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Supply Chain Risk Analysis in the Ready-to-Drink Beverage Industry Based on the Combination of SCOR and FMEA Methods

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ABSTRACT

The performance of the supply chain department requires precision and loyalty to vendors, which must, of course, align with established work procedures. The supply of raw materials that do not comply with the specified standards can lead to errors in the ongoing procedures. This study aims to identify risk priorities using the SCOR research method, analyze the sources of risk through the FMEA analysis method, and examine priority risks along with proposed strategies in the RTD (Ready-to-Drink) industry supply chain using a fishbone diagram supported by the 5W+1H model. Primary data was collected through direct observation at PT Great Giant Pineapple, interviews, and questionnaires distributed to 10 respondents with key roles in the RTD industry supply chain process. The findings of the study indicate that: (1) A total of 27 risks were identified in the RTD beverage industry supply chain, consisting of 9 risks in the planning process, 3 in sourcing, 8 in manufacturing, 4 in delivery, and 3 in returns; (2) There are three top-priority risks with the highest rankings; (3) The proposed strategies are predominantly focused on improving the work systems of vendors and the purchasing department to prevent recurrence in future periods.

1. INTRODUCTION

The ready-to-drink food and beverage processing industry represents an innovation in manufacturing that transforms raw fruit materials into ready-to-consume beverage products. The manufacturing industry continues to evolve through various innovations that enhance product competitiveness. This competitiveness is developed based on current market trends that appeal to consumers. Processed food companies are also beginning to expand their product lines by adding beverage categories to compete with other companies that have already produced ready-to-drink products. In the era of globalization, marked by increasingly intense competition, companies in the manufacturing sector must continuously innovate and seek competitive advantages to survive and grow in a highly competitive market (Syafi'i *et al*., 2023).

Product diversification is a common strategy employed by companies in the food and beverage industry to remain competitive in the globalized market (Gobel *et al*., 2022). Ready to drink (RTD) refers to packaged beverages that are available in a form ready for consumption. RTD packaging comes in various forms depending on the production process and product type. Common types of packaging found in the market for RTD products include glass bottles, plastic bottles, pouches, cans, and others (Nuraini, 2021).

This ready-to-drink beverage is made from pineapple juice as the primary raw material, complemented by small fruit chunks tailored to the available flavor variants. The flavor variants include apple, guava, mango, passion fruit, and pineapple. The pineapples are sourced from plantations owned by PT Great Giant Pineapple. At the same time, the other fruits used as supplementary ingredients are imported in a form ready to be mixed into the beverage. The procurement process for raw materials naturally involves various risks that may affect the performance of the

purchasing department and the company as a whole. These risks may be either external or internal. Based on survey results conducted at the company, potential internal risks in the raw material procurement process include the inability of the pineapple supply to meet production demand within a short time frame. There are also risks related to interdepartmental communication, such as between end users and the purchasing team, which may lead to errors in conveying material specifications or order volumes. On the other hand, external risks in the procurement process may arise from logistical and delivery activities, which are vulnerable to delays due to customs clearance issues, export-import regulations in the country of origin, or port congestion.

According to Vanany *et al*. (2009), common manufacturing industry risks include planning, procurement, transportation/distribution, and warehousing activities. Risks that affect company performance must be addressed through risk management, with the most critical steps being risk identification, risk analysis, and risk evaluation (Deviyanti *et al*., 2022). Given the risk-related issues in supply chain management within the manufacturing industry, particularly in the ready-to-drink beverage sector, it is necessary to conduct risk identification and analysis to determine appropriate corrective measures.

The objective of this study is to analyze supply chain risks by combining the SCOR (Supply Chain Operations Reference) model to map the overall supply chain processes at each stage, and the FMEA (Failure Mode and Effects Analysis) method as a tool to analyze the sources and root causes of quality-related problems, as well as the impact and prioritization of risks. The proposed risk mitigation strategies will utilise a fishbone diagram integrated with the 5W+1H approach. The benefits derived from this research activity are intended to serve as a foundation for academic study and a reference for future research. Additionally, it aims to provide insights that contribute to improving supply chain management.

2. RESEARCH METHODS

The research was conducted at PT Great Giant Pineapple, with the location selected through purposive sampling. The researcher chose PT Great Giant Pineapple because it is one of Indonesia's largest pineapple production companies, which sparked the researcher's interest in conducting the study at this company. PT Great Giant Pineapple (GGP) is one of the companies located in Central Lampung Regency. It is recognized as one of the world's largest exporters of canned pineapple (Pamungkas, 2019). The company has adopted a product diversification strategy by launching a ready-to-drink (RTD) beverage line. The RTD beverages produced by PT Great Giant Pineapple are marketed under its subsidiary, PT Sewu Segar Nusantara (PT SSN), under Sunpride. Sunpride offers a range of processed products, including various fresh fruits, canned pineapple across multiple menu variants, banana chips, and now pineapple-based ready-to-drink beverages combined with real fruit flavors (Sunpride, 2024).

Data collection will be directed toward the Supply Chain Manager, Production Manager, Cannery Manager, Labeling Manager, and Logistics Manager, with 10 respondents, including PPIC and staff from each respective division or department. The required data will be obtained through direct field observation, discussions, and stakeholder interviews. The selected respondents include managers or heads of divisions who can provide comprehensive information regarding the risks encountered within each division. Meanwhile, division staff serve as sources of technical and operational information to enhance understanding of the detailed implementation of tasks in the field. The data analysis methods used in this study include risk identification using the SCOR (Supply Chain Operations Reference) model, risk analysis using the FMEA (Failure Mode and Effects Analysis) method, and the Fishbone Diagram combined with the 5W+1H principles.

2.1. Data Analysis Methods

2.1.1. SCOR (Supply Chain Operation Reference)

The process of identifying supply chain activities is based on the SCOR model, which includes the activities of plan, source, make, deliver, and return (Kusmantini *et al*., 2021). Similarly, in the study conducted by Hasibuan *et al*. (2021), Risks were identified using the SCOR model, which encompasses supply chain activities ranging from planning to product returns in case of customer complaints.

2.1.2. FMEA (Failure Mode and Effects Analysis)

FMEA (Failure Mode and Effects Analysis) is used to identify the sources and root causes of quality-related issues. According to Slimdots (2020), FMEA is a conventional method for assessing the level of risk associated with failure or workplace accidents, based on three parameters: Severity (S), Occurrence (O), and Detection (D). The combination of these three parameters is known as the Risk Priority Number (RPN). These three parameters will be used to evaluate five elements based on the SCOR model: plan, source, make, deliver, and return. The relationship among these parameters can be formulated as follows:

$$RPN = S \times O \times D \tag{1}$$

The interpretation of RPN values is categorized as follows: a score of 1–40 indicates a low level of risk, 41–120 indicates a medium level, and 121–1000 indicates a high level of risk. The criteria for each parameter –Severity (S), Occurrence (O), and Detection (D). According to Nuchpho *et al*. (2014), severity is as follows: Severity 1 (no effect) to 10 (hazardous), Occurrence is 1 (rare) to 10 (almost certain), and Detection is 1 (almost specific detection) to 10 (nearly impossible to detect). Subsequently, recommended actions will be taken to reduce severity and further analyzed using the Fishbone Diagram method.

2.1.3. Fishbone Diagram

According to Putra (2019), the fishbone diagram is an analytical method used to identify quality issues and inspection points, which includes four main aspects: materials or equipment, labor, and techniques. In this method, the initial step involves determining the categories of risk sources commonly used in the manufacturing industry, known as the 6Ms. These include: man, method, machine, material, measurement, and milieu/mother nature (Kurniasih *et al*., 2021).

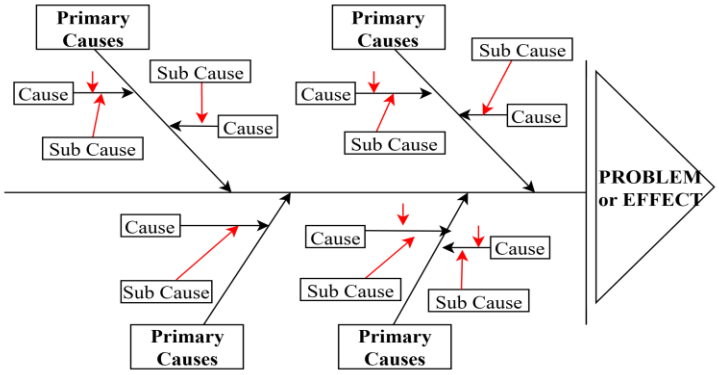

Figure 1. Fishbone diagram structure (Tech Quality Pedia, 2020)

The main categories contributing to the problem are man**,** method**,** machine, and material. Other parts of the fishbone diagram include sub-causes or minor bones, representing specific causes related to the main categories. Based on the researcher's observations and brief interviews with company staff, the 4M categories are considered sufficient to represent the possible causes. The research boundaries established by the researcher identify them as having a high-risk potential at PT Great Giant Pineapple.

2.1.4. 5W+1H Principle

The 5W+1H principle can be described as a questioning framework used to explore detailed information regarding the priority risks in this study. The 5W+1H consists of the elements: "**what"** needs to be improved, "**why"** it needs improvement, "**where"** the improvement should take place, "**when"** it should be implemented, "**who"** is responsible for the improvement, and **how** the improvement will be carried out. As stated in the study by (Xiao *et al*., 2023). This seemingly fundamental and straightforward approach allows for deeper, more scientific reasoning. This principle is commonly used to assist companies in solving problems and enhancing their capacity for innovation.

3. RESULTS AND DISCUSSION

The discussion in this article will be divided into three parts, beginning with identifying risks within the supply chain of the ready-to-drink beverage industry under the Sunpride brand at PT Great Giant Pineapple. This will be followed by a supply chain risk analysis using the FMEA method, and the proposed risk mitigation strategies will be concluded using a fishbone diagram to map the root causes of each top-ranked risk. The discussion will then be wrapped up using the 5W+1H principle.

3.1. Highest Risk Assessment Analysis

This study identified 27 supply chain risks based on risk event parameters derived from the SCOR model, through interviews with respondents directly involved in the supply chain at PT Great Giant Pineapple, particularly within the supply chain department. The assessment results for each parameter, obtained through the completion of questionnaires, produced average RPN scores for each risk, as shown in Table 5.

Table 1. Assessment results for S, O, D using the FMEA model.

No	RISK EVENT	S	O	D	RPN
1	Incorrect ordering	3.6	3.9	2	28.08
2	Increase in raw material prices	3.1	4.7	3.4	**49.54**
3	Failure to reach an agreement with the supplier	3.7	3.5	2.5	32.38
4	Supplier unable to fulfil demand	3.9	3.8	2	29.64
5	Errors in raw material purchase calculation	4.8	3.5	2	33.60
6	Errors in production scheduling plans	4.1	3.9	1.8	28.78
7	Errors in raw material delivery scheduling plans	3.7	3.4	1.7	21.39
8	Inaccurate forecasting (demand forecasting)	3.8	3.4	2.1	27.13
9	Sudden changes in production demand	3.2	4.2	1.6	21.50
10	Non-conformity in goods delivered by the vendor	3.6	4.7	7.2	**121.82**
11	Delays in payment to suppliers	3.3	3.4	2.4	26.93
12	Vendor lead time does not match the user's schedule	4.1	3.3	2.9	**39.24**
13	Production machine breakdown	4.8	4.8	1.5	34.56
14	Lack of space for finished goods	1.3	1.4	1	1.82
15	Uncertainty in production costs	2.5	2.3	1.9	10.93
16	Workplace accidents	3.1	2.6	1.6	12.90
17	Decline in production quality	2.9	2.7	1.7	13.31
18	Errors in the production process (leakage. spills. contamination. etc.)	2.7	2.7	1.4	10.21
19	Shrink sleeve plastic does not match the size of the can	3.5	3.6	2.1	26.46
20	Errors in the cooking process	3.4	2.8	1.4	13.33
21	Lack of storage for finished goods	1.2	1	1.2	1.44
22	Delivery of finished goods to customers is delayed	1.7	1.9	1.2	3.88
23	Delivery transportation of goods from the factory to the primary dealer	1.8	1.9	1.3	4.45
24	Delivery delays due to inadequate storage capacity	1.7	1.5	1.3	3.32
25	Products returned by the customer	2.3	2.3	1.8	9.52
26	Complaints from customers	3	2.6	1.9	14.82
27	Product damage occurred	4	3.6	2	28.80

The 27 supply chain risks were assessed using the multiplication formula of S, O, and D, with the average scores for each parameter presented in Table 1. The lowest RPN value was 1.44, associated with the risk of "insufficient storage for finished goods." In contrast, the highest RPN value was 121.82, linked to the risk of "non-conformity in goods delivered by the vendor." This high-risk category is identified as the top-priority risk, as it can potentially significantly disrupt the company's supply chain operations. Based on the assessment of Severity, Occurrence, and Detection, this top-ranked risk is difficult to detect within a short timeframe, indicating the need for preventive measures in future periods. On the other hand, although low-ranked risks are not expected to cause significant operational losses, they may still result in minor inefficiencies if not addressed early. Therefore, it is crucial to resolve

these issues promptly, as ignoring them could lead to long-term losses, with operational costs exceeding revenue (Ilman, 2022).

Based on the FMEA analysis, the results for severity, occurrence, and detection values will be ranked according to their criticality category to determine the risk priorities requiring treatment. The criticality categories are classified into low, medium, and high. An important aspect to consider in the ranking process is the cut-off point, where the RPN values for each category can be adjusted to align with the nature and characteristics of the process being analyzed (Alijoyo *et al*., 2020). The cut-off point is calculated by dividing the range of RPN values into three categories: low, medium, and high. The length of this interval range is divided equally across the three categories (Susantho *et al*., 2023).

As stated by Susantho *et al*. (2023) RPN value serves as a key parameter in identifying the primary sources of risk that require prioritized handling to prevent business failure. Therefore, establishing low, medium, and high risk classes is necessary to use the RPN value as a benchmark for each risk. Once the criticality ranking categories have been calculated, the next step is determining which risks fall into the high-priority category. The classification of criticality levels selected based on the highest risks is as follows:

Table 2. Classification of Criticality Levels Based on the Highest Risk Results.

Priority	Risk	RPN	Criticality Level
1	Non-conformity in goods delivered by the vendor	121.824	High
2	Increase in raw material prices	49.538	Middle
3	Vendor lead time not aligned with user schedule	39.237	Low

The results show that there is one high-priority risk with an RPN score of 121.82, making it the top-priority risk due to its significant potential impact on the company's supply chain continuity. In second place is one medium-priority risk with an RPN score of 49.54, indicating that the risk can still be managed without requiring substantial costs or extended time. In third place, one low-priority risk is represented by an RPN score of 39.237, selected to represent the low-risk category. According to Alijoyo *et al*. (2020), Failures or risks classified as medium or high in criticality should be followed by recommended control or mitigation actions. After identifying the issues and conducting the risk assessment using FMEA, the next step is to analyze the root causes of the highest-ranking risk using a fishbone diagram.

3.2. Risk Cause Analysis

The analysis of risk-causing factors is intended to establish an initial form of participation for prioritizing actions, which will serve as a reference for risk mitigation strategies. The analytical tool used at this stage is the Fishbone Diagram, which aims to illustrate the relationship between the problem and all contributing factors that influence the issue (Kurniasih *et al*., 2021). The categories used in the fishbone diagram are not strictly required to follow the 6M or 4M framework, but should be adjusted according to field observations and actual conditions. The fishbone diagram identifies various potential causes of a single effect or problem and analyzes the issue through brainstorming sessions (Ishikawa, 1992). Below is the fishbone diagram analysis based on the identification of the three (3) priority supply chain risks.

1. Nonconformity in goods delivered by the vendor

The first fishbone diagram (Figure 2) will illustrate the issue related to the risk of "Non-conformity in goods delivered by the vendor." Several categories of risk sources contribute to this issue, including man, method, material, and machine. In the man category, two causes are identified: jobdesk exchange and employees' lack of attention during the packaging stage. Jobdesk exchange occurs due to shift changes, and there is poor coordination among employees. Regarding the method, the issue stems from errors in sorting goods, as there is no rechecking process in place. Additionally, the procedures for shipping and checking goods are not well-documented, and this is compounded by a surge in demand from other buyers. This requires immediate intervention from both the expedition team and the goods transit location (Saputra & Perdana, 2020).

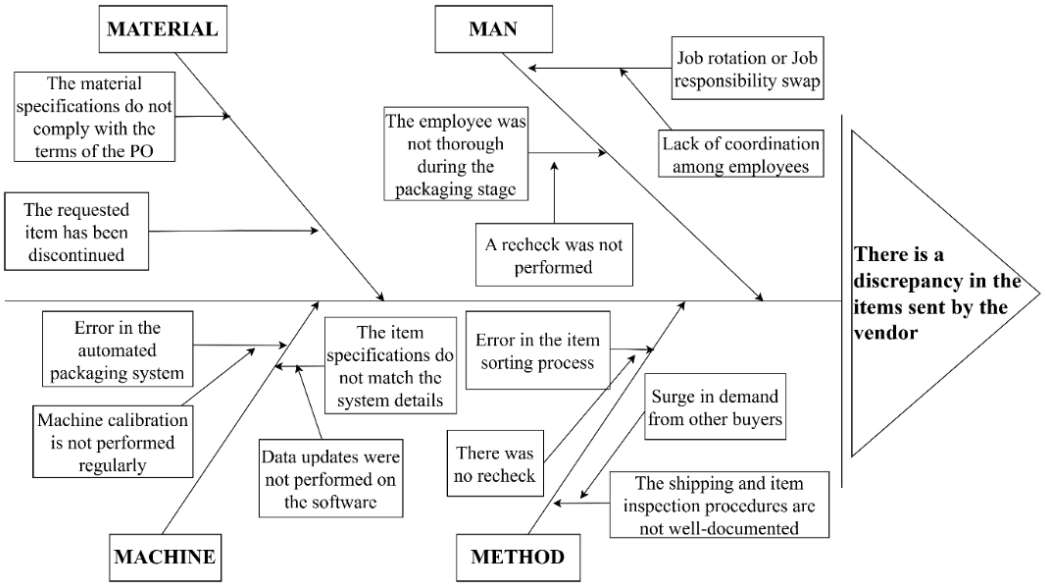

Figure 2. Fishbone diagram result for risk ranked number 1.

In the material category, the problem arises when the goods delivered do not match the specifications outlined in the purchase order (PO), and some of the requested items have been discontinued. Finally, in the machine category, the issue occurs due to the vendor's system not listing the requested goods' specifications, as the data in the vendor's software system has not been updated. Failure to update this data (backup) may lead to the loss of critical information such as customer data, financial records, or business documents (Merdeka, 2024).

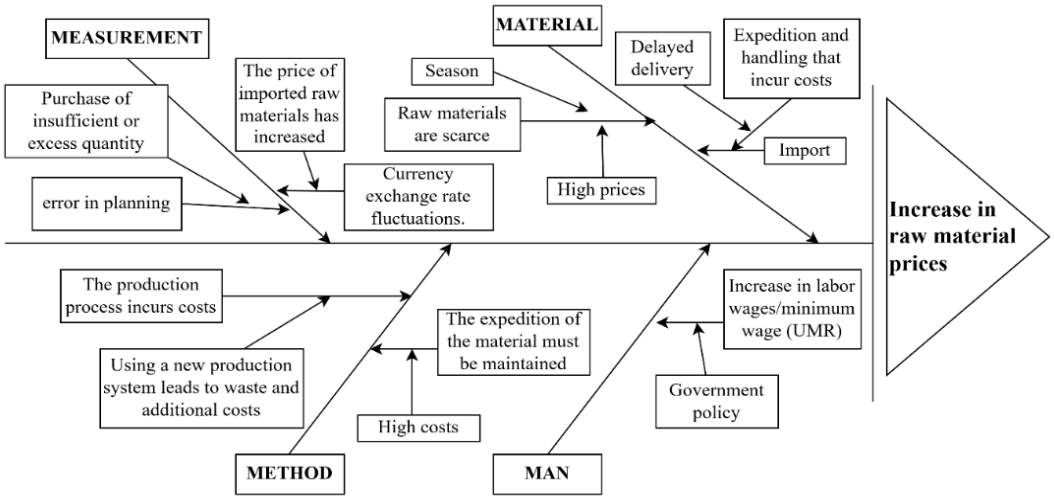

Figure 3. Fishbone diagram result for risk ranked number 2.

2. Increase in Raw Material Prices

The fishbone diagram for this priority supply chain risks is depicted in Figure 3. The Measurement category addresses the fluctuations in currency exchange rates caused by high inflation rates, which in turn drive up the price of raw materials and increase various operational costs for the company. This results in higher selling prices, and if errors occur in planning or purchasing raw materials either in insufficient or excessive quantities, this can lead to inefficiencies and increased costs (Harahap *et al*., 2024). In the Material category, the increase in raw material prices is influenced by several factors, such as the rise in import prices due to extended shipping times and high shipping and

administrative costs. Additionally, seasonal scarcity of raw materials can lead to higher prices. The Method category highlights that when coupled with trials of new production systems, production processes can generate waste and incur additional costs. Moreover, handling shipments for certain goods, particularly food ingredients, must be carefully managed, as these materials have specific characteristics that differ from those in manufacturing. These characteristics include machinability, workability, formability, castability, weldability, and hardenability (Fajrah *et al*., 2023). In the Man category, factors such as high labor costs, wage increases, minimum wage policies, and government regulations contribute to the rising costs of raw materials.

3. Vendor Lead Time Not Aligned with User Schedule

The leading causes of delays in the material category include vendors' late delivery of raw materials or parts due to a scarcity of raw materials. According to Hersanto *et al*. (2023), one of the main reasons for delivery delays is human error, which is categorized under the man category in the fishbone diagram. Butar (2022) also, problems such as incomplete shipping documents or discrepancies between the cargo details on the build-up checklist and the cargo manifest can lead to shipping delays.

The risk sources affecting these three priority risks are predominantly categorized under man**,** material**,** machine**,** and method. Such risks are commonly encountered during the goods shipping process due to a lack of rechecking and monitoring activities at the transit center. Therefore, it is necessary to address this issue directly with the expedition team and the goods transit location (Saputra & Perdana, 2020).

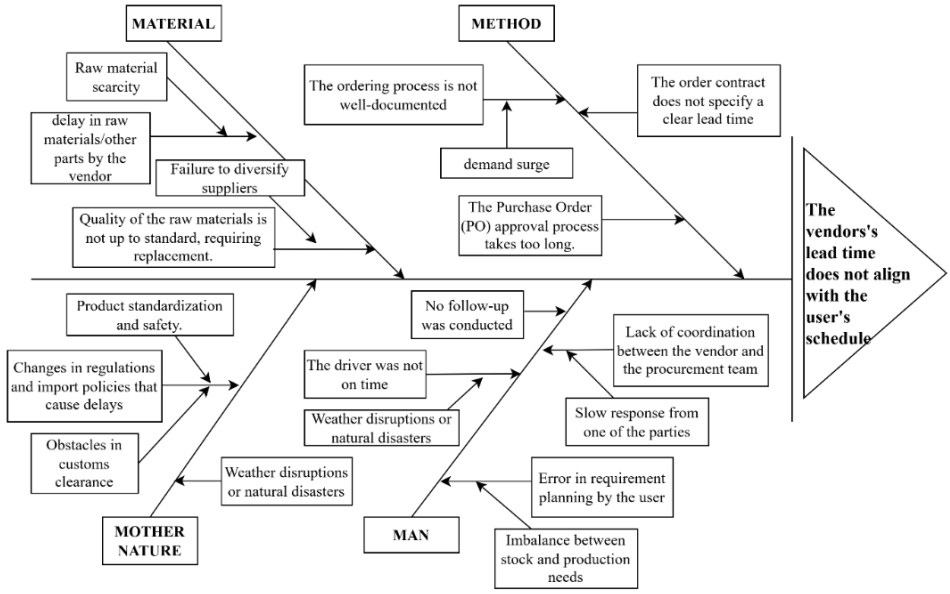

Figure 4. Fishbone diagram result for risk ranked number 3.

3.3. Proposal for Priority Risk Mitigation Strategy

The proposed risk mitigation strategy is carried out using the 5W+1H principle. The researcher will use this element as an analysis method to suggest improvements by identifying the highest risks, which have already been mapped using a fishbone diagram. The 5W+1H principle is used in planning corrective actions to simplify the implementation process clearly, and it is presented in a table format, as shown in Table 3, to make it easier for the researcher and readers to view the strategic analysis mapping. This principle is commonly used to help companies solve their problems and enhance their innovation capabilities (Xiao *et al*., 2023). The proposed risk improvements using the 5W+1H model for the 3 highest risks, as shown in Table 3, are organized based on the researcher's perspective and the results from the questionnaires presented to each respondent, including:

Table 3. Recommended Mitigation Strategies for Priority Supply Chain Risks.

Rank	Risk	5W + 1 H Model					
		What	**Why**	**Where**	**When**	**Who**	**How**
1	Non-conformity in goods delivered by the vendor	Ensuring that the goods delivered by the vendor match the order specifications	Lack of clear communication between the company and the vendor regarding product specifications	During the communication process between the company and the vendor, before production and delivery	When the goods are finished being produced by the vendor	Purchasing department	Request the vendor to document the goods before shipment to ensure they match the purchaser's and user's requests upon arrival at the warehouse.
		Ensuring that the materials delivered by the vendor comply with the specifications listed in the Purchase Order (PO)	The vendor does not follow the specifications stated in the PO document	In the goods receiving and inspection system at the warehouse or factory	Before ordering, the specifications in the PO must be complete and approved by all relevant parties. After the goods are received	The purchasing department and the checker warehouse	Implement a layered inspection system and utilize a digital or ERP system to match the PO specifications with the received goods automatically.
2	Increase in raw material prices	Controlling raw material costs to avoid significant impacts on production costs and product selling prices	Dependency on imported raw materials that are affected by currency exchange rates and trade regulations	In raw material procurement strategies to obtain the best prices	Periodically during vendor contract evaluations to adjust for the best price	Purchasing department	Supplier diversification and long-term contract negotiations.
		Improving efficiency in raw material usage to reduce waste	Lack of alternative raw materials that are more affordable but still maintain quality	In the production process to improve the efficiency of raw material usage	Before production planning to anticipate potential future price surges	Production department	Production efficiency to reduce waste and improve raw material utilization through lean manufacturing techniques.
3	Vendor lead time not aligned with user schedule	Ensuring that the vendor can meet delivery schedules according to production needs	Lack of clear lead time standards in the contract	During the planning and scheduling of raw material orders	Before the ordering process, by establishing clear lead times in the contract	Purchasing department	Establish a clear Service Level Agreement (SLA) in the contract with the vendor regarding delivery timelines.
		Improving coordination and transparency between the company and the vendor	Delays in delivery or policies from the expedition team	In communication and coordination between the company and the vendor	During the ordering process, by tracking and following up with the vendor	Purchasing department	Implement a real-time monitoring and tracking system using ERP (Enterprise Resource Planning) or IoT technologies to track order status.

(1) There is a non-conformity in goods delivered by the vendor, by requesting the vendor to document the goods before shipping to ensure that the items match the request of purchasers and users when they arrive at the warehouse. Additionally, a layered inspection system can be implemented, using a digital system or ERP to automatically match the purchase order (PO) specifications with the goods received.

(2) Due to an Increase in raw material prices, implementing a supplier diversification strategy means the company establishes partnerships with multiple suppliers to obtain the best prices and reduce dependency on a single vendor. Another strategy is negotiating long-term contracts and production efficiency measures that can reduce waste and improve raw material utilization through lean manufacturing techniques.

Vendor lead time is not in line with user schedule, a suitable strategy would be to establish a clear Service Level Agreement (SLA) in the contract with the vendor regarding delivery times. Another approach is to implement a real-time monitoring and tracking system using technologies such as ERP (Enterprise Resource Planning) or IoT to monitor order status.

4. CONCLUSION

Based on the analysis conducted, several conclusions can be drawn as follows:

1. A total of 27 risks were identified using the SCOR method, with three risks detected as having the highest scores: "Non-conformity in goods delivered by the vendor" with an RPN score of 121.82 (high), "Increase in raw material prices" with an RPN score of 49.54 (medium), and "Vendor lead time does not match user schedule" with an RPN score of 39.237 (low).
2. The mapping of priority risks revealed that the root causes were due to poor communication between the company and the vendor. Preventive strategies were proposed using the 5W+1H method.
3. This research resulted in proposed mitigation strategies that are primarily focused on improving the vendor's workflow system and the purchasing department to prevent similar issues in the future.

CONFIDENTIALITY STATEMENT

Authors confirm that all data used in this study were collected with official approval from the company and have undergone a revision process based on company feedback to ensure the information's accuracy and confidentiality. Therefore, authors take responsibility that the data meet the requirements for publication in a scientific journal.

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