House of Risk (HOR) Analysis as a Supply Chain Risk Mitigation Method at CV. XYZ

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Abstract

CV. XYZ is a company engaged in the manufacture of rice crispies as a complement to snacks. The purpose of this research is to determine problems in the company's supply chain process and how to mitigate existing risks by using the House of Risk (HOR) method which has 2 stages. The priority risk agents are determined in phase 1, and the effective actions to deal with the priority risk agents are determined in phase 2. Based on research results, there are 23 risk events with 36 risk agents that cause these risk events. The results of stage 1 HOR, there are 12 priority risk agents that need to be mitigated. The results of the stage 2 HOR, there are 11 preventive actions that can be implemented by companies to mitigate 12 priority risk agents. Then, four preventive actions were taken: performing daily, weekly, monthly, and annual maintenance by machine operators and maintenance parties; repairing machines / machine service; adding production hours; and evaluating supplier performance. This paper was proposed to the company's main manager who is involved in the supply chain process, and it includes several mitigations to be implemented, so they can mitigate the risks that they face, which are expected to improve the company in the future.

Keywords
Supply Chain Risks, House of Risk, Preventive Action, Risk Mitigation, Supply Chain Risk Mitigation.

1. Introduction
Supply chain management is the most important thing that is found in all companies, especially companies engaged in production. A good supply chain process will certainly have a good impact on the company today and its reputation in the future. All companies are competing to continue to develop their supply chain activities in various ways and methods. Each company will make every effort to improve productivity, efficiency, fast, easy service, and continue to create various new innovations to stay ahead and survive in the market. In addition to productivity and efficiency that need to be improved, companies must also understand and know what consumers need. Improving customer satisfaction is the primary goal of all businesses in all industries. One way for businesses to develop and create innovations is to reduce supply chain risks. The company examines problems that arise during the manufacturing process and then analyses the improvement and prevention of risks that exist at all stages of production in order to prevent problems that now frequently occur from recurring in the future. Disruptions or risks must be managed and controlled so that businesses can continue to operate and grow. Supply chain risks have a long-term negative impact on businesses, and many are unable to recover quickly from these negative impacts (Magdalena and Vannie, 2019).

Supply chain risk management model using the House of Quality (HOQ) and Failure Models and Effects Analysis (FMEA) concepts to develop a framework for managing supply chain risk, known as the House of Risk (HOR) approach. The HOR approach aims to identify risks and design treatment strategies to reduce the probability of occurrence of risk agents by providing preventive actions to risk agents. The risk agent or the cause of the risk is the causative factor that drives the risk. Therefore, reducing risk agents means reducing the incidence of several risk events (Fitrianto and Sudaryanto, 2016). CV XYZ is a company that specializes in supporting ingredients for snacks, specifically rice crispies. CV XYZ already has ISO 9001:2008 certification, indicating that it has a well-implemented quality management system. CV XYZ frequently encounters issues in supply chain activities, such as rice quality, which is not always satisfactory from suppliers. Another issue is that when demand rises, the company does not have enough raw materials because many companies compete for raw materials from the supplier, which has an impact on the production process. The company currently lacks a structured risk management system for identifying and mitigating risks, particularly in the supply chain function. According to the background information, CV XYZ can

perform risk mitigation analysis using the House of Risk (HOR) method to determine the root cause of a problem and prevent it from recurring in the future. The HOR method can also assist company in identifying solutions or ways to mitigate these risks in order to improve the quality of the company's operations and allow the company to become a more superior and competitive company.

2. Literature Review

2.1 Supply Chain Management (SCM)

Supply chain management is a process that all businesses use to manage their supply chain activities. Supply chain management aims to build relationships and coordinate processes from other companies in business pipelines, from suppliers to customers, while still prioritizing supply chain logistics between companies from upstream to downstream (Fitrianto and Sudaryanto, 2016). In supply chain management, the material context includes not only raw materials and output, but also auxiliary materials, components, spare parts, work in process (semi-finished goods), and various supplies that support the company's overall operational activities (Purwaditya et al. 2019). Supply chain management can provide benefits for companies, including physically being able to convert raw materials into finished products and then send them to the final consumer (Irawan et al. 2019).

2.2 Supply Chain Operation Reference (SCOR)

The SCOR model has a framework that combines supply chain business processes, performance measurement based on best practices into an integrated structure (Mutakin and Hubeis, 2016). It is also intended that communication between divisions in the supply chain process can also run smoothly (Putri, 2020).

The following are the stages of the supply chain process based on the SCOR theory (Supply Chain Council 2010):

1. Plan: process that balances demand and supply as a whole which aims to balance delivery needs and production operational activities, such as planning production schedules, machine operating schedules, calculating raw material requirements to be ordered from suppliers for the production process.
2. Source: process of purchasing goods and services to suppliers for the production process in accordance with actual demand or through forecasting calculations.
3. Make: process in converting raw materials into final products which are semi-finished products or finished products to meet the planned actual demand.
4. Deliver: process of sending products that have been produced by the company to the final consumer. The deliver process includes order management, transportation, and distribution.
5. Return: process related to product returns. This process can include the activities of returning or returning goods from consumers to the company, and the process of returning raw materials from the company to the supplier.

2.3 House of Risk (HOR)

The House of Risk (HOR) method is used to identify problems which in the supply chain process have the aim of mitigating risks in order to prevent risk causes from reappearing in the future (Supply Chain Council 2010). HOR analysis begins with obtaining the data obtained by making a list of identifying risks that can occur in the company's supply chain process contained in the SCOR table (plan, source, make, deliver, and return). One risk agent can cause several risk events, so the data of risk agent will be more than risk event data (Lintang 2017). After collecting data regarding the supply chain process with the SCOR model, then this HOR method will be divided into 2 phases (Octavia et al. 2019):

1. HOR 1: The output of the HOR phase 1 is the determination of risk agents that need to be prioritized first to be given preventive action by identifying risks.
2. HOR 2: The output of the HOR 2 phase is the priority of several mitigation actions that are used to mitigate risk agents which are the output of HOR 1 by taking into account the effectiveness and level of difficulty, to be able to measure whether the proposed mitigation actions can be implemented by the company.

3. Methods

The data used in this study are supply chain problems that have occurred in the company and their severity values, the causes of risks that cause risks to occur and their occurrence values, and the correlation value between risk events and risk agents. The flowchart is as in Figure 1. The step of this research is:

1. The CV XYZ research method begins with the identification and problem planning stage, which is based on the background of the company's problems.
2. Followed by literature study by looking at theoretical references from journals about the House of Risk.
3. Next is to collect data obtained through 2 ways, namely primary data and secondary data.

    a. Primary data is data obtained directly from data sources collected specifically and directly related to the problems studied (not through intermediaries). In this study, primary data were obtained from online interviews with the general manager of CV XYZ. Through the results of the interview, data will be obtained regarding the confirmation of supply chain problems that have occurred in the company. The data that will be obtained from online interviews with the company include the supply chain process on the CV. XYZ, confirmation of risk identification that has occurred in the company's supply chain process and its severity value, confirmation of risk causes that cause risks to occur and their occurrence value, correlation value between risk events and risk agents, preventive actions to mitigate priority risk causes , the value of the correlation between risk agents and preventive action, and the level of difficulty of each preventive action and the reasons.
    b. Secondary data obtained from libraries such as books, internet, journals, and other data sources related to this research
    .
4. The next stage is data processing. The data processing stage is divided into 2, namely:
    a. HOR 1. The work steps carried out in the HOR 1 framework are as follows:
        - Mapping for each process carried out by CV XYZ in the form of a SCOR table.
        - Identify risk events and their severity values. Identify risk events that occur in business processes that occur in the plan, source, make, delivery, and return areas. The risk event is denoted by *Ei*. Assess the impact that occurs (severity) on the risk event if the risk occurs. The assessment is carried out by adjusting the real conditions of the company. This is done so that the results of the assessment carried out are appropriate and actual. The severity value of each risk event is denoted by *Si*. The rating scale given is 1-5, a value of 1 means that the risk event is not very impactful and a value of 5 means very bad impact.
        - Identification of occurrence assessment or the chance of occurrence of a risk agent. The rating scale given is 1-5, a value of 1 means that the risk agent is rare and a value of 5 means that the risk agent often occurs. Risk agent is denoted by *Aj* and occurrence value is denoted by *Oj*.
        - Assess the correlation between risk agents and risk events with *Rij* notation which has a value of 0, 1, 3 or 9. A value of 0 indicates that there is no correlation between risk agent and risk event, a value of 1 indicates a low correlation value, a value of 3 indicates a medium correlation and the value shows a high correlation value.
        - Calculation of the value of Aggregate Risk Potential (ARP) as input in determining the priority of risk agents that need to be addressed first and given preventive measures against risk agents. Each ARP value is obtained through calculations using the following formula:

$$ARP = Oj \; x \; \Sigma \; Si \; Rij$$

    b. HOR 2. After obtaining the ARP risk agent ranking order from the largest to the smallest in HOR 1, then the second stage, namely HOR 2, is carried out which aims to assist management/companies in prioritizing effective risk management. The work steps carried out in the HOR 2 framework are as follows:
        - Determine 80% of priority risks that will be included in the HOR 2 analysis with the output of solutions for mitigating these risks which can also be obtained from the Pareto 80:20 analysis.
        - Identify one or more preventive measures that are considered effective in dealing with the risk agent. Actions taken later simultaneously can reduce the probability of more than one risk agent. Preventive action is denoted by *PAk*.
        - Determine the magnitude of the correlation between risk prevention measures and each risk agent with values of 0, 1, 3, and 9 which means the value is the same as the HOR correlation 1. The correlation between preventive measures (*k*) and the risk agent (*j*) is denoted by *Ejk*.
        - Calculate the total effective value of each preventive action with the following formula:

$$Tek = \Sigma j \; ARPj \; Ejk$$

– Determine the assessment of the level of difficulty to carry out each preventive action notated by *Dk*. The scale value for this *Dk* can refer to the Likert scale (1-5).

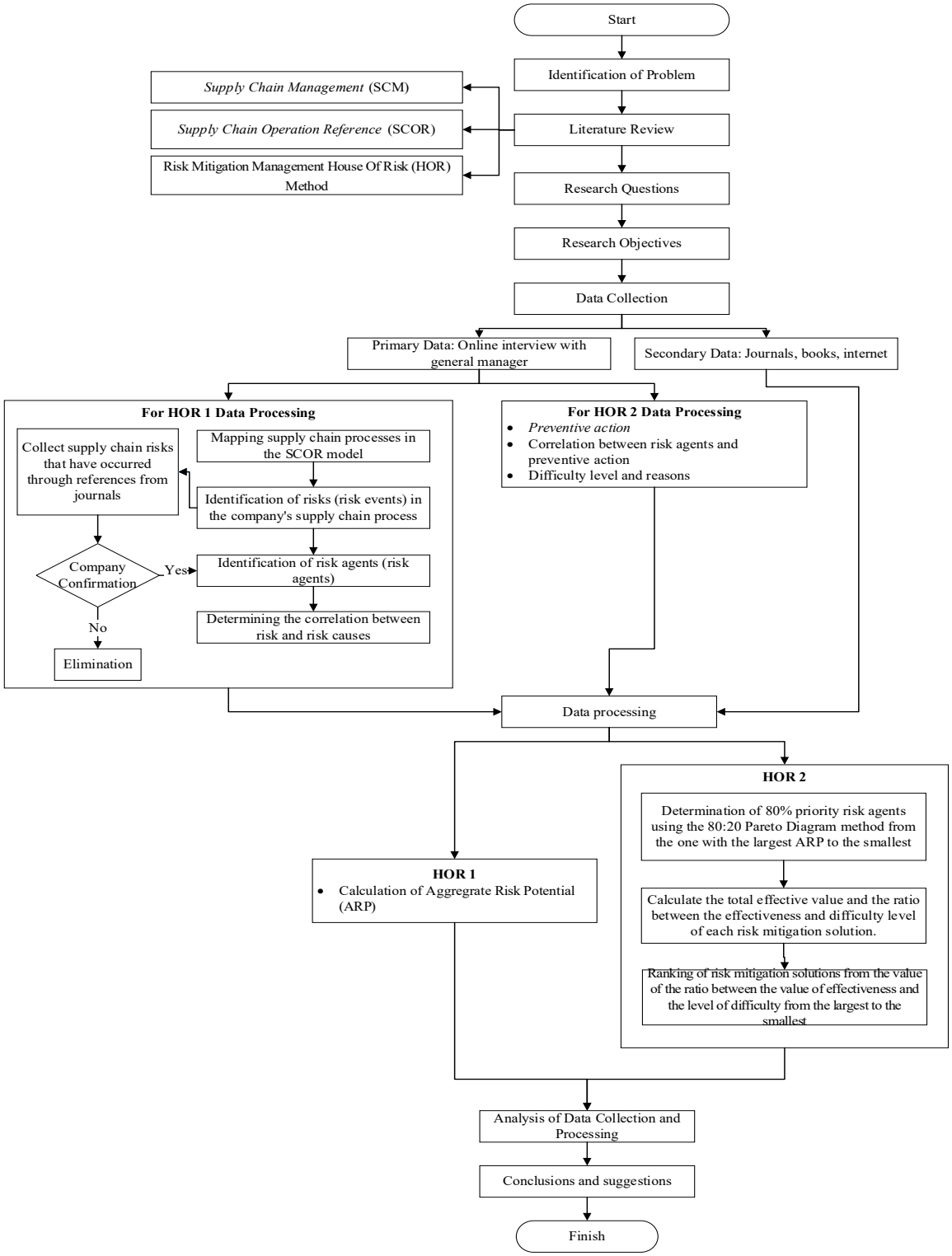

Figure 1. Research Flowchart

4. Data Collection

Activity mapping with the SCOR model is used to make it easier to identify each activity in the supply chain. The SCOR model is structured on five processes: Plan, Source, Make, Deliver, and Return. Activities on CV XYZ based on SCOR can be seen in Table 1.

Table 1. Supply Chain Operation Reference (SCOR)

Major Processes	***Sub Processes***
Plan	1. Production planning and control 2. Analysis and calculation of raw materials needed for the production process
Source	1. Purchase of raw materials (rice and corn) from suppliers 2. Receive raw materials from suppliers 3. Quality control of raw materials received from suppliers 4. Storing raw materials in the warehouse 5. Receive orders from customers
Make	1. Implementation of rice crispies production Packaging 2. Quality control
Delivery	1. Updated data information of finished products availability 2. Delivery of finished products to customers
Return	1. Return of rejected raw materials to suppliers 2. Handling if there is a product return from the customer

The risk in each of these activities is determined using the activity division based on the SCOR. The risk identification process in the company's supply chain is carried out by brainstorming with the company regarding the risks that occur, the source of the causes of the risk and where the risk occurs. Data on risk events that occurred at CV XYZ and their severity values are presented in the Table 2.

Table 2. Risk Events and Severity Value

Code	Risk Events	Severity (S_i)
E1	Sudden change of production plan	3
E2	Errors in the analysis and calculation of raw materials	3
E3	needed for the production process	2
E4	Delay in arrival of raw materials	3
E5	The condition of the raw material received is defective / reject	2
E6	Changes in the quality of raw materials	2
E7	Incompatibility of raw materials that come with those ordered to suppliers	2
E8	Delays in the implementation of the production process	2
E9	Inefficient process	1
E10	Machine scheduling error	2
E11	Incompatibility of data on the number of products in the system (SAP) with actual conditions during the production process	2
E12	Production yields down	3
E13	Machine failure (downtime)	3
E14	Lack of machine/equipment maintenance	1
E15	Production results do not meet the target / demand	1
E16	Production results do not match the calculation	2
E17	Production process stopped	2
E18	Decrease in product quality during the process	1
E19	Inappropriate packaging	1
E20	Physical incompatibility of goods with documents (errors)	2

E21	barcode) resulting in misinformation regarding the number of finished products available	1
E22	Product damage during delivery to customer	1
E23	Delay in delivery of products to customers	1

The causes of the emergence of the above said risks must be identified. The process of identifying risk agents is carried out in the same way that the process of risk identification is carried out. Data on risk agents contained in CV. XYZ based on supply chain activities and their occurrence values are presented in the Table 3.

Table 3. Risk Agents and Occurrence Value

Code	Risk Agents	Occurrence (*Oj*)
A1	Lack of communication between planning and implementation divisions	1
A2	Long distance between supplier and company	2
A3	Sudden product demand	5
A4	Suppliers lack capacity or not enough to meet demand	3
A5	Late order to supplier	3
A6	The ability of suppliers to meet demand on schedule is low	3
A7	Supplier's ability to meet low demand in quality	2
A8	Misinformation of arrival estimation data between divisions purchasing with suppliers	2
A9	Bad weather conditions or other things so that the arrival of raw materials is late	2
A10	An accident or something else occurred during the delivery so that the raw materials arrived in defective condition	1
A11	The quality of raw materials from suppliers decreases	2
A12	Production machine operators are less focused and thorough	3
A13	Delays in the arrival of raw materials, thus hampering the production process	3
A14	Inaccuracy of workers during the production process	4
A15	Damage to the engine resulting in engine failure	4
A16	Limited machine capacity in producing output resulting in a lack of products to meet demand	5
A17	Sudden product demand	5
A18	Data input error on machine scheduling	2
A19	Machine performance that has deteriorated so that it affects machine scheduling	2
A20	Machine performance that has deteriorated so that it affects the resulting production (production output may decrease)	5
A21	Lack of raw materials so that production results are also reduced from the target / demand	3
A22	Errors in maintenance resulting in engine damage	1
A23	Lack of attention to machine maintenance and lack of maintenance	2
A24	Error in the analysis of how many raw materials are needed, so that the impact on production results does not match the calculation	2
A25	Damage to the machine so that the production process stops	2
A26	Disruption of electricity (power failure) so that production stops	3
A27	Damage to the machine resulting in a decrease in product quality during the process	3
A28	Machine setup and setting errors	2
A29	Error in naming or cover packaging	1
A30	Dirty packaging paper with oil or other	1
A31	The packaging machine has problems or is damaged	2
A32	Delay in updating data on the system (human error) resulting in data errors regarding the number of products available	2
A33	Error inputting customer's destination address data on products that are ready to ship, resulting in shipping errors	1
A34	Bad weather conditions or other things so that the product delivery is late	2
A35	Lack of transportation so that the delivery of products to customers is late	2
A36	Weaknesses in the memorandum of agreement with the supplier, can't claim insurance	1

	for defective or bad goods

The severity and occurrence of the identified risk events and risk agents are then evaluated. Prior to the assessment, adjustments are made to the level of impact and occurrence through company interviews or the so-called determination of KPIs (Key Performance Indicators). This is done to ensure that the results correspond to the company's actual conditions. The aggregate risk potential (ARP) value for each risk agent can be calculated using the severity, occurrence, and correlation values. This ARP value is used as a guideline to determine which risk agents should be addressed first. Table 4 shows HOR 1 processing data based on data collection that has been completed.

Table 4. House of Risk 1

Risk Events	*Risk Agents*																																		*Si*
	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	A24	A25	A26	A27	A28	A29	A30	A31	A32	A33	A34	A35	A36	
E1			9															1	1									3								3
E2																												3								3
E3	1																							3												2
E4		1		9	3	3		1	1																											3
E5										1																										2
E6							3				3																									2
E7																	1																			2
E8													3																							2
E9												3																								1
E10														3																						2
E11																				3	1															2
E12															3							1														3
E13																							9													3
E14			9													9					3															1
E15																												3				3				1
E16																									9	3		1								2
E17																				3							9									2
E18																													3	1	3					1
E19																																1				1
E20																																	1			2
E21																																	3	1		1
E22																																1				1
E23																																			1	1
Oj	1	2	5	3	3	3	2	2	2	1	2	3	3	4	4	5	3	2	2	5	3	1	2	2	2	3	3	2	1	1	2	2	1	2	2	1	
ARPj	2	6	180	81	27	27	12	6	6	2	12	9	18	24	36	45	6	6	6	60	15	3	54	12	36	18	54	28	3	1	6	2	1	10	2	1	
Pj	30	21	1	2	10	11	16	22	23	31	17	20	13	12	7	6	24	25	26	3	15	28	4	18	8	14	5	9	29	34	27	32	35	19	33	36	

5. Results and Discussion

The results of the HOR data processing stage 1, followed by the 80:20 Pareto diagram method to take 80% of risk agents based on the ARP value. This stage involves the evaluation of risk events, specifically determining which risk agent will be treated first. The goal of creating a Pareto diagram is to determine which risk agent will be handled first. Pareto diagram presented in Figure 2.

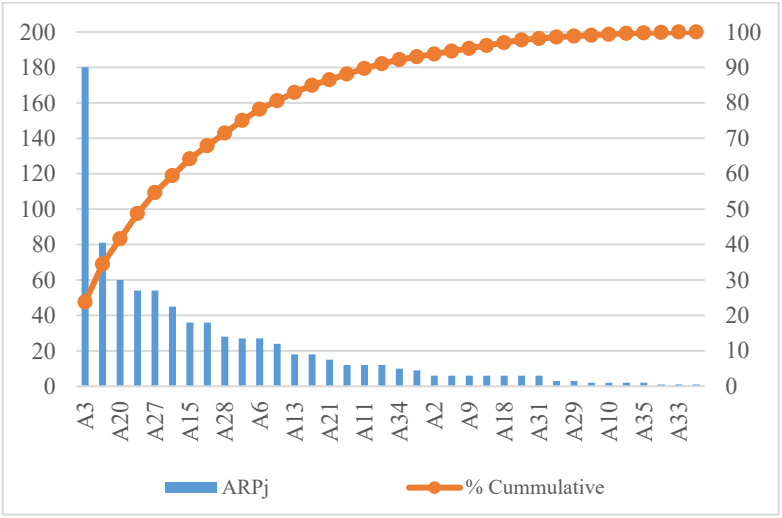

Figure 2. Pareto Diagram of Risk Agents Based on ARP Value

Based on the calculation of the Aggregate Risk Potential (ARP) at the HOR 1 data processing stage, a Pareto diagram is made to determine the risk agents that influence the risk in the system. In accordance with the principle of the Pareto Diagram 80:20, the priority problems that must be solved are problems with a percentage of up to 80% and can be seen in Table 5.

Table 5. Risk Agents Priority

Code	Risk Agents Priority	*ARPj*	*Pj*	% Cum
A3	Sudden product demand	180	1	23,8
A4	Suppliers lack capacity or not enough to meet demand	81	2	34,5
A20	Machine performance that has deteriorated so that it affects the resulting production	60	3	41,6
A23	Lack of attention to machine maintenance and lack of maintenance	54	4	48,7
A27	Damage to the machine resulting in a decrease in product quality during the process	54	5	54,7
A16	Limited machine capacity in producing output resulting in a lack of products to meet demand	45	6	59,4
A15	Damage to the engine resulting in engine failure	36	7	64,2
A25	Damage to the machine so that the production process stops	36	8	67,9
A28	Machine setup and setting errors	28	9	71,5
A5	Late order to supplier	27	10	75
A6	The ability of suppliers to meet demand on schedule is low	27	11	78,2
A14	Inaccuracy of workers during the production process	24	12	80,6

So, it is obtained from the results of the Pareto diagram of 12 risk agents which are included in the priority category of the existing 36 risk agents. Furthermore, the 12 risk agents that have been successfully identified will be managed in HOR 2 where in HOR 2 risk mitigation will be obtained for these priority risk agents. Data on preventive action proposed for priority risk agents and the correlation value between risk agents (*PAk*), along with the level of difficulty (*Dk*) and the reason for the level of difficulty can be seen in Table 6.

Table 6. Preventive Action with Correlation with Risk Agents and Difficulty Value

Preventive Action	*PAk*	*Dk*	Reason for Difficulty Level
Provide safety stock	PA1	4	- Limited storage/warehouse space - Short shelf life of raw material
Perform supplier performance evaluation	PA2	5	Because it includes criteria such as price, quantity, quality, and on time delivery, it will be very difficult to find a good supplier according to the criteria above
Looking for additional suppliers	PA3	5	- Limited number of suppliers - Each supplier has its own brand that will be different on the product
Perform machine repairs / machine service	PA4	3	- Difficulty getting original spare parts - Busy production schedule
Perform daily, weekly, monthly, yearly maintenance periodically by machine operators and maintenance parties	PA5	3	Difficult to do when there are many product requests
Using machine spare parts that match the original	PA6	5	- Most spare parts must be ordered from other countries - Expensive spare part prices
Addition of engine capacity	PA7	5	- Expensive price - Unstable requests
Additional production hours	PA8	1	- Increase working hours / overtime to 24 hours

Preventive Action	*PAk*	*Dk*	Reason for Difficulty Level
			- Saturday, Sunday overtime
Conduct regular employee briefings and training	PA9	4	- Usually done when there are cases / findings of product problems from customers
Reviewing contracts with suppliers (contact review) and giving penalties	PA10	5	- "Maklon" cooperation system - Not based on contract but based on PO
Carry out work measurements	PA11	4	- Different working hours - Different educational background

Based on data regarding priority risk agents that need to be mitigated, as well as preventive actions to mitigate priority risk agents. The ranking of preventive actions to determine priority levels can be sorted from largest to smallest by the value of the ratio between effectiveness and difficulty (ETDk). HOR 2 data processing can be seen in Table 7.

Table 7. House of Risk 2

Risk Agents	*Preventive Action*											ARP
	PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	PA9	PA10	PA11	
A3	3											180
A4		9	3									81
A20				9	9							60
A23					9							54
A27				9	9	9						54
A16							1	9				45
A15				9	9							36
A25				9	9							36
A28									3			28
A5	3								3			27
A6		9								3		27
A14									9		3	24
Effectiveness (TE)	621	972	243	1674	2160	486	45	405	381	81	72	
Difficulty (D)	4	5	5	3	3	5	5	1	4	5	4	
TEk to Dk Ratio (ETD)	155,25	194,4	48,6	558	720	97,2	9	405	95,25	16,2	18	
Rank Priority (R)	5	4	8	2	1	6	11	3	7	10	9	

Based on the HOR 2 table above, the priority risk mitigation sequence proposed to CV. XYZ presented in the Table 8.

Table 8. Preventive Action Based on Priority Level

Priority	Code	Preventive Action (PA)
1.	PA5	Perform daily, weekly, monthly, yearly maintenance periodically by machine operators and maintenance parties
2.	PA4	Perform machine repairs / machine service
3.	PA8	Additional production hours
4.	PA2	Perform supplier performance evaluation
5.	PA1	Provide safety stock
6.	PA6	Using machine spare parts that match the original
7.	PA9	Conduct regular employee briefings and training
8.	PA3	Looking for additional suppliers
9.	PA11	Carry out work measurements
10.	PA10	Contract review and giving penalties
11.	PA7	Addition of engine capacity

Based on priority preventive actions, the following are the 4 best preventive actions that can be implemented by CV. XYZ, where these 4 priority preventive actions have a cumulative percentage of 80% of all preventive actions presented in the Table 9.

Table 9. 80% Preventive Action Priority

Priority	Code	Preventive Action (*PA*)
1.	PA5	Perform daily, weekly, monthly, yearly maintenance periodically by machine operators and maintenance parties
2.	PA4	Perform machine repairs / machine service
3.	PA8	Additional production hours
4.	PA2	Perform supplier performance evaluation

Based on the results of the proposed mitigation actions, the following is a more detailed explanation from researchers that can be implemented by CV XYZ:

1. Perform daily, weekly, monthly, yearly maintenance periodically by machine operators and maintenance parties. This can be done by providing briefings and training to all staff who work in the production sector every day after production activities is completed, they are required to check machines such as checking engine lubricating oil volume, checking engine lubricating oil flow to ensure that the lubrication oil circulation is functioning. properly, check the volume of lubricating grease to ensure there are no leaks in the lubrication system from engine components. Then for weekly and monthly maintenance such as doing a vibration check to find out how much vibration occurs in engine components, checking temperature conditions or temperatures on engine components, running inspections to find out the actual condition of the production machine when it is running and if it finds anything abnormal it will immediately be repaired, and so on. Then for annual maintenance usually in the form of a tune up and a thorough inspection to ensure the condition of the machine is still usable. The existence of regular maintenance both daily, weekly, monthly, and yearly is an absolute thing to do so that the quality of the products produced is maintained and prevents machine damage in the future.

2. Perform engine repairs / engine service. The staff can make a repair request form and address it to the maintenance operator, and it will be repaired immediately. After being repaired, the maintenance party can inform about the cause of the machine being damaged, so that it can prevent the cause from happening again. This machine repair is carried out to prevent poor production quality, machine failure, machine failure, and so on.

3. Additional production hours. This can be done by the company by calculating the targeted production output to meet demand, especially when the demand is very high. Then, it can be calculated how much time it takes to produce the target output. The addition of production hours means the company must increase the working hours for employees by providing shift work so that production can run 24 hours, with night shifts and day shifts. Another thing that can be done is to apply additional working hours or overtime for employees, or additional working hours on Saturdays and Sundays, so that there are no open days and production can continue for 7 days a week. The application of additional production hours will prevent the risk of the lack of finished products from happening again in the future.

4. Evaluate supplier performance. Companies can measure supplier performance by looking at the value of the Vendor Performance Indicator (VPI) using the quality cost delivery flexibility responsiveness method. Supplier performance assessment is carried out by the company as a competitive strategy with other companies, where the supplier's role is very important as a supplier of raw materials, where if the raw materials are of good quality, it will produce good quality output as well.

6. Conclusion

The supply chain process at CV. XYZ has 23 risk events and 36 risk agents that cause risk events. Based on the results of the HOR stage 1 processing followed by making a Pareto diagram, it was found that 12 priority risk agents need to be mitigated in order to prevent risk events from happening again and continue with HOR data processing. Based on the processing of HOR 2 stage, 11 preventive actions can be obtained that can be implemented by the company to mitigate the 12 priority risk agents. Then, the cumulative 80% of all preventive actions are taken. First, carry out daily, weekly, monthly, yearly maintenance periodically by machine operators and maintenance parties (PA5). The second is to repair the engine / engine service (PA4). Third, the addition of production hours (PA8). Lastly, evaluate supplier performance (PA2).

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