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Risk Analysis and Mitigation in Supply Chain at PT. XYZ with Best Worst Method and House of Risk

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Abstract

Risk is a known uncertainty while uncertainty is an unknown risk. Risk can only be reduced by risk management. The purpose of this study is to solve the problems at PT. XYZ in the field of LPG tank product manufacturing. The problems experienced by the company are frequent material delays and overproduction. In this study, the problem-solving methods used are the BWM and HOR methods. The results of the study found that material delays are the main risk and with mitigation s trategies to improve supplier selection criteria.

Introduction

In competition, each company must have different strategies in running its company and each company must have risks that occur in running the company (Widiaswanti & Faizal, 2023). To minimize risks, a company needs to have risk mitigation in its company. Every company definitely has risks in the supply chain due to over production and customer demand in this supply chain can be disrupted by materials, production and delivery (Rolf et al.,2023). Supply chains have an important role in the global economy because they ensure the smooth production and distribution of goods, which has an impact on efficiency, product prices, and international competitiveness (Kazmi & Ahmed, 2021). In companies, the supply chain is very important because the scope that is measured comes from the desires of customers and stakeholders, which are economic, environmental and social dimensions (Ellsia et al, 2024; Baah et al., 2022; Tiwari et al., 2023; Michalski, 2024; Amirian et al., 2022; Agu et al., 2024).

PT. XYZ, a manufacturer of custom-built fuel tanks, LPG tanks, and equipment tanks for major domestic and international companies, is facing supply chain issues. Significant issues include delays in the completion of LPG tanks due to material delays, incorrect materials requiring returns, and backlogs. These disruptions cause scheduling problems and inefficiencies. The company needs risk management to identify and mitigate supply chain risks. According to previous research "Identification of supply chain risks using the House of Risk (HOR) method" was carried out in the textile industry (Hadi & Febrianti, 2020), "Supply chain risk management in French companies" was carried out in industries in France, namely the chemical industry, food and drink manufacturing (Lavastre et al., 2020). and the novelty in this research is HOR and BWM in the LPG tank manufacturing industry have not been implemented and additional analysis of the risk of cracks in LPG tanks during the production process. And using the combination of BWM and HOR presents new innovations in

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managing supply chain risks, where companies are not only able to identify risks systematically, but also make more accurate and strategic decisions in implementing mitigation actions. With this approach, companies can reduce the potential for supply chain disruptions, increase operational efficiency, and maintain the continuity of tank production more effectively (Ezeaku et al., 2024; Raja Santhi & Muthuswamy, 2022; Maheshwari & Jaggi, 2024; Khalili et al., 2024; Khosravian et al., 2025).

Supply chain Management

Supply Chain Management is a unity of production processes and activities starting from raw materials obtained from suppliers, the value-added process that changes raw materials into finished goods, the process of storing inventory to the process of sending finished goods to retailers and consumers (Andrejić et al., 2021; Yusifli, 2022; Yusifli, 2022). Supporting elements of Supply Chain Management (SCM) include 9 management elements that play an important role in the success of the movement of goods including procurement, logistics (transportation, warehousing, distribution), inventory, demand forecasting, suppliers, production, information, quality with customers (Moosavi et al., 2022; Czinkota et al., 2021; Monjur & Akon, 2023; Ailawadi & Singh, 2021). The purpose of supply chain management is to align demand and supply effectively and efficiently (Tadayonrad & Ndiaye, 2023). Supply chain is a series of approaches used to integrate suppliers, manufacturers, warehouses and stores so that the goods produced and distributed are in the right quantity and at the right time to minimize costs (Mohsen, 2023; Odeyinka & Omoegun, 2023).

Risk

Risk is the possibility of deviation from expectations that can result in losses. This includes uncertainty about events that can cause losses, both small and large, which have an impact on the sustainability of the company (Rolf et al.,2023). Risk refers to the possibility of an event occurring that could cause a loss within a certain period, and also includes uncertainties that impact the primary objective (Lestari et al., 2021). These uncertainties are the primary source of risk. The supply chain is a series of processes that involve the flow of goods or services from the stage of providing raw materials to the final product that reaches consumers (Kasidi, 2016). In the supply chain there is a relationship between goods or services, money and information, involving all parties involved directly or indirectly in fulfilling customer requests (Hugos, 2024; Jum'a & Bushnaq, 2024). This includes manufacturers, suppliers, transporters, warehouses, retailers and customers. Overall, the supply chain (Chua, 2020). Risk can only be reduced by having risk management to reduce the possibility of an undesirable event occurring and reduce its effects (Can et al., 2021).

Supply chain risk management

Risk management and supply chain management are closely related. Supply chain risk management aims to manage various risks that may arise in supply chain activities, so that the supply chain operates optimally and avoids disruption (Wahyuni et al., 2021; Shahed et al., 2021; Piprani et al., 2022). This issue is very important because frequent risks can have a significant impact on the performance of actors in the supply chain. In supply chain risk management, there are certain characteristics that must be considered, considering the impact that can continue. etrisk management in supply chain involves coordination or collaboration between chain members to ensure profitability and sustainability (Yang et al., 2023). supply chain risk management as a series of activities that include identification, analysis, and response to risks in the management process. Supply chain management is a proactive approach to reducing or managing risk by identifying, analyzing, and managing all potential risks faced by the company (Can Saglam et al., 2021; Deiva Ganesh & Kalpana, 2022).

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Risk Mitigation

Risk mitigation is an effort to minimize danger. Risk mitigation is an action to overcome a certain level of risk (Lestari et al., 2021; Shafqat et al., 202). Risk mitigation is a method used by companies to reduce the possibility of risk and the impacts that can be caused (Sutrisno et al., 2023). Risk mitigation is a process to handle risks that have been assessed so that the company can overcome the risks that will occur (Prasetyo et al., 2022).

House of Risk

House of Risk (HOR) is the latest method in risk analysis that combines the principles of FMEA (Failure Mode and Effect Analysis) and House of Quality (HOQ) (Nadhira et al.,2020). This method aims to measure risk quantitatively and help determine the priority of which risk agents should be handled first (Haqi et al., 2024). HOR focuses on risk prevention by reducing the likelihood of risk from agents that have been identified (Defriyanti & Ernawati, 2022). In HOR there are two phases that are carried out, namely HOR 1, used to determine the risk agent that will be given priority for corrective action, and HOR 2, used to prioritize several actions that are considered effectively with financial feasibility and resource fulfillment (Chua, 2020).

Best Worst method

Best Worst Method (BWM) is a multi-criteria decision-making (MCDM) method designed to simplify the decision-making process by reducing cognitive load. In BWM, the best and worst criteria from a number of criteria are selected, and other criteria are compared against these two criteria (Liang et al., 2020). Its advantage is that it reduces the number of comparisons required compared to traditional methods such as AHP, while maintaining consistency. Since its introduction in 2015, BWM has been used in various fields, such as supply chain management, sustainable infrastructure, and energy projects. A 2020 study emphasized its efficiency in decision-making by combining BWM with other techniques such as fuzzy logic and VIKOR for prioritization.

Methods

Data collection from interview results to the company and distribution of questionnaires Interviews and distribution of questionnaires to the company identify all incidents and causes of potential risks in the company's supply chain, while the questionnaire is used to determine the severity of the impact of risk events (Severity), risk agent opportunities (Occurrence), and the correlation value between risk events and risk agents (Correlation). As well as the best worst method questionnaire to determine the most important and unimportant criteria as a ranking of criteria. After the questionnaire is distributed, calculations are carried out using the BWM and HOR methods. The BWM method is used to determine which criteria are the most important and unimportant while HOR is used to analyze risks and risk mitigation actions. The distribution of this questionnaire to the head of the Production Planning and Inventory Control Division, Warehouse Division, LPG Tank Production Division, Material Cutting Division, Material Cutting Division staff and Assembly Divisio.

Results and Discussion

Best Worst Method

Based on the calculation results, the optimal weight of the main criteria and sub-criteria is obtained. After the final results are obtained, the consistency level of each criterion and sub-criteria can be determined. The consistency ratio value of the bwm results.

Table 1. Results of the recapitulation of criteria weighting

Main criteria	Decision Maker	Average	Ranking

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	1	2	3	4	5	6		
Material import dependency	0.092	0.125	0.114	0.124	0.145	0.144	0.124	4
Production schedule flexibility	0.122	0.125	0.114	0.106	0.145	0.18	0.132	3
Storage capacity	0.04	0.036	0.047	0.044	0.043	0.475	0.114	6
Production efficien	0.081	0.504	0.1	0.093	0.471	0.09	0.223	2
Material delivery accurancy	0.52	0.083	0.521	0.483	0.09	0.433	0.355	1
Material planning accuracy	0.15	0.125	0.1	0.148	0.103	0.103	0.122	5
CR	0.048	0.066	0.122	0.113	0.11	0.29	0.12483	

Source: Processing results, 2025

From the results of the Recapitulation of the Calculation Results of the Main Criteria Weight, it was obtained 0.355, the accuracy of material delivery was ranked 1st, production efficiency by fulfilling the second rank of 0.223; then the Flexibility of the Production Schedule ranked 3rd with a total of 0.132; ranked 4th, dependence on material imports 0.124; ranked 5th, Accuracy of material planning 0.122; ranked 6th 0.114 ranked 6. From the results of the weighting of these criteria, the accuracy of material delivery is the most important criterion.

House of Risk

After identifying risks using scoring tools and knowing the risks that arise in supply chain activities, the next stage is to determine a list of causes of risk events in the company's supply `chain activities.

Tabel 1. Identification Risk event and Risk Agent

Ei	(Risk Event)	Ai	(Risk Agent)
E1	Error in checking the order card	A1	Lack of coordination between related teams
E2	Overproduction	A2	Inaccurate production planning
		A3	Imbalance between market demand and production capacity
E3	Insufficient workforce	A4	Production targets not achieved
E4	Production targets not achieved	A5	Lack of supervision in BOM creation process
E5	Unavailability of raw materials	A6	Suboptimal procurement planning
		A7	Logistics issues or distribution constraints
E6	Material delays	A8	Imported materials requiring long lead times
		A9	Return of goods causing delays
E7	Defective material	A10	Supplier negligence
E8	Incorrect or downgraded material received	A11	Poor communication with suppliers
		A12	Lack of quality control system
E9	Product delivery delays	A13	Inefficient production process
		A14	Order backlog

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E10	Machine failure in the production process	A15	Lack of machine maintenance
E11	Incorrect cutting of predefined patterns	A16	Uncalibrated cutting tools
E12	Thickness error	A17	Incorrect machine or tool settings
E13	Improper machine height causing cracks under pressure	A18	Lack of strict operator supervision
E14	Poor paint application	A19	Improper paint application process
E15	Welding defect	A20	Human error
E16	Untidy painting	A21	Lack of attention to detail in the painting process
E17	Incorrect cable assembly installation	A22	Incorrect installation
E18	Late delivery causing rescheduling	A23	Logistics and distribution constraints
E19	Product defects due to improper storage	A24	Human error in the production process

The table above is a table of risk and risk agent identification. At this stage, a list of causes of risk events in the company's supply chain activities is determined.

Table 2. Determination of the Severity Level of the Impact of Risk Events (Severity)

Ei	(Risk Event)	Serverity
E1	Error in checking the order card	2
E2	Overproduction	9
E3	Insufficient workforce	5
E4	Production targets not achieved	4
E5	Unavailbility of raw materials	9
E6	Material delay	9
E7	Defective Material	6
E8	Incorrect or downgraded material received	4
E9	Product delivery delays	8
E10	Machine failure in the production process	8
E11	Incorrect cutting of predefined patterns	3
E12	Thickness error	3
E13	Improper machine height causing cracks under pressure	4
E14	Poor paint application	2
E15	Welding defect	5
E16	Untidy painting	2
E17	Incorrect cable assembly installation	4
E18	Late delivery causing rescheduling	9
E19	Product defects due to improper storage	4

Based on the results of the severity recapitulation, it can be concluded that the severity of each identified potential risk varies, with several risk categories showing a significant impact on the operational process. From the data obtained, the risks with the highest severity are excessive production, unavailability of raw materials, material delays and delays in product delivery due to rescheduling.

Table 3. Determining the Level of Chance of Occurrence of Risk Causes (Occurance)

Ai	(Risk Event)	Occurance
A1	Lack of coordination between related teams	3
A2	Inaccurate production planning	8
A3	Imbalance between market demand and production capacity	8
A4	Production targets not achieved	8
A5	Lack of supervision in BOM creation process	4

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Ai	(Risk Event)	Occurance
A6	Suboptimal procurement planning	9
A7	Logistics issues or distribution constrains	8
A8	Imported materials requiring long lead times	9
A9	Return of goods causing delays	9
A10	Supplier negligence	8
A11	Poor communication with suppliers	9
A12	Lack of quality control system	4
A13	Inefficient production process	8
A14	Order backlog	9
A15	Lack of machine maintenance	8
A16	Uncalibrated cutting tools	5
A17	Incorrect machine or tool settings	5
A18	Lack of strict operator supervision	2
A19	Improper paint application process	4
A20	Human error	6
A21	Lack of attention to detail in the painting process	6
A22	Incorrect installation	4
A23	Logistics and distribution constraints	7
A24	Human error in the production process	7

Based on the recapitulation of occurrences, it can be concluded that the occurrence rate of each identified risk shows quite significant variation. The risks with the highest frequency of occurrence are non-optimal procurement planning, material imports, time-consuming returns of goods, poor communication with suppliers, and order backlog.

Table 4. Risk Agent based on ARPj and Rank Pj

Rank	Ai	(Risk Agent)	ARP
1	A6	Suboptimal procurement planning	2646
2	A14	Order backlog	2511
3	A8	Imported materials requiring long lead times	2106
4	A7	Logistics issues or distribution constrains	1704
5	A9	Return of goods causing delays	1377
6	A11	Poor communication with suppliers	1161
7	A10	Supplier negligence	1152
8	A24	Human error in the production process	567
9	A15	Lack of machine maintenance	480
10	A23	Logistics and distribution constraints	357
11	A13	Inefficient production process	336
12	A17	Incorrect machine or tool settings	300
13	A3	Imbalance between market demand and production capacity	216
14	A22	Incorrect installation	144
15	A2	Inaccurate production planning	120
16	A12	Lack of quality control system	120
17	A21	Lack of attention to detail in the painting process	108
18	A20	Human error	90
19	A19	Improper paint application process	72
20	A18	Lack of strict operator supervision	62
21	A1	Lack of coordination between related teams	54
22	A16	Uncalibrated cutting tools	45

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Rank	Ai	(Risk Agent)	ARP
23	A4	Production targets not achieved	40
24	A5	Lack of supervision in BOM creation process	16

After the Aggregate Risk Potential calculation is carried out, the next step is to conduct a risk evaluation. In this stage, risk ranking will be carried out by selecting several risk agents that have the highest level of occurrence based on the Pareto analysis concept. In accordance with the principle of the Pareto diagram, namely 80%: 20%, the priority of the problem that must be resolved is the risk with a cumulative percentage of up to 80% of the ranking of the ARP value of each risk from the largest to the smallest. The cause of the risk (Risk Agent) that will be mitigated based on the ARP value using a Pareto diagram. The following is a Pareto diagram for each risk agent.

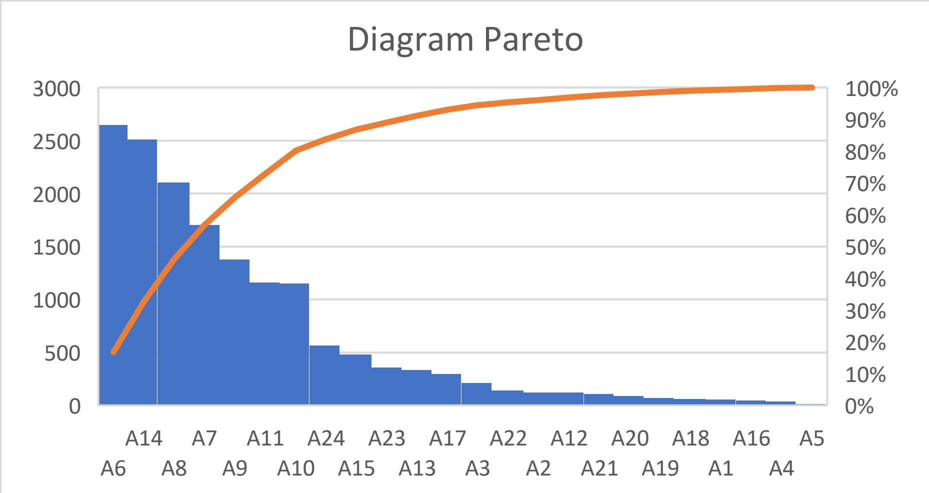

Figure 1. Pareto diagram

Based on the explanation of the ARP calculation above, it can be identified that the cause of the risk with the highest ARP value is suboptimal procurement planning (A6) with a value of 2,646. In addition, other risks with high ARP include order backlog (A14) with a value of 2,511 and the import of materials that take a long time (A8) with a value of 2,106. Meanwhile, the causes of risk with low ARP, such as production targets not being achieved (A4) and minimal supervision in the BOM making process (A5).

Table 5. Risk Agent Priority Based on Pareto Diagram

Rank	Ai	(Risk Agent)	ARP
1	A6	Suboptimal procurement planning	2646
2	A14	Order backlog	2511
3	A8	Imported materials requiring long lead times	2106
4	A7	Logistics issues or distribution constraints	1704
5	A9	Return of goods causing delays	1377
6	A11	Poor communication with suppliers	1161
7	A10	Supplier negligence	1152

Based on the explanation of the ARP calculation above, it can be identified that the cause of the risk with the highest ARP value is suboptimal procurement planning (A6) with a value of 2,646. In addition, other risks with high ARP include order backlog (A14) with a value of 2,511 and the import of materials that take a long time (A8) with a value of 2,106. Meanwhile, the causes of risk with low ARP, such as production targets not being achieved (A4) and minimal supervision in the BOM making process (A5).

Table 6. Risk mitigation strategy

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PA	Risk mitigation strategy
PA 01	Optimizing communication with suppliers using digital technology.
PA 02	Conducting production capacity planning
PA 03	Reducing production lead time
PA 04	Improving supplier selection criteria
PA 05	Implementing work contract SOPs
PA 06	Optimizing communication with suppliers so that returns are handled faster.
PA 07	Conducting monthly meetings
PA 08	Increasing contract security with risk insurance

Source: Data Processing Results

is a structured approach to minimizing risks in the supply chain or production process. The strategies listed focus on key aspects such as communication, production efficiency, supplier management, and contract security. One of the key mitigation efforts involves optimizing communication with suppliers through digital technology (PA 01) and improving response time for returns (PA 06), ensuring smoother coordination and reducing potential delays. Additionally, production efficiency is addressed through capacity planning (PA 02) and reducing lead times (PA 03), which help prevent bottlenecks and improve workflow. To improve supplier management, strategies such as improving supplier selection criteria (PA 04) and implementing standard operating procedures (SOPs) for work contracts (PA 05) are emphasized, ensuring consistency and reliability in procurement. Furthermore, regular monitoring and coordination through monthly meetings (PA 07) helps organizations stay proactive in addressing potential risks. Lastly, contract security is strengthened by enhancing contract protection with risk insurance (PA 08), protecting businesses from financial losses due to unforeseen disruptions. By implementing these strategies, companies can improve their risk management framework, increase operational stability, and strengthen supplier relationships, ultimately leading to more resilient and efficient business processes.

Table 7. TEk Calculation Results After obtaining the Total Effectiveness of Action (TEk)

PA	Risk Mitigation Strategy	Tek
PA 01	Optimizing communication with suppliers using digital technology	38,772
PA 02	Conducting production capacity planning	36,855
PA 03	Reducing production lead time	34,992
PA 04	Improving supplier selection criteria	75,978
PA 05	Implementing work contract SOPs	57,276
PA 06	Optimizing communication with suppliers so that returns are handled faster	60,102
PA 07	Conducting monthly meetings	26,298
PA 08	Increasing contract security with risk insurance	37,998

Value of each mitigation strategy, the next step is to determine the level of difficulty of implementing the action (DK). The Dk value indicates the level of difficulty of each mitigation strategy. The following Dk values are obtained from the results of the questionnaire below, which is the scale used to determine the level of difficulty of each mitigation strategy.

Table 8. ETDk Calculation Results

Ranking	PA	Mitigation Strategy	Tek	Dk	ETDk
1	PA4	Improving supplier selection criteria	75,978	3	25,326
2	PA6	Optimizing communication with suppliers so that returns are handled faster	60,102	4	15,026

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3	PA5	Implementing work contract SOPs	57,276	4	14,319
4	PA1	Optimizing communication with suppliers using digital technology	38,727	3	12,909
5	PA3	Reducing production lead time	34,992	3	11,664
6	PA8	Increasing contract security with risk insurance	37,998	4	9,500
7	PA2	Conducting production capacity planning	36,855	4	9,214
8	PA7	Conducting monthly meetings	26,298	5	5,260

From calculating the ETDk value, the next stage will be to rank the mitigation actions. This ranking is done based on the results of calculating the level of effectiveness and level of difficulty of each mitigation action. The ranking is done from the highest to the lowest ETDk value. The following table below is the result of the mitigation action evaluation summary.

Based on the table above, the ranking results for each mitigation action are obtained. The higher the value of the mitigation action, the greater its influence. This can be seen from how large the ratio of effectiveness to the level of difficulty is. Of the 8 mitigation actions that have been ranked, this is a risk that has a major impact on supply chain activities in the company.

Conclusion

From the results above, it is known that the weighting of the criteria carried out using the BWM method. The results of the calculation of the main criteria weight are obtained 0.355, the accuracy of material delivery is ranked 1, production efficiency by fulfilling the second rank of 0.223; then the flexibility of the production schedule is ranked 3rd with a total of 0.132; rank 4 dependence on material imports 0.124; rank 5 Accuracy of material planning 0.122; rank 6 0.114 rank 6. From the results of the weighting of these criteria, the accuracy of material delivery is the most important criterion. From the results above, it can be seen that the source of risk in the plan, source, make, deliver activities. based on the principle of the Pareto diagram, namely 80%: 20%, the priority of the problem that must be resolved is the risk with a cumulative percentage of up to 80% of the ranking of the ARP values of each risk from the largest to the smallest so that the results of group A have the most dominant risk priority with 7 risk agents for risk mitigation results on HOR 2, improvements in supplier criteria were obtained PA04, Optimizing communication with suppliers so that returns are handled faster PA 06, Implementation of work contract SOP PA 05, optimizing supplier communication using digital technology PA01, Reducing production waiting time PA03, Increasing contract security with risk insurance PA 08, Carrying out production capacity planning PA 02, Holding monthly meetings PA07. Due to the study's focus on LPG tanks, the findings may not be directly applicable to other storage tank types. Future research should explore similar risk assessments for different tank products specification or others product.

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