. Research Design and Approach

The research adopts a quantitative approach, using both primary and secondary data to measure and analyze the supply chain performance of PT XYZ Indonesia's WIP warehouse. The study employs SCOR and Analytical Hierarchy Process (AHP) methods for data processing and analysis. The SCOR model provides a framework to assess the warehouse's supply chain performance, while the AHP method helps in weighting the performance indicators through expert judgment.

C. Data Collection Techniques

Data collection at this point will be done using a predefined approach. In order to analyze this data, every effort will be made to use it. Primary and secondary data include the two types of data that are required. Managers and specialists in the warehouse of heavy equipment distribution companies were surveyed and asked pairwise comparison questions in order to get primary data. Secondary data is past information gleaned from heavy equipment distribution businesses' warehouses in 2022. This information includes receipts, deliveries, inventory, maximum and minimum targets, and more.

D. Data Processing

Primary and secondary data that have already been gathered will be used in this step of data processing. Warehouse accomplishments are calculated using historical warehouse data as the first stage in the data processing process. The Snorm equation from De boer was then used to standardize the data for each performance measure. The following stage involves calculating and validating paired computations that were completed by delivering AHP- method questionnaires to managers and warehousing specialists. Expert Choice Software was utilized to perform this comparison and determine the relative importance of each signal.

E. Data Analysis

Analysis based on the outcomes of data processing will be done at this point. To get results that are consistent with expectations, this analysis is conducted. In order to identify priority indicators that require improvement, the Importance Performance Analysis (IPA) method will be utilized for the analysis. Following that, suggestions will be developed in this research phase as concepts for problem-solving techniques for previously identified issues. Apart from that, this research also provides recommendations as a proposed strategy for improving company performance.

F. Research Location and Duration

The research was conducted at PT XYZ Indonesia's WIP warehouse, located in Depok and Cikarang, from March to June 2024. The chosen period allowed for a comprehensive assessment of the warehouse's performance under various conditions.

III. RESULT AND DISCUSSION

A. Objectivity Analysis of Performance Indicator Weighting

Objectivity analysis evaluates the conclusions drawn from collected data to validate respondents' weightings in the research. Despite selecting respondents based on relevance, experience, and knowledge, objectivity analysis ensures consistency. This is measured by the Ratio Inconsistency, where a value of 10% or less is acceptable. If it exceeds this, it indicates inconsistency in respondents' assessments. Using Expert Choice, the respondents' weighting results showed an inconsistency ratio of 0.05, indicating a high level of consistency and making the results valid and reliable.

B. Analysis of the Importance of Performance Indicators

The analysis of performance indicators assesses their impact on the overall supply chain performance. This indicator is crucial for ensuring on-time delivery, customer satisfaction, and effective inventory management, reducing stock outs or overstocking, and lowering logistical costs.

Other important indicators include Supplier Product Defect Rate, Raw Material Usage Accuracy, Orders Received with Correct Content, and Mean Time to Recover from Disruption (MTTR). These indicators ensure operational efficiency and customer satisfaction. A lower defect rate means higher reliability and fewer returns. Accurate raw material usage minimizes waste and aligns inventory with demand, enhancing cost-effectiveness. MTTR measures the speed of response to disruptions, ensuring service standards are maintained. Overall, these indicators are prioritized for their impact on operational success, customer satisfaction, and cost efficiency.

- Top Level Measurement Analysis

  The analysis of performance measurements based on top-level SCOR was conducted to evaluate warehouse processes. The results, shown in Figure 1.1, were analyzed using the traffic light system.

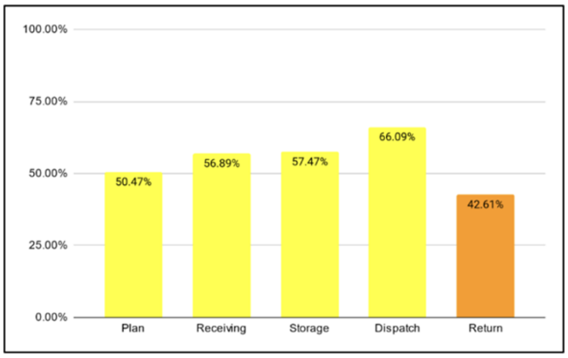

Figure 1.1 Top Level Warehouse Supply Chain Performance Value (by activities)

  According to Figure 3.2, the return process has the lowest value at 42.61%, placing it in the marginal category (40-50%). Four attributes—Plan, Receive, Storage, and Dispatch—fall into the average category (50-70%). This analysis concludes that the overall warehouse performance is still in the average category.

- Overall Measurement Analysis

  The analysis of performance values based on SCOR was conducted to observe monthly performance trends over a year. The results, visualized using the traffic light system in Figure 3.3, show a stagnant performance pattern for the PT XYZ Warehouse supply chain in 2023.

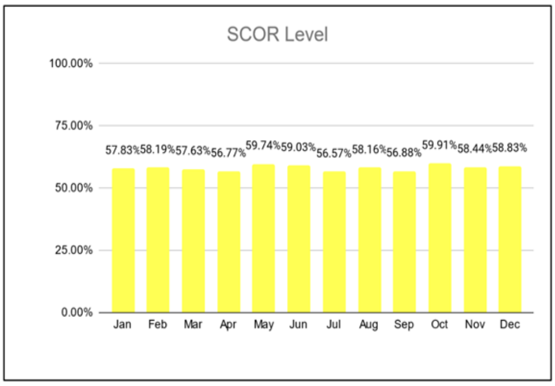

Figure 1.2 Top Level Warehouse Supply Chain Performance Value (by month)

  Figure 1.2 indicates that the supply chain performance did not experience significant fluctuations throughout the year. The overall performance is categorized based on predetermined percentage ranges, providing an overview of how well the supply chain performed during each period.

  The performance was highest in May and October, exceeding 59%, placing it in the average category (50-70%). This stability indicates consistent performance over the period, though it has not reached an excellent level. The Traffic Light System data shows that the 2023 WIP Warehouse performance falls into the average category, suggesting potential for improvement. Further analysis is needed to identify the indicators to focus on for enhancement.

- Priority Performance Indicators Based on Importance Performance Analysis

Table 1.1 Proposed Supply Chain Performance Indicators

SCOR Model				
Level 1	**Level 2**		**Level 3 (KPI)**	
PLAN (P)	P. 1	Reliability	P. 1. 1	Raw Material Usage Accuracy
			P. 1. 2	Inventory Level
			P. 1. 3	Purchase in Time and Budget
			P. 1. 4	Time to Make Strategic Plan
			P. 1. 5	Time to Make Order Schedule
			P. 1. 6	Forecast Accuracy
	P. 2	Responsiveness	P. 2. 1	Purchase Order Cycle Time
			P. 2. 2	Emergency Purchase Order
	P. 3	Cost	P. 3. 1	Cost of Purchase Order
	P. 5	Flexibility	P. 5. 1	Risk Mitigation Plan Implementation Rate
			P. 5. 2	Mean Time to Recover (MTTR) from Disruptions
			P. 5. 3	Number of Identified Risk
			P. 5. 4	Market Adaptability
RECEIVING (R)	R. 1	Reliability	R. 1. 1	Supplier Fill Rate
			R. 1. 2	Supplier Product Defect Rates (SCRM)
			R. 1. 3	Orders Received On-Time To Demand Requirement
			R. 1. 4	Orders Received with Correct Content Percent
			R. 1. 5	Orders Received Defect Free Conformance
			R. 1. 6	Unfinished Receiving Process Rate
			R. 1. 7	Productivity of Receiving Employee
	R. 2	Responsiveness	R. 2. 1	Supplier Delivery Lead Time
			R. 2. 2	Material Received
			R. 2. 3	Receiving Cycle Time
			R. 2. 4	Receiving Product Lead Time
			R. 2. 5	Supplier Responsiveness to Order
			R. 2. 6	Put Away Cycle Time
			R. 2. 7	Put Away Productivity
			R. 2. 8	Employee Absenteeism Rate in Receiving per month
	R. 3	Cost	R. 3. 1	Cost of Receiving
	R. 4	Asset	R. 4. 1	Dock Utilization
	R. 5	Flexibility	R. 5. 1	Supplier Availability
STORAGE (S)	S. 1	Reliability	S. 1. 1	Defect in Storage Process
			S. 1. 2	Inventory Accuracy
	S. 2	Responsiveness	S. 2. 1	Inventory Turnover Rates
			S. 2. 2	Stock Taking Schedule Accuracy
	S. 3	Cost	S. 3. 1	Maintenance Cost
			S. 3. 2	Inventory Carrying Cost
	S. 4	Asset	S. 4. 1	Labor and Equipment Utilization
			S. 4. 2	Equipment Downtime
			S. 4. 3	Equipment Utilization
			S. 4. 4	Number of Manpower
DISPATCH (D)	D. 1	Reliability	D. 1. 1	On-time delivery to production lines (Quantity)
			D. 1. 2	On-time delivery to production lines (Location)
			D. 1. 3	On-time delivery to production lines (Item)
			D. 1. 4	Total Order Lead Time
			D. 1. 5	Picking Cycle Time
			D. 1. 6	Picking Accuracy
			D. 1. 7	Number of Faultiness in Delivery
			D. 1. 8	Back Order Rate
	D. 2	Responsiveness	D. 2. 1	Respond to Urgent Delivery
			D. 2. 2	Product Shipping Cycle Time
			D. 2. 3	Production Stopped Due to Late Supply
	D. 3	Cost	D. 3. 1	Picking and Packing Cost
			D. 3. 2	Shipping Cost per Line
	D. 4	Asset	D. 4. 1	Vehicle Capacity Utilization
			D. 4. 2	Vehicle Utilization
RETURN (R')	R'. 2	Responsiveness	R'. 2. 1	Rate of Return
			R'. 2. 2	Defective Material Replacement Time
	R'. 3	Cost	R'. 3. 1	Cost of Return

Identification of priority performance indicators is crucial for focusing on areas that need improvement. This is done using Importance-Performance Analysis (IPA), which considers two main factors: importance value and performance of each indicator. These values are plotted on an XY chart with four quadrants.

After analyzing the data using Microsoft Excel, the indicators were categorized into four quadrants: "Concentrate Here" for high importance but low performance; "Keep Up The Good Work" for high importance and good performance; "Low Priority" for low importance and low performance; and "Possibly Overkill" for low importance but good performance.

According to Figure 1.3, five indicators are in the "Concentrate Here" quadrant: P.1.1 Raw Material Usage Accuracy, P.4.2 MTTR from Disruption, R.1.2 Supplier Product Defect Rate, D.1.3 Total Order Lead Time, and R'.2.1 Rate of Return. These indicators, showing high importance but poor performance, will be further analyzed to identify underlying issues. The validation and root cause analysis involved discussions and interviews with PT XYZ officers and employees. Detailed findings are presented in the following sections.

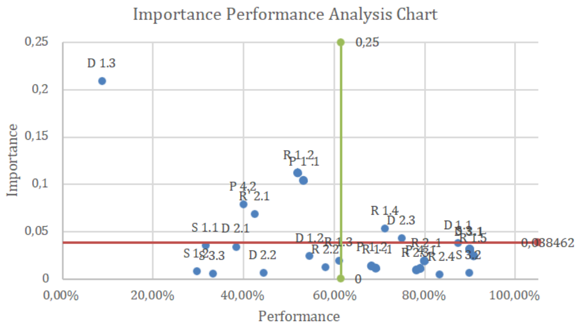

Figure 1.3 Indicator Mapping Based on Importance-Performance Analysis

These indicators are P.1.1 Raw Material Usage Accuracy, P.4.2 MTTR from Disruption, R.1.2 Supplier Product Defect Rate, D.1.3 Total Order Lead Time, and R'.2.1 Rate of Return. These indicators will then be analyzed to find out the problems that are the cause of the low performance of the indicators. The validation process and root cause analysis was carried out by conducting discussions and interviews with officers and employees at PT XYZ. Further analysis has been explained in the section below.

- Priority Indicators D.1.3 Total Order Lead Time

Total Order Lead Time (TOLT) is a key performance indicator measuring the time from order placement to delivery. It is critical for efficient inventory management, customer satisfaction, and operational efficiency. Optimizing TOLT, which has a high importance value of 0.2087672, enhances supply chain resilience and agility, allowing quick adaptation to market changes. Despite its importance, PT XYZ's current TOLT performance is only 8.91%, indicating significant room for improvement. After conducting interviews and discussions with the company, the root of the problem was obtained which can be seen in Figure 1.4 below.

Figure 1.4 Analysis of Factors Contributing to Total Order Lead Time

- Priority Indicators R.1.2 Supplier Product Defect Rate

Supplier Product Defect Rate measures the percentage of defective goods received from suppliers. By monitoring and addressing supplier defect rates, warehouses can minimize the risk of receiving poor-quality products, reduce waste, and ensure that only high-quality goods are supplied to customers. The importance value of the Supplier Product Defect Rate is 0.1115329, the second highest impact on business operations, indicating its significant weight in business management. However, its current performance is only 51.98%, highlighting a substantial gap between its importance and actual performance. This discrepancy suggests a need for focused improvement to enhance supplier quality management and overall supply chain efficiency. After conducting interviews and discussions with the company, the root of the problem was obtained which can be seen in Figure 1.5 below.

Figure 1.5 Analysis of Factors Contributing to Supplier Product Defect Rate

- Priority Indicators P.1.1 Raw Material Usage Accuracy

  Raw Material Usage Accuracy measures the percentage of raw materials used compared to the demand for those materials. This indicator is crucial for inventory planning, ensuring that the correct amounts of raw materials are used in production, which helps prevent waste, overstocking, and stockouts. Despite its high importance value of 0.1035808, which ranks it as the third most impactful indicator on business operations, the current performance is only 53.3%. This significant gap indicates a need for better raw material management practices to align actual performance with its critical importance. After conducting interviews and discussions with the company, the root of the problem was obtained which can be seen in Figure 1.6 below.

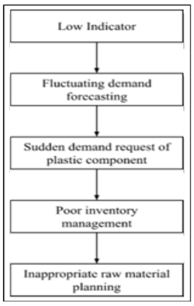

Figure 1.6 Analysis of Factors Contributing to Raw Material Usage Accuracy

- Priority Indicators P.4.2 Mean Time To Recover from Disruption

  Mean Time to Recover from Disruption (MTTR) measures the average time taken to restore full functionality after a disruption in the warehouse. It is a critical indicator for optimizing recovery procedures and minimizing downtime, thereby enhancing overall productivity and customer satisfaction. Despite its significant importance value of 0.0780175, which ranks it as the fourth most impactful indicator on business operations, the current performance is only 40%. This low performance highlights a need for improvement in resilience management to better align with its importance. After conducting interviews and discussions with the company, the root of the problem was obtained which can be seen in Figure 1.7 below.

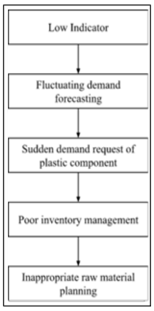

Figure 1.7 Analysis of Factors Contributing to MTTR from Disruption

- Priority Indicators R’.2.1 Rate of Return

  Rate of Return is defined as the percentage of material returned from the production department compared to the amount of material sent. In warehousing, this metric is crucial as it indicates the proportion of sent items that are returned to the facility, highlighting errors, damage, or inefficiency. Monitoring and managing high rates of return can enhance customer satisfaction, streamline operations, reduce waste, and optimize processes, ultimately benefiting the warehouse's bottom line.

  The Rate of Return indicator has a significant importance value of 0.068, making it the fifth most impactful factor on business operations. This underscores its critical weight in overall business management. However, despite its high importance, the performance of the Rate of Return is only 42.61%, indicating suboptimal performance. This imbalance between the importance of quality management and its actual performance suggests a need for improvement. Interviews and discussions with the company identified the root causes of the issue, which are illustrated in Figure 1.8 below.

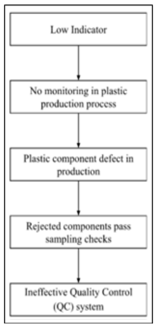

Figure 1.8 Analysis of Factors Contributing to Rate of Return

C. Strategy Explanation

- Strategy 1: Computer-aided Visual for Inspection

Computer-aided visual inspection plays a crucial role in quality control by automating inspection processes in manufacturing (Zhang, 1996). The process begins with image acquisition using solid-state CCD cameras and specialized illumination equipment to ensure high-quality images of the inspected objects. These images are then digitized and quantized into a digital format for further analysis. Several image processing techniques are used to enhance the images, reduce noise, and highlight critical details such as edges. This preprocessing phase prepares the images for detailed analysis, which includes tasks like edge detection, thresholding, contour tracking, region construction, and feature extraction. Inspection algorithms then analyze these features to determine if the products meet the required quality standards.

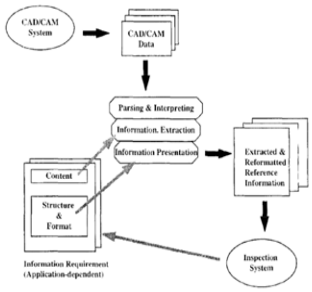

Figure 1.9 CAD Visual Inspection

By employing automated inspection systems, companies can achieve higher throughput for product inspections, greater reliability, and more consistent inspection results. Early detection of defects in the production cycle helps maintain low product scrap rates and high product quality. Integrating inspection systems with process and quality control systems, such as statistical process control (SPC), ensures that errors are promptly identified and corrected, enhancing overall product quality. The intelligent utilization of inspection information can further improve processes and quality control. Figure 1.9 illustrates the system model, which consists of three functional layers: parsing and interpreting data from the CAD/CAM database, extracting necessary information items, and representing the extracted information in a suitable format for the inspection system. This approach helps address issue R.1.2 Supplier Product Defect Rate by ensuring products meet quality standards through early defect detection and corrective action, reducing the likelihood of product returns due to defects. Additionally, it helps tackle issue R'.2.1 Rate of Return by providing real-time quality control, enabling immediate corrective actions to be taken when defects are detected.

- Strategy 2: Vehicle Routing Problem (VRP)

The goal of integrating zone picking and vehicle routing with time windows in warehouse operations is to effectively coordinate order picking and delivery activities, thereby maximizing the order fulfillment process (Chen et al., 2022). This method divides the warehouse into zones, assigns pickers to specific locations, and uses a systematic route for picking goods. Orders are batched, and a sort-while-pick policy is implemented to facilitate selection. Vehicles stationed at the warehouse are assigned routes with precise delivery windows, considering factors like driving speed changes and soft time window limits. This integration optimizes order fulfillment, reducing costs and enhancing service quality for businesses.

The integrated scheduling approach accounts for real-world factors such as setup time, travel time between picking zones, fulfillment dates, and varying driving speeds. The Two-stage Iterated Search (TIS) algorithm, based on the Genetic Algorithm, optimizes order batching, picking sequencing, and vehicle routing decisions, effectively solving the integrated scheduling problem. This strategy helps retailers reduce order fulfillment costs, improve delivery reliability, and meet consumer needs by balancing practicality and tractability. The integrated scheduling of zone picking and vehicle routing with time windows significantly advances warehouse management techniques, enhancing overall productivity and performance by synchronizing order picking and delivery activities.

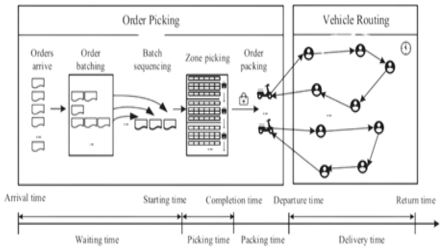

Figure 1.10 Illustrates the system model focusing on the TIS algorithm

Figure 1.10 illustrates the system model focusing on the TIS algorithm:

1. Initializing a population of solutions representing possible schedules.
2. Grouping orders into batches, determining the picking sequence, and considering due times.
3. Reverse scheduling to gain information from the zone picking stage and make decisions based on the latest departure times.
4. Batch sequencing to determine the optimal sequence for delivering batches of orders to customers.
5. Achieving global optimization by effectively coordinating the two stages of zone picking and vehicle routing.

This strategy addresses the issue of Total Order Lead Time (D.1.3) by leveraging the TIS algorithm and reverse scheduling to coordinate order batching, picking sequencing, and delivery routing, enhancing efficiency and optimizing the order fulfillment process

- Strategy 3: Digital Twin for Resilience

The Digital Twin for Resilience strategy uses a computerized model to represent the real-time state of the supply chain. It combines data from various sources like IoT sensors and ERP systems to monitor, predict, and simulate disruptions. This helps in making quick and accurate decisions to manage risks and recover from issues faster. Figure 1.11 illustrates this concept by showing how data is collected from different sources to create a real-time model. This model helps detect disruptions, simulate their impacts, and optimize recovery strategies, reducing the time needed to recover from disruptions. By using a digital twin, companies can enhance their ability to respond to and recover from supply chain issues efficiently .

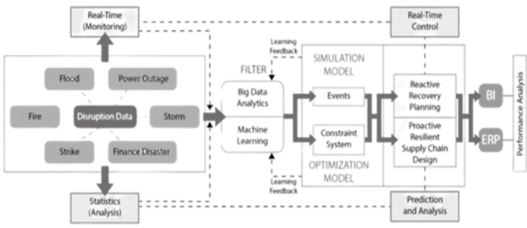

Figure 1.11 Digital Twin for Resilience

- Strategy 4: Just In Time (JIT) System in Warehousing Process.

The Just In Time (JIT) system emphasizes delivering materials exactly when they are needed, reducing inventory levels and waste, and improving operational efficiency. Implementing JIT in the warehousing process involves maintaining minimal inventory levels, ensuring timely delivery, and handling materials efficiently. Lean principles and structured Standard Operating Procedures (SOPs) are incorporated to streamline processes and eliminate non-value-added activities. This help company to address the ineffective communication procedure and ineffective operator workflow. The work procedure in SOP can be shown at 1.12 below.

Logo dan Nama Perusahaan	SOP No. :
	Tanggal Berlaku :
***Standard Operating Procedure* Proses *Pre-assembly* Gudang Work in Process**	Revisi No. :
	Tanggal Revisi :
	Halaman :

Tujuan:	Meningkatkan efisiensi pengerjaan proses *pre-assembly* pada gudang Work in Process dengan mewujudkan kelancaran aliran material dan informasi pada setiap aktivitas.
Cakupan:	Aktivitas pemesanan komponen, penjagaan *workstation* dan alur pengerjaan pada proses *pre-assembly* gudang Work in Process
Pihak Terkait:	1. Kepala gudang 2. Operator gudang *work in process* 3. Operator *pre-assembly*
Prosedur:	1. Notifikasi pemesanan komponen *pre-assembly* paling lambat dikirimkan H-1 sebelum komponen dibutuhkan untuk pemenuhan *part list*. 2. Operator *pre-assembly* memastikan dan memperbarui jadwal *pre-assembly* setiap hari paling lambat pada pukul 16.30 ketika waktu kerja selesai. 3. Operator *pre-assembly* mencocokkan jadwal pemesanan yang diterima dengan permintaan *part list* gudang WIP setiap pagi hari pada pukul 07.30 ketika waktu kerja dimulai. 4. Operator *pre-assembly* harus memastikan keadaan *workstation* sebelum dan sesudah digunakan tidak mengalami perubahan dan tetap siap untuk digunakan. 5. Operator *pre-assembly* harus langsung memisahkan jika ditemukan komponen NG ketika melakukan proses menggunting komponen. 6. Jika terdapat urgensi permintaan mendadak di luar jadwal, maka permintaan tersebut dapat diprioritaskan dengan persetujuan dari Kepala Gudang dan operator *pre-assembly* harus memperbarui jadwal *pre-assembly*.

Keterangan	Nama	Jabatan	Tanda Tangan
Dibuat oleh :			
Diperiksa oleh :			
Disetujui oleh :			

Figure 1.12 SOP Work Procedure

Employee training is also essential for effective JIT implementation. This strategy aims to enhance raw material usage accuracy and reduce total order lead time, leading to improved efficiency and cost savings in the warehousing process. The list of training are divided into two unit of competency which elaborated as:

2. Perform Industry Calculations in Warehousing Operations

This unit involves the skills and knowledge required to carry out basic routine workplace calculations. It specifically includes carrying out required mathematical operations; preparing basic estimates of mass, size and volume; and interpreting basic graphical representations of data. Training list and evidence guide are elaborated at figure 1.13 and 1.14 below.

ELEMENT	PERFORMANCE CRITERIA	REQUIRED KNOWLEDGE	REQUIRED SKILLS
1. Carry out calculations	1.1 Items are counted singly and in batches and sorted numerically, as required in workplace tasks 1.2 Calculations needed to complete work tasks are performed using the mathematical operations in accordance with workplace procedures 1.3 Results of calculations are validated.	1.1 Mathematical operations and techniques 1.2 Procedures in using relevant workplace technology in carrying out calculations 1.3 Problem analysis and solving	1.1 Counting of items singly and inbatches and storing numerically as required in workplace tasks 1.2 Performing needed calculations in accordance with workplace procedures1.3 Validating results of calculations
2. Prepare estimates	2.1 Materials and resources that require estimates are identified 2.2 Estimates on materials and resources are prepared in accordance with workplace requirements 2.3 Adjustment is made for any discrepancy between the estimates and actual materials and resources	2.1 Classification of materials and resources 2.2 Materials and resource planning 2.3 Techniques in preparing estimates 2.4 Analysis of deviation versus standards	2.1 Preparing estimates on materials and resources 2.2 Analyzing deviation 2.3 Preparing adjustment for discrepancies
3. Interpret graphical representations of data	3.1 Data are collated 3.2 Data are translated into graphical representations 3.3 Graphical representations are interpreted in accordance with workplace requirements	3.1 Data analysis 3.2 Graphical representations 3.3 Methods of interpreting graphs	3.1 Collecting data 3.2 Analyzing data 3.3 Interpreting graphs

Figure 3.13 Warehousing Calculation Training List 01

ELEMENT	PERFORMANCE CRITERIA	REQUIRED KNOWLEDGE	REQUIRED SKILLS
1. Carry out calculations	1.1 Items are counted singly and in batches and sorted numerically, as required in workplace tasks 1.2 Calculations needed to complete work tasks are performed using the mathematical operations in accordance with workplace procedures 1.3 Results of calculations are validated.	1.1 Mathematical operations and techniques 1.2 Procedures in using relevant workplace technology in carrying out calculations 1.3 Problem analysis and solving	1.1 Counting of items singly and inbatches and storing numerically as required in workplace tasks 1.2 Performing needed calculations in accordance with workplace procedures1.3 Validating results of calculations
2. Prepare estimates	2.1 Materials and resources that require estimates are identified 2.2 Estimates on materials and resources are prepared in accordance with workplace requirements 2.3 Adjustment is made for any discrepancy between the estimates and actual materials and resources	2.1 Classification of materials and resources 2.2 Materials and resource planning 2.3 Techniques in preparing estimates 2.4 Analysis of deviation versus standards	2.1 Preparing estimates on materials and resources 2.2 Analyzing deviation 2.3 Preparing adjustment for discrepancies
3. Interpret graphical representations of data	3.1 Data are collated 3.2 Data are translated into graphical representations 3.3 Graphical representations are interpreted in accordance with workplace requirements	3.1 Data analysis 3.2 Graphical representations 3.3 Methods of interpreting graphs	3.1 Collecting data 3.2 Analyzing data 3.3 Interpreting graphs

Figure 1.14 Warehousing Calculations Evidence Guide 01

3. Supervise Warehouse Operations

This unit involves the skills and knowledge required to supervise the warehouse operations from receiving of stocks, order processing to dispatching using cost efficient transport and logistics resources. This also involves the skills and knowledge required to apply warehouse management systems in managing stocks. Training list and evidence guide are elaborated at figure 1.15 and 1.16 below.

ELEMENT	PERFORMANCE CRITERIA	REQUIRED KNOWLEDGE	REQUIRED SKILLS
1. Organize warehouse operations	1.1 Warehouse activities are executed to meet objectives 1.2 Operational resources are made available 1.3 Work schedules and cut-offs are observed 1.4 Warehouse policies and procedures are complied with	1.1 Warehouse Operations 1.2 Warehouse policies and procedures 1.3 Warehouse Operational Resources 1.4 Workplace Schedules and Cut-offs	1.1 Organizing warehouse operations 1.2 Delegating tasks 1.3 Scheduling activities and tasks
1. Organize warehouse operations	1.5 Key performance indicators are put in place to measure effectiveness of warehouse operations	1.5 Warehouse key performance indicators	1.4 Implementing workplace policies and procedures 1.5 Using key performance indicators
2. Supervise warehouse inventory activities	2.1 Inventory Management and Warehouse Management (IM/WM) system is adapted 2.2 Stock inventory control policies are reinforced 2.3 Physical counts are conducted to validate inventory records accuracy	2.1 Inventory Management/ Warehouse Management System 2.2 Personnel Management 2.3 Stock inventory control policies 2.4 Cycle counts 2.5 Physical counts 2.6 Problem solving 2.7 Decision-making 2.8 Occupational Safety and Health Standards (OSHS) on warehousing operations 2.9 Relevant government regulatory requirements on warehousing operations 2.10 Report writing	2.1 Supervising skills 2.2 Working collaboratively with others 2.3 Coordinating activities 2.4 Conducting Physical counts 2.5 Reinforcing inventory control policies 2.6 Dealing with complexity 2.7 Implementing workplace policies and procedures 2.8 Preparing warehouse and inventory reports 2.9 Resolving conflicts
3. Engage with efficient transport and logistics service providers	3.1 Customer transport requirements are identified 3.2 Services of efficient transport providers are engaged with 3.3 Transport planning system is utilized 3.4 Conducts a review of performance with transport and logistics service providers	3.1 Different transport Mode 3.2 Third Party Logistics Provider Outsourcing Service Providers service management 3.3 Cost-Budget Analysis 3.4 Negotiation 3.5 Relevant Government Regulations on Transport and Logistics 3.6 Fleet Management 3.7 Safety Management 3.8 Transport Planning	3.1 Selecting and hiring logistics service provider 3.2 Dealing with logistics service providers 3.3 Assessing performance of service providers 3.4 Negotiating 3.5 Transport Planning

Figure 1.15 Warehousing Supervising List 02

1. Critical Aspects of Competency	Assessment requires evidence that the candidate: 1.1 Organized warehouse activities 1.2 Identified warehouse operational resources 1.3 Adapted inventory and warehouse management system 1.4 Determined selection criteria for transport providers
2. Resource Implications	The following resources should be provided: 2.1 Access to relevant workplace or appropriately simulated environment where assessment can take place 2.2 Materials, supplies, tools and equipment relevant to the end-to-end warehousing process
3. Methods of Assessment	Competency in this unit may be assessed through: 3.1 Written Examination 3.2 Observation 3.3 Oral Examination 3.4 Demonstration with questioning
4. Context of Assessment	4.1 Competency maybe assessed in actual workplace or at the designated TESDA accredited Assessment Center

Figure 1.16 Warehousing Supervising Evidence Guide 02

IV. CONCLUSION

A. Conclusion

This research focuses on enhancing supply chain performance at PT XYZ Warehouse through a comprehensive strategy. It integrates the SCOR Model for identifying performance gaps, the Analytical Hierarchy Process (AHP) for assigning indicator weights, and Importance Performance Analysis (IPA) to pinpoint areas needing improvement. Out of 26 studied indicators, five were found lacking: Total Order Lead Time, Supplier Product Defect Rate, Raw Material Usage Accuracy, Mean Time To Recover (MTTR) from Disruption, and Rate of Return. The warehouse's overall performance score in 2023 was 58.16%, categorizing it as average (50-70%) per the Traffic Light System. To address these issues, four tailored strategies are proposed: Computer-aided Visual Inspection for defects and returns, Vehicle Routing Problem (VRP) to streamline order lead times, Digital Twin for resilience during disruptions, and Just In Time (JIT) System integration for efficient raw material use and order processing. These strategies are derived from academic research and aim to optimize warehouse operations effectively.

B. Recommendations

For future research employing the SCOR Model, several recommendations are proposed to enhance methodology and outcomes: Firstly, it is advised to conduct comprehensive SCOR calculations encompassing all aspects, including financial evaluations and resilience dimensions tailored to warehouse conditions. This approach ensures a thorough assessment of supply chain performance. Secondly, expanding the application of resilience concepts to cover all dimensions within each supply chain activity, adjusted to warehouse-specific conditions, will offer a more detailed evaluation of resilience in overall performance assessments. Lastly, future studies should include detailed analyses of proposed improvement strategies, focusing on effective risk management methodologies. This approach will provide deeper insights into managing feasibility and mitigating risks associated with implementing changes in the company's operations.

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