

Risk Mitigation in Sausage Production Using a Combination of Supply Chain Operations Reference (SCOR) and House of Risk (HOR) Methods

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ABSTRACT

Objective: This study aims to identify risk factors that affect product quality in the sausage production process at PT Ciomas Adisatwa and determine appropriate mitigation measures to address these risks. **Method:** The methods used are SCOR mapping and House of Risk (HOR). In HOR phase 1, risk events and risk agents were identified, severity and occurrence were assessed, correlations between risk events and risk agents were determined, and ARP values were calculated. **Result:** The results identified 17 risk events and 24 risk agents, with the highest ARP values in A3, A6, and A10. In the second phase of the HOR, seven mitigation strategies were developed. Some of the highest-priority strategies included PA2, PA5, and PA6. **Novelty:** The novelty of the study lies in the combination of SCOR mapping and House of Risk to identify and mitigate risks in the production flow, offering a structured approach to improve product quality in the sausage production process.

INTRODUCTION

The food industry has undergone many developments, one aspect of which is food preservation, where food is preserved by freezing. In Indonesia, the frozen food market is growing rapidly as some people are switching from consuming fresh food to frozen food products as an alternative because they are quick and easy to prepare [1]. Sausages are food products made from a mixture of meat, fat, binding agents, fillers, and spices that are specially prepared by companies, which are usually cooked by steaming or using a special oven. The meat used is usually beef or chicken because it is easily available and liked by many people [2].

Supply chain management encompasses all activities involved in the flow of the supply chain from upstream to downstream. This process applies standards set by the company, starting from supplier selection, production processes, storage, to distribution [3]. An effective supply chain is one of the main ways to increase competitive advantage and maintain business continuity. However, in the supply chain process, various risks often arise that can affect the smooth flow of the supply chain [4]. In the application of supply chain management in industry, obstacles or constraints are often encountered, which can also be defined as risks. These risks reflect the existence of uncertainties that can hamper the performance of the industry facing them. In other words, the more complex the supply chain activities, the greater the risks faced [5].

PT. Ciomas Adisatwa is a subsidiary of PT Japfa Comfeed Tbk., which focuses on chicken slaughterhouses and processing. The company produces large quantities of chicken meat using modern technology and strict food safety procedures. Its main

products include chicken carcasses, boneless chicken, chicken cuts, frozen chicken, marinades, and chicken sausages and meatballs.

Although the production system at PT Ciomas Adisatwa generally runs well, several risk factors have been identified that result in non-compliance with company standards, both in production and other factors. It is known that the defect rate in January was 0.84%, in February it reached around 2.4 tons or 1.04%, which exceeded the company's tolerance limit of below 1%, while in March it was 0.94%. This high defect rate has a significant impact on production results because the products produced do not meet company specifications and customer expectations, resulting in losses. Therefore, improvements are needed to address this issue.

This study uses the House of Risk (HOR) method and is supported by the SCOR method for business process mapping. The SCOR method is a reference model for supply chain activities that includes the stages of plan, source, make, deliver, and return. In the HOR method phase 1, the FMEA model is integrated to identify, analyze, and measure risks. Meanwhile, HOR phase 2 is used to find effective mitigation strategies for handling risks in the production flow at PT Ciomas Adisatwa. The objectives of this study are to identify risk factors in the production flow, determine the highest risk priorities based on ARP values, and determine recommendations or improvement strategies for the company.

In a previous study entitled "Supply Chain Risk Analysis using the House of Risk (HOR) Model at PT Tatalogam Lestari," 21 risk events and 20 risk agents were identified in the production of roof tiles and lightweight steel. The HOR results produced eight risk mitigation priorities that could improve the operational quality of PT Tatalogam Lestari. The main difference between this study and the previous study is that the previous study only identified risks in three SCOR processes: Source, Make, and Delivery [6], while this study covered all five SCOR processes: Plan, Source, Make, Delivery, and Return. In another study entitled Chicken Supply Chain Management Using the House of Risks Method, the object of study was Cil_ans Distributor, a trading company that distributes broiler chickens from farms to traders. The results of the study identified 9 risk events and 10 types of risk agents, resulting in 9 risk mitigation priorities [7]. Meanwhile, this study uses a different object, namely PT Ciomas Adisatwa, which is a chicken slaughterhouse (RPA) and processing company that produces products such as chicken carcasses and sausages.

RESEARCH METHOD

The research location for data collection was at PT. Ciomas Adisatwa (JAPFA), Waruberon Village, Balongbendo District, Sidoarjo Regency. The methods used in this study were qualitative and quantitative approaches. The qualitative approach involved direct observation of the production flow system to identify risks or problems occurring at PT Ciomas Adisatwa, as well as interviews and questionnaires distributed to the head of Quality Assurance (QA), Quality Control (QC) supervisors, and production

supervisors. The quantitative approach utilized the Supply Chain Operations Reference (SCOR) method and the House of Risk (HOR) method to resolve the issues encountered.

1. Supply Chain Operations Reference (SCOR)

The Supply Chain Operation Reference (SCOR) model is a tool used by companies to communicate a framework that describes the supply chain in detail. SCOR defines and categorizes the processes that form the measurement indicators needed to evaluate supply chain performance [8]. SCOR is capable of mapping parts of the supply chain, serving as a basis for understanding supply chain operations, identifying all parties involved, and analyzing supply chain performance [9]. Specifically, SCOR is used to measure supply chain performance by breaking down the supply chain process into five core processes consisting of planning (Plan), sourcing (Source), production (Make), delivery (Deliver), and returns (Return) [10].

2. House of Risk (HOR)

House of Risk (HOR) is a model used to proactively manage risk. This method identifies risk agents as the causes of risk events and ranks them based on their potential impact. Based on this order, effective proactive measures can be determined to reduce the likelihood of risks occurring [11]. In dealing with emerging risks, the HOR model consists of two stages. The first stage is HOR phase 1, where risks are identified. The stages in the HOR phase 1 method include:

- Identifying risk events.
- Assessing the severity level on a scale of 1 to 10 (S_i).
- Identify the cause of risk (risk agent) and assess the probability of occurrence on a scale of 1-10 (O_j).
- Determine the relationship or correlation between risk events and risk agents.
- Calculate the Aggregate Risk Potential (ARP_j) value.
- Sorting ARP values from largest to smallest

The following is the equation for calculating the ARP value:

$$ARP = O_i \sum S_i R_{ij} \quad [12],[13],[14]$$

Explanation:

O_i = Risk occurrence rate

S_i = Risk severity level

R_{ij} = Correlation between occurrence and cause of risk

The ARP value calculation model can be seen in the HOR phase 1 calculation table in Table 1.

Table 1. Calculation of *house of risk* phase 1.

Risk Event (E_i)	Risk Agent			Severity of Risk (S_i)
	A1	A2	A3	
E1	R11	R12	R13	S1
E2	R21	...	...	S2
E3	...	...	...	S3

E4	...	...	...	S4
<i>Occurrence of Factors (Oj)</i>	O1	O2	O3	
<i>Aggregate Potential Risk (ARPj)</i>	ARP1	ARP2	ARP3	
<i>Priority Rank of Factors</i>				

Sources: [12], [6], [7]

The next step after determining the ARP value is to conduct a phase 2 HOR analysis, which is used to determine the priority of mitigation based on the findings from phase 1 HOR. At this stage, decisions are made regarding the mitigation actions that should be prioritized. The steps are as follows:

- Using Pareto chart analysis based on ARP values to determine which risk factors should be addressed first.
- Identifying effective mitigation strategies for managing and mitigating potential risks.
- Determining the correlation between mitigation strategies and risk sources.
- Calculating the Total Effectiveness (TEk) value.
- Determining the difficulty level (Dk) and calculating the total effectiveness ratio, also known as Effectiveness to Difficulty (ETD).
- Determining the priority ranking of each strategy, where the strategies are ordered from highest to lowest ETD value.

$$TEk = \sum ARP_i R_{ij}$$

Explanation:

TEK = Total Effectiveness

ARP = Aggregate Risk Potential

R = Relationship

$$ETDk = \frac{TEk}{Dk}$$

Explanation:

ETDk = Effectiveness to Difficulty

TEk = Total Effectiveness

Dk = Degree of Difficulty

In calculating the TEk (Total Effectiveness) and ETDk (Effectiveness to Difficulty) values, you can also use the HOR phase 2 model calculation as shown in Table 2. The analysis in HOR phase 2 is used to create preventive actions or mitigation proposals based on the highest ARP priority findings from HOR phase 1.

Table 2. Calculation of house of risk phase 2.

Risk Agent (Ai)	Preventive Action (PAk)			ARPj
	PA1	PA2	PA3	
A1	E11	E12	E13	ARP1
A2	E21	...	...	ARP2
A3	...	...	...	ARP3

Tek	TE1	TE2	TE3
Dk	D1	D2	D3
ETDk	ETD1	ETD2	ETD3
Priority Ranking	R1	R2	R3

[6], [7], [15]

Description:

Ak : Mitigated *risk agent*

PAk : Proposed mitigation strategy

Ek : Correlation between mitigation strategy and *risk agent*

TEk : Total Effectiveness

Dk : Degree of Difficulty

ETDk : Effectiveness to Difficulty

R : Ranking of mitigation strategies from highest ETD

The flowchart of this research can be seen in Figure 1, which shows the research process, starting with problem identification through observation and literature study. Next, data collection for SCOR mapping was carried out through interviews and observation, then the data obtained was processed using the House of Risk (HOR) phase 1 analysis to identify risk events and causes. Next, House of Risk (HOR) phase 2 analysis is conducted to determine appropriate mitigation strategies for the company.

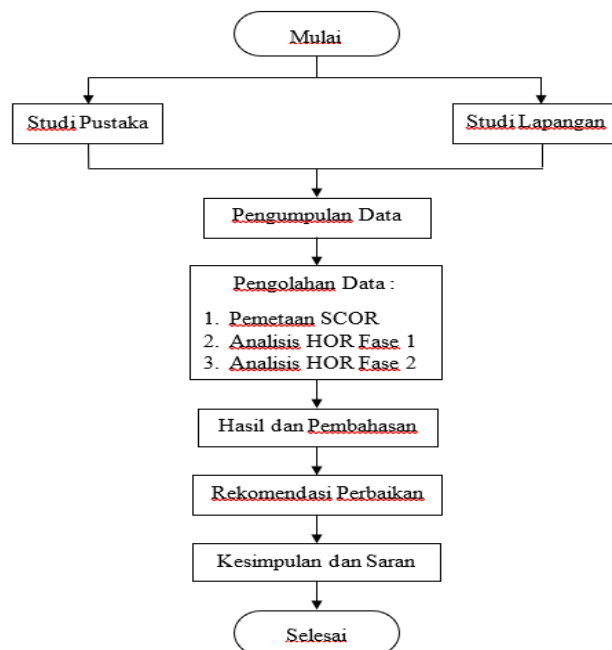


Figure 1. Research Flowchart.

In Figure 1, the research flowchart shows the process that begins with problem identification through observation and literature study. The next stage is data collection and processing using the SCOR model to map the stages of the production supply chain. The collected data is then analyzed with HOR phase 1 to identify risk events and causes.

Next, HOR phase 2 analysis is used to determine the appropriate mitigation strategy for the company.

RESULTS AND DISCUSSION

A. Mapping of SCOR Activities

Mapping activities at PT Ciomas Adisatwa using this method is done to obtain activities or sub-processes at each stage. The function of this mapping is to facilitate the identification of the scope of the supply chain, thereby helping to determine where risks may arise. By using the SCOR approach to map supply chain activities as shown in the table below, the process of identifying risks in the supply chain will become easier.

Table 3. SCOR Activity Identification [9] [6].

No.	Activity Details	Reference
A. Plan (Production Planning)		
1	Conducting production planning and forecasting	[7]
2	Calculating raw material requirements	[6]
B. Source (Raw Material Procurement)		
1	Purchasing raw materials	[6]
2	Receipt of raw materials	Interview
3	Raw material quality inspection	[6]
C. Make (Production Process)		
1	Process of converting raw materials into finished products	Interview
2	Conducting product quality checks	Interview
3	Labeling and packaging process	Interview
4	Storage	Interview
D. Delivery		
1	Product Delivery	[6], [7]
E. Returns		
1	Returns Handling	[6], [7]

Table 3 summarizes the main activities in the supply chain using the SCOR model to analyze the supply chain flow by dividing the main processes into five stages, namely Plan, Source, Make, Deliver, and Return. In the Plan stage (Production Planning), activities include production planning and forecasting, as well as calculating raw material requirements. The Source stage (Raw Material Procurement) includes purchasing, receiving, and quality inspection of raw materials. The Make (Production Process) stage covers the processing of raw materials into finished products, product quality inspection, labeling and packaging, and storage. The Delivery stage covers the delivery of products to customers, while the Return stage covers the handling of product returns from customers.

B. House of Risk Phase 1

Risk identification in this study uses the FMEA concept with two main variables, namely the probability of risk occurrence and risk severity. This approach aims to understand the problems that occur at PT Ciomas Adisatwa. This process includes field observations to thoroughly identify risk events and interviews with the heads of QA and production. Risk identification covers all business processes in the company's supply chain, which is divided into five stages: planning, sourcing, production, delivery, and returns. This division of business processes helps identify all potential disruptions in the supply chain that could hinder the achievement of the company's objectives. Meanwhile, the assessment of variables is carried out through interviews and questionnaires completed by the heads of the QA (), QC (quality control), and production departments, as they have in-depth knowledge and experience regarding the processes and quality in the supply chain and production operations. The involvement of experts ensures accurate and relevant data that reflects real-world conditions. This is crucial for obtaining a comprehensive overview of supply chain risks and process effectiveness, as well as identifying specific areas for improvement and appropriate solutions to enhance operational performance.

Table 4. Risk Event *Severity* Assessment Results.

Process	Activity	Risk Event	Code	Severity			Ave rage
				R1	R2	R3	
Plan	Conduct production planning and forecasting	Fluctuating demand	E1	6	2	5	4
	Calculating raw material requirements	Errors in production capacity planning	E2	6	5	6	6
	Purchase of raw materials	Delays in the arrival of raw materials from suppliers	E3	6	5	5	5
Source	Receipt and quality inspection of raw materials	Instability of raw material supply	E4	6	6	5	6
		Discrepancies in the quantity of raw materials	E5	6	5	6	6
		Raw material quality does not meet factory standards	E6	6	6	7	6
Make	Process of converting raw materials into finished products	Delays in the production process	E7	6	5	7	6
		Occurrence of work accidents among employees	E8	6	6	5	6
			E9	10	4	7	7

		Machine occurred	<i>downtime</i>	E10	6	7	7	7
	Conducting product quality checks	Defects found in the product		E11	7	6	7	7
	<i>Labeling</i> and <i>packaging</i> process	An error occurred during the packaging process		E12	7	6	7	7
	Storage	Storage conditions are not suitable		E13	7	7	7	7
		<i>Delivery delay</i>		E14	6	5	6	6
<i>Delivery</i>	Product delivery	Damage to products/packaging during shipping		E15	6	7	7	7
		<i>Customer complaints</i>		E16	7	5	7	6
<i>Return</i>	Returns handling	Return of raw materials to <i>suppliers</i>		E17	6	5	6	6

Table 4 shows the results of interviews and questionnaires, identifying 17 risk events in the supply chain of PT Ciomas Adisatwa, as well as 24 risk agents listed in Table 5. Furthermore, the company assessed the severity and frequency of each risk. The severity level reflects the extent of the risk's impact on the company's business operations. Meanwhile, the assessment of the frequency of occurrence was carried out for each risk agent that had been identified previously, based on how often the risk agent occurred or appeared.

Table 5. Results of Occurrence Risk Cause Assessment.

No.	Risk Agent / Risk Cause	Code	Occurrence			Average
			R1	R2	R3	
1	Failure to set production targets	A1	2	1	6	3
2	<i>An error</i> occurred in the prediction	A2	2	1	6	3
3	There was a sudden change in the production plan	A3	3	3	6	4
4	Sudden changes in demand	A4	6	1	6	4
5	Errors in production capacity estimates	A5	5	1	6	4
6	Logistics issues from <i>suppliers</i>	A6	6	2	5	4
7	<i>Supplier</i> cannot meet demand	A7	3	1	5	3
8	Seasonal raw materials	A8	2	1	3	2
9	Errors in machine <i>setup</i> or <i>settings</i>	A9	5	1	5	4
10	Machine malfunction	A10	6	2	7	5
11	Worker negligence	A11	5	1	4	3
12	Workers do not comply with SOPs	A12	5	1	5	4
13	Workers not wearing complete PPE	A13	3	2	3	3
14	Machine inspection lacks detail	A14	3	4	3	3
15	Operational errors	A15	5	1	3	3
16	Machine components are worn out	A16	5	2	6	4
17	Inadequate human resource capabilities	A17	5	1	4	3

18	Products contaminated with hazardous substances	A18	2	1	2	2
19	Inadequate packaging	A19	5	1	6	4
20	An error occurred in the packaging section	A20	5	1	6	4
21	Miscommunication between departments	A21	5	1	6	4
22	Cooling system temperature is not optimal	A22	3	1	6	3
23	Lack of employee involvement and concern during the delivery process	A23	2	1	6	3
24	Products received by <i>customers</i> do not match the PO	A24	5	1	6	4

After assessing severity and occurrence, the next step is to calculate the Aggregate Risk Potential (ARP) value using HOR phase 1 to determine the priority of risk sources. In calculating ARP, data on the level of correlation between risk agents and risk events is obtained through interviews, observations, and assessments of supply chain activities by the company. As shown in table 6, the following is the correlation level assessment scale.

Table 6. Correlation level assessment scale.

Scale	Description
0	No correlation
1	Weak correlation/relationship
3	Moderate correlation/relationship
9	Strong correlation/relationship

Table 7. Results of ARP HOR phase 1 calculations.

Risk Event Code	Risk Agent																								Severity Of Risk
	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	A24	
E1	3	3	9	3	9	1	3																		4
E2	9	9	9	9	9																				6
E3	9	9	9	9	9																3				5
E4						9	9	9																	6
E5						9	9	9																	6
E6	9	3	9	1	9	9	3	3													3				6
E7			9			3	9	1										1							6
E8			9		9				3	9	1			9	9	9		3							6
E9											9	9	9				3								7
E10									9	9				9		9									7
E11										9	1	1			3			3	3	9		9			7
E12									1	1	3	9		1	1	3	3		9	9					7
E13									3	9		9		9					3			9			7
E14																				9	1	9	9		6
E15																							9		7
E16						9													9	9	3		3	9	6
E17						9	9																		6
Occ	3	3	4	4	4	4	3	2	4	5	3	4	3	3	3	4	3	2	4	4	4	3	3	4	
ARP	495	387	1188	468	972	1168	738	264	436	1250	291	784	189	561	246	552	126	90	636	936	228	540	405	216	13166
Rank	12	16	2	13	4	3	7	18	14	1	17	6	22	9	19	10	23	24	8	5	20	11	15	21	

In this stage, after identifying risk events and their causes, assessing severity and occurrence, and calculating the ARP value in Table 7, the next step is to sort the ARP values from largest to smallest for each risk agent to determine the most dominant risk agents. Then, a Pareto diagram will be formed to determine and identify the main risk agents that need to be addressed. This Pareto diagram illustrates the cumulative percentage of each ARP.

Table 8. Calculation of the Pareto diagram of ARP values.

Rank	Code	Risk Agent	ARP	Cumulative %
1	A10	Machine malfunction	1250	9
2	A3	There was a sudden change in the production plan	1188	19
3	A6	Logistics issues from <i>suppliers</i>	1168	27
4	A5	Errors in production capacity estimates	972	35
5	A20	Errors occurred in the <i>packaging</i> section	936	42
6	A12	Workers did not comply with SOP	784	48
7	A7	<i>Suppliers</i> cannot meet demand	738	53
8	A19	Inadequate packaging	636	58
9	A14	Machine inspection not detailed enough	561	63
10	A16	Engine components are worn out	552	67
11	A22	Engine cooling temperature is suboptimal	540	71
12	A1	Failure to set production targets	495	75
13	A4	Sudden changes in demand	468	78
14	A9	Errors in machine <i>setup</i> or <i>settings</i>	436	81
15	A23	Lack of involvement and concern from workers during the shipping process	405	85
16	A2	<i>An error</i> occurred in the forecasting process	387	87
17	A11	Worker negligence	291	90
18	A8	Seasonal raw materials	264	92
19	A15	Operational errors	246	94
20	A21	Miscommunication between departments	228	95
21	A24	Products received by <i>customers</i> do not match the PO	216	97
22	A13	Workers did not use complete PPE	189	98
23	A17	Inadequate human resource capabilities	126	99
24	A18	Products contaminated with hazardous substances	90	100

In Table 8, the calculation of the ARP value Pareto chart, the cumulative percentage value is calculated based on the ARP value of each risk agent. This is done to determine the percentage of each risk agent that is a priority for handling. Next, a Pareto chart is created to illustrate the cumulative percentage of each ARP.

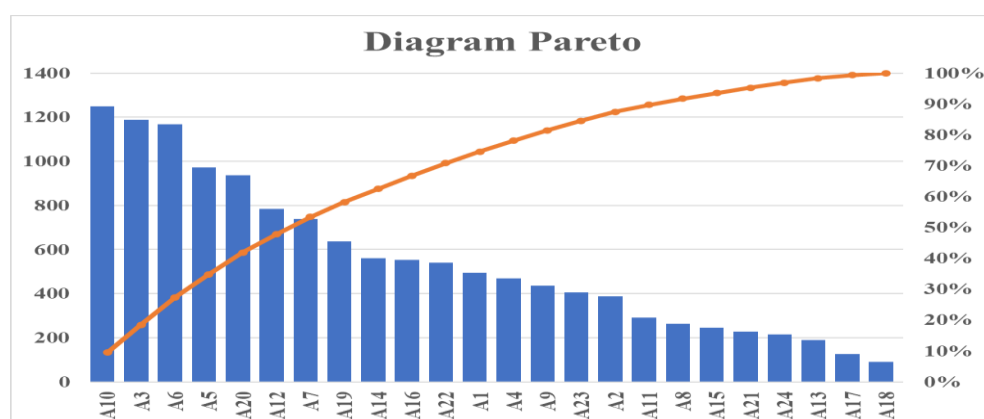


Figure 2. ARP Value Pareto Diagram.

In figure 2, the Pareto diagram shows that there are risk agents with high risk levels that have a cumulative ARP value of 27% of the total cumulative value of risk agents. The causes of risk (risk agents) with high ARP values include A10, A3, and A6.

C. House of Risk Phase 2

Based on the results of calculations and determination of risk agent priorities from the ARP values in HOR phase 1, the next process is to design strategies and set mitigation action priorities using HOR phase 2. This process involves determining the initial actions that must be taken, taking into account the level of difficulty in their implementation. Through this approach, it is hoped that effective and efficient mitigation strategies can be obtained to reduce risks in the company's supply chain. Table 9 shows the assessment scale for the level of difficulty in implementing mitigation.

Table 9. Assessment scale for the level of implementation.

Scale	Description
3	Easy to implement
4	Somewhat difficult to implement
5	Difficult to implement

This assessment scale aims to determine the level of difficulty in implementing the risk management strategy plan that will be used in the company. The results of this difficulty assessment are based on interviews with PT. Ciomas Adisatwa, as described in Table 10 below.

Table 10. Results of the difficulty level assessment.

Code	Risk Management Strategy / Preventive Action (PA)	Difficulty Scale (Dk)
PA1	Developing a flexible production plan	4
PA2	Maintaining reserve stock	3
PA3	Establishing partnerships with flexible <i>suppliers</i>	5
PA4	Implementing advanced shipment tracking and monitoring technology	4

PA5	Conducting regular evaluations and audits	3
PA6	Conducting emergency response training	3
PA7	Using a monitoring system to monitor machine performance in <i>real time</i>	4

After determining the mitigation strategy, the next step is to calculate the total effectiveness value (TEk) and the Effectiveness to Difficulty (ETD) value. Next, a correlation assessment is carried out to determine the extent of the relationship between the recommended mitigation strategy and the selected risk agent. This assessment also aims to show the level of effectiveness of each mitigation measure. The calculation of the Effectiveness to Difficulty ratio (ETD) also aims to help determine which mitigation strategies can be implemented first based on the order of ETDk values from largest to smallest.

Table 11 shows the results of phase 2 calculations from the House Of Risk (HOR) model used to manage risk in the supply chain. This table identifies three main risk agents with codes A3, A6, and A10, and provides various preventive measures (PA1 to PA7) measured based on their effectiveness values.

Table 11. Results of the HOR phase 2 calculation.

Risk Agent Code	Handling Strategy / Preventive Action (PA)							ARP
	PA1	PA2	PA3	PA4	PA5	PA6	PA7	
A3	9	3			3			1250
A6		9	9	9	3			1188
A10					3	9	9	1168
TEk	11250	14442	10692	10692	10818	10,512	10512	
Dk	4	3	5	4	3	3	4	
ETDk	2813	4814	2138	2673	3606	3504	2628	
Rank	4	1	7	5	2	3	6	

Based on the results of the mitigation action calculations in HOR 2 and the strategic handling priority ranking, the following sequence was obtained: storing reserve stocks (PA2) with an ETD value of 4814 [7], conducting regular evaluation and audit (PA5) with an ETD value of 3606, conducting emergency response training (PA6) with an ETD value of 3504, developing a flexible production plan (PA1) with an ETD value of 2813, implementing advanced shipment tracking and monitoring technology (PA4) with an ETD value of 2673, using a monitoring system to monitor machine performance in real-time (PA7) with an ETD value of 2628 [6], and establishing partnerships with flexible suppliers (PA3) with an ETD value of 2138.

CONCLUSION

Fundamental Finding : The study identified 17 risk events and 24 risk agents in production flow activities. The risk factors with the highest aggregate risk potential

(ARP) values are machine damage (ARP = 1250), sudden changes in production plans (ARP = 1188), and logistical problems from suppliers (ARP = 1168). **Implication :** The proposed mitigation strategies, such as developing flexible production plans, maintaining reserve stocks, establishing partnerships with flexible suppliers, implementing advanced delivery tracking technology, conducting regular evaluations, providing emergency response training, and monitoring machine performance in real time, can help address these risks and improve the production process. **Limitation :** The study is focused on identifying and addressing risks in the production flow of a single company, which may limit the broader applicability of the findings. **Future Research :** Future research could explore the effectiveness of the proposed mitigation strategies across different industries and evaluate their impact on reducing risks and improving operational efficiency in the long term.

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