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Risk Management in the Seafood Frozen Food Supply Chain Using the House of Risk Method

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ABSTRACT

The frozen seafood supply chain, especially in emerging markets like Indonesia, is prone to various operational risks, including raw material degradation, inconsistent storage temperatures, and human error. PT Winaros Kawula Bahari, a shrimp processing company expanding into the Japanese market, faces these critical risks that threaten efficiency and product quality. This study aims to identify, analyze, and prioritize supply chain risks in the frozen seafood industry to support risk-based decision-making. This research employs the House of Risk (HoR) method, a proactive supply chain risk management approach combining Failure Modes and Effects Analysis (FMEA) with the House of Quality (HoQ). A mixed-methods approach was used, involving three domain experts (procurement, production, and logistics) to assess the severity and occurrence of risks. Risk events and agents were identified and evaluated using Aggregate Risk Potential (ARP), followed by the prioritization of mitigation actions in HoR Phase 2. The analysis identified 9 risk events and 22 risk agents. Based on ARP values, two dominant risk agents were identified: labor negligence and insufficient shrimp temperature during handling, which together accounted for over 25% of total ARP. Recommended mitigation strategies include enhanced supervision, occupational health and safety (OHS) training, supplier evaluation, and continuous quality audits. This study provides practical guidance for small and medium seafood enterprises in implementing data-driven supply chain risk management strategies. It sets the groundwork for integrating dynamic or fuzzy HoR methods in future research.

Keywords: *Frozen Food, House of Risk, Supply Chain Management, Risk, SCOR*

Introduction

Shrimp is one of the prima donnas in Indonesian fisheries because it has considerable resource potential, high market value, and excellent market opportunities. Shrimp products are in high demand both domestically and abroad, especially in countries with high demand, such as the United States and Japan [1]. Indonesia has abundant potential shrimp resources in its marine waters. The diversity of ecosystems in Indonesia creates ideal conditions for natural shrimp breeding and growth. This makes shrimp one of the most valuable fishery resources and attracts the attention of the fishing industry in the country [2], [3], [4].

A supply chain is a process that begins with the collection of available resources and ends with the processing of a finished product that is then delivered and promoted to the end customer, considering cost, quality, availability, after-sales support, and reputation [5]. The supply chain has a complex structure, making it challenging for business actors to manage their processes, especially when it involves numerous stakeholders. Companies with proper management will be able to survive and compete in today's industrial environment [6], [7], [8]. The supply chain division works to integrate suppliers, factories, warehouses, and retailers to produce and deliver products accurately, on schedule, and to the right location [9].

PT Winaros Kawula Bahari is a shrimp processing company that initially focused on exporting its products to the United States. However, since 2010, the company has seen promising opportunities in the Japanese market. PT Winaros Kawula Bahari faces quality issues in raw shrimp materials, such as

Billow Standard (BS) defects, scratches, mushiness, and red discoloration, which cause serious problems in production. Damage to these raw materials slows the quality-sorting process and requires more time and labor to separate them according to the set quality standards. This condition not only reduces operational efficiency but also increases production costs and reduces the quality of the final product. Therefore, PT Winaros Kawula Bahari needs to implement a robust risk management strategy to identify, measure, and manage these risks. By understanding and proactively responding to potential risks, adapting to changing market conditions, mitigating the negative impact of unforeseen risks, and enhancing the success of their new strategy in the Japanese market, while still ensuring business sustainability and long-term profits [10], [11].

However, studies that focus on identifying and managing supply chain risks in the seafood or frozen food industry in Indonesia remain limited. Previous research on supply chain risk management (SCRM) has generally focused on manufacturing or agribusiness sectors, without specifically addressing the cold-chain challenges in seafood exports.

The House of Risk (HOR) method is used to identify and analyze problems arising from existing risks [12], [13], [14]. The House of Risk method is carried out by selecting risk agents with high Aggregate Risk Potential (ARP), meaning that risk agents have a high probability of occurrence and cause many risk events with severe consequences, and then mitigation action is carried out [15], [16], [17]. Actions are assigned to selected risk agents based on high Aggregate Risk Potentials (ARP) values and the ratio of total effectiveness to the difficulty level [18]. HOR is a method of combining or modifying the House of Quality model and FMEA (Failure Modes and Effects of Analysis), which is used to assess the risk levels and prioritize which risk sources have the most potential to be addressed or mitigated appropriately based on the risk source [19]. Compared to traditional tools such as FMEA, AHP, or ISM, the House of Risk offers a more structured prioritization approach by combining risk magnitude (severity and occurrence) with mitigation effectiveness. This makes HoR suitable for complex environments such as seafood cold chains, where multiple risk sources interact simultaneously and must be managed proactively.

Prior studies have demonstrated the effectiveness of HoR in agricultural and food supply chains, particularly in identifying critical control points and formulating targeted mitigation measures. However, its application in the Indonesian frozen seafood industry remains limited, leaving a research gap in local risk profiles and appropriate mitigation frameworks. This study aims to fill that gap by applying the HoR method in the frozen shrimp supply chain of PT Winaros Kawula Bahari, to identify dominant risk agents and propose prioritized mitigation actions. This research addresses the following question: "Which risk sources have the highest priority in the seafood frozen food supply chain, and what strategic actions are most effective in mitigating them?"

Research Methods

This research method is the HOR (House of Risk) method. This study utilizes a mixed-methods approach, combining both qualitative and quantitative research. This quantitative research uses numerical data for analysis. This quantitative research is applied to the HOR calculation. As for qualitative research, it is descriptive research. Figure 1 shows the stages of this research. The House of Risk (HoR) approach in this study follows the model developed by Pujawan and Geraldin (2009), which integrates Failure Modes and Effects Analysis (FMEA) with the House of Quality (HoQ) to enable proactive supply chain risk management.

This study involved three experts selected from key divisions at PT Winaros Kawula Bahari: PPIC and production. These experts were chosen due to their direct involvement and knowledge in the daily operations of the seafood frozen food supply chain. Data were collected through structured interviews and questionnaires. The experts were asked to evaluate the identified risk events and risk agents using a ten-point scale, scoring: (1) Severity (S): the level of impact of a risk event if it occurs. (2) Occurrence (O): the frequency or likelihood of a risk agent triggering a risk event. The severity and occurrence scale values were obtained by averaging the results of questionnaires completed by three company experts and then rounded up.

Risk agents are then ranked by their ARP scores. The 80% ARP cutoff is applied using the Pareto principle, which assumes that a small number of risk sources account for most of the overall risk. Risk agents with cumulative ARP in the top 80% are selected for priority mitigation.

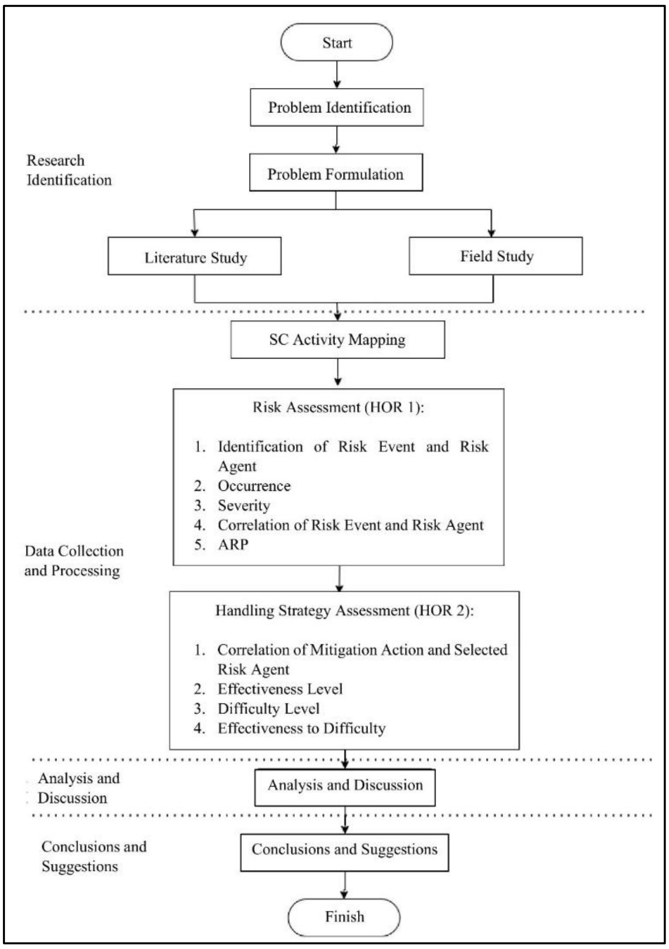

Figure 1. Research stage

Results and Discussion

The following results and discussion are based on data processed using the House of Risk (HOR) method applied to PT's supply chain. Winaros Kawula Bahari.

Supply Chain Flow

After an order from a client, the marketing department contracts with the client regarding product specifications and cost budgets. After the agreement, the purchase of raw materials in accordance with the agreement is made and the production process starts running [20]. The product delivery process will be carried out by a third party that provides export transportation services. This third party is fully responsible for maintaining product quality from shipment until delivery to the client.

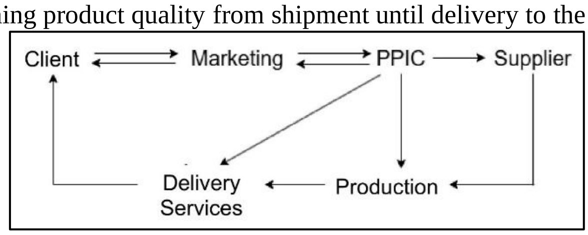

Figure 2. Supply chain flow

House of Risk Phase 1

The first stage of the House of Risk phase 1 process is identifying risks that need to be prioritized for prevention [21], [22], [23]. Discussions with company experts and the distribution of questionnaires carry out the risk identification process. Based on the results of discussions and questionnaires, nine risk events occur in the Supply Chain (Table 1).

Table 1. Risk Event (Severity)

Risk Event	Code	Severity
The production planning for breaded products is not in accordance with the container shipment schedule, including non-sequential processing, unavailable materials, and ingredients that do not match the planned production quantities.	E1	6
Damaged raw materials such as Billow Standard (BS), scratches, and mushy shrimps	E2	7
In the size-sorting process, the machine is not accurate in separating shrimp by size, so manual sorting is required.	E3	4
In the peeling process, there is an error in fulfilling the order	E4	8
The quality sorting process requires more time to separate raw materials according to their quality.	E5	4
In the chemical addition process, there was an error in the order of chemical doses.	E6	8
In the soaking process, the quality of the shrimp becomes poor	E7	6
Product cook (cook commodity/cooking) rejects the metal detector if it includes non-standard core temperature or foreign object debris	E8	7
Delays in shipping include not passing lab tests, stock shortages, and packaging damage	E9	5

After identifying the risk event, the next step is to identify the cause of each risk event (Risk Agent). Table 2 shows 22 risk agents in supply chain activities.

Table 2. Risk Agent (Occurrence)

Risk agent	Code	Occurrence
Materials tied to planned sales orders are not ready because they are below the standard limit.	A1	5
The frying machine experienced damage to the heater, which resulted in the production schedule not in accordance with the production plan.	A2	7
The number of production or non-production labor is not in accordance with the planned numbers.	A3	3
The shrimp temperature is not cold enough	A4	6
The shrimp container (from the supplier) is too small, so the shrimp rubs too much and causes scratches.	A5	6
Treatment from suppliers that is not in accordance with Standard Operating Procedures (SOP)	A6	7
The shrimp sizes provided by the supplier are inconsistent, containing both large and small shrimp.	A7	7
Labor negligence	A8	3
The room temperature is very cold, causing labor to be less focused	A9	4
Too many scratches on the raw material	A10	6
The shrimp temperature in the process is less cold (lack of ice cubes from suppliers)	A11	6
High defects in one supply of shrimp	A12	6
Labor negligence	A13	1
New workers lack the necessary skills	A14	1
The shrimp's temperature before soaking is not at or below 5°C.	A15	3
Freezing machine temperature is not standardized (long freezing time, iqf machine settings, shrimp capacity that exceeds iqf machine standards)	A16	5
The number of production workers is not directly proportional to the production planning capacity.	A17	3
Lack of maintenance on the basin/plate / iqf machine.	A18	3
Setting the metal detector machine is different between actual products and those registered on the machine.	A19	3

Lab test results are not in accordance with buyer specifications	A20	2
Stock that must be loaded in the container is not in accordance with the buyer's order (lack of production in fulfilling product planning or loss of product when stored in cold storage).	A21	4
During the transfer of products from cold storage to containers, items fell off the pallets.	A22	7

Identifying the risk events and risk agents to handle first is a step in risk evaluation. Not all risk sources in risk management will be addressed. Many elements influence this, including the costs associated with handling, but they have a small impact. By ranking ARP values from highest to lowest, the priority of a risk agent is determined by its ARP; vice versa. [24], [25], [26]. The Aggregate Risk Potential (ARP) for each risk agent is calculated using the following formula:

$$ARPj = O_j \sum S_i . R_{ij} \quad (1)$$

Where:

ARP : Aggregate Risk Potential
Si : Severity of risk event i
Oj : Occurrence of risk agent j
Rij : Correlation value between risk event i and risk agent j

An example of ARP calculation is as follows :

ARP A4 = 6 × [(9 × 7) + (1 × 4) + (9 × 6)]
= 726
ARP A8 = 3 × [(3 × 6) + (1 × 4) + (9 × 8) + (9 × 8) + (3 × 6) + (9 × 7) + (9 × 5)]
= 876
Cumulative ARP A4 = Nilai ARP A8 + Nilai ARP A4
= 876 + 726
= 1602

% ARP A8 $= \frac{\text{Nilai ARP A8}}{\text{Nilai Total ARP}} \times 100\%$
$= \frac{876}{6180} \times 100\%$
= 14,2%

Table 3 shows the prioritization of each risk source.

Table 3. Priority level of risk agents

Priority Rank	Code	ARP	Cumulative ARP	% ARP	Cumulative % ARP
1	A8	876	876	14,2%	14,2%
2	A4	726	1602	11,7%	25,9%
3	A11	594	2196	9,6%	35,5%
4	A6	553	2749	8,9%	44,5%
5	A5	450	3199	7,3%	51,8%
6	A15	387	3586	6,3%	58,0%
7	A10	342	3928	5,5%	63,6%
8	A16	315	4243	5,1%	68,7%
9	A13	292	4535	4,7%	73,4%
10	A7	252	4787	4,1%	77,5%
11	A18	189	4976	3,1%	80,5%
12	A19	189	5165	3,1%	83,6%
13	A12	168	5333	2,7%	86,3%
14	A14	151	5484	2,4%	88,7%
15	A9	144	5628	2,3%	91,1%
16	A21	132	5760	2,1%	93,2%
17	A17	117	5877	1,9%	95,1%
18	A22	105	5982	1,7%	96,8%
19	A20	90	6072	1,5%	98,3%
20	A1	90	6162	1,5%	99,7%
21	A3	18	6180	0,3%	100,0%

22	A2	0	6180	0,0%	100,0%

Problems with the supply chain flow are mainly caused by factors to the left of the 80 percent line. According to the 80/20 rule, 2 of 22 risk sources were identified as the main causes in the supply chain of PT Winaros Kawula Bahari.

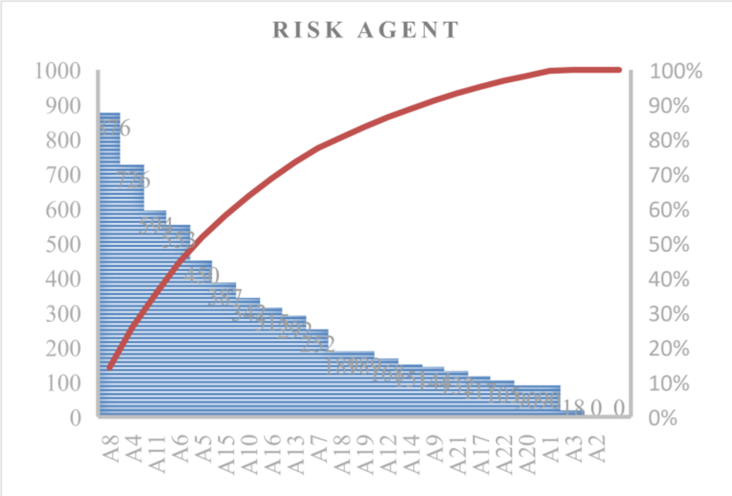

Figure 3. Pareto diagram of risk agent

Based on the Pareto diagram with the 80/20 principle, 2 priority risk sources must be resolved, as shown in Table 4:

Table 4. Risk agent priority

Priority Rank	Code	Risk Agent	ARP
1	A8	Labor Negligence	876
2	A4	Shrimp temperature is not cold enough	726

The results showed that labor negligence (A8) and shrimp temperature not cold enough (A4) were the two most dominant risk agents, with ARP values of 876 and 726, respectively. The dominance of A8 indicates that human error remains a critical issue in manual-intensive stages such as sorting, peeling, and processing. This aligns with findings from Ghasemi et al. (2018), which emphasized labor-related risks as a major factor in perishable food chains. On the other hand, A4 represents a typical cold chain challenge, where temperature deviations—often due to inadequate supplier practices—directly compromise product safety and quality, as also highlighted by Moradi & Jafari (2020) in the context of dairy and seafood supply chains.

House of Risk Phase 2

The House of Risk phase 2 involves handling risk agents prioritized in phase 1. Based on the Pareto diagram, there are two prioritized risk sources, indicating that several preventive actions can either fully prevent or reduce the likelihood of these risk sources occurring. Based on these risk causes, suggested preventive measures for the supply chain can be provided (Table 5):

Table 5. Preventive action

No	Risk Agent	Code	Preventive Action	Code
1	Labor Negligence	A8	Training and Education on Occupational Health and Safety (OHS) and the Frozen Food Seafood Industry	PA1
			Awarding and Sanctioning.	PA2
			Conduct counseling and consultation with the workforce to ensure that they understand and implement the applicable OHS rules.	PA3
			Developing human resources and technology related to improving OHS implementation.	PA4
2		A4	Tighter Supervision and Monitoring	PA5

The shrimp temperature is not cold enough	Supplier Selection and Evaluation	PA6
	Periodic Quality Audit.	PA7
	Maintain good communication with suppliers to ensure they understand and comply with the established temperature standards.	PA8

The strength of the relationship between the risk source and the preventive action is evaluated on a four-point scale: 0 indicates no correlation; 1, 3, and 9 indicate weak, moderate, and strong correlation, respectively. Based on the opinions of the company's experts, the relationship between risk sources and preventive actions is assessed.

Table 6. Correlation of strategy

Risk Agent	Preventive Action							
	PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8
A8	9	9	3	3	9		3	
A4	3			3	9	3	3	9

The Degree of difficulty assessment, often called the level of difficulty, indicates how difficult it is to implement preventive actions. There are three difficulty scales: 3 indicates low difficulty, 4 indicates medium difficulty, and 5 indicates great difficulty. Based on the experts' opinions, the degree of difficulty of each preventive measure is presented in Table 7.

Table 7. Difficulty level of the strategy

Code	**Preventive Action**	**D_k**
PA1	Training and Education on Occupational Health and Safety (OHS) and the Frozen Food Seafood Industry	4
PA2	Awarding and Sanctioning.	4
PA3	Conduct counseling and consultation with the workforce to ensure that they understand and implement the applicable OHS rules.	3
PA4	Developing human resources and technology related to improving OHS implementation.	3
PA5	Tighter Supervision and Monitoring	4
PA6	Supplier Selection and Evaluation	5
PA7	Periodic Quality Audit.	4
PA8	Maintain good communication with suppliers to ensure they understand and comply with the established temperature standards.	4

Table 8 presents the ranked recommendations for improving the supply chain at PT. Winaros Kawula Bahari.

Table 8. Proposed Improvement Rankings

Code	**No**	**Preventive Action**
PA5	1	Tighter Supervision and Monitoring
PA1	2	Training and Education on Occupational Health and Safety (OHS) and the Frozen Food Seafood Industry
PA2	3	Awarding and Sanctioning
PA8	4	Establish good communication with suppliers to ensure they understand and comply with the temperature standards set
PA4	5	Developing human resources and technology related to improving OHS implementation.
PA7	6	Periodic Quality Audit
PA3	7	Conduct counseling and consultation with the workforce to ensure that they understand and implement the applicable OHS rules.
PA6	8	Supplier Selection and Evaluation

The most effective strategy, according to the ETD ranking, is PA5 – Tighter supervision and monitoring, especially relevant for mitigating both labor behavior and temperature handling. While this action may require moderate operational cost (e.g., increased supervision, audits), its effectiveness is high due to its broad applicability across processes. The second-best action is PA1 – Training and Education on Occupational Health and Safety (OHS). Although it requires time and consistent scheduling, this action offers long-term benefits in shifting behavior, reducing negligence, and improving safety compliance. This echoes the findings of Zeng et al. (2021), who found that structured safety training significantly reduced operational risks in the food processing sector. Meanwhile, PA6 – Supplier selection and evaluation is ranked lowest due to its great difficulty. Changing or pressuring suppliers to meet standards involves negotiations and may affect supply continuity. However, in the long term, strengthening supplier relationships (PA8) and periodic quality audits (PA7) can gradually improve raw material consistency.

Compared with previous applications of the House of Risk in agri-food or agriculture, this study emphasizes the dual focus on internal (labor) and external (supplier) risk sources. For example, studies by Moradi & Jafari (2020) focused heavily on production-floor risks, while this case shows that upstream supplier management is equally vital in frozen seafood chains. Additionally, this study demonstrates the feasibility of applying HoR even in small or medium-sized seafood exporters, who often lack formal risk mapping. The structured use of HoR, supported by expert judgment and quantified evaluation, provides clarity and prioritization for limited-resource contexts.

Conclusion

This study applied the House of Risk (HoR) method to identify, prioritize, and mitigate risks in the frozen seafood supply chain of PT Winaros Kawula Bahari. Of the 9 risk events and 22 risk agents identified, labor negligence and insufficient shrimp temperature were found to be the most critical, leading to recommendations for strategic actions such as supervision, safety training, supplier communication, and quality audits. The findings provide a practical framework for SMEs in the seafood sector to implement structured, data-driven risk management. Future research is encouraged to enhance this approach by incorporating dynamic HoR models, integrating fuzzy methods to handle uncertainty, and adopting IoT-based digital monitoring systems to strengthen cold chain control.

References

[1] L. A. Wati, "Determinants of Indonesia's shrimp commodity export," *Journal of International Studies*, vol. 16, no. 1, pp. 112–127, 2023, doi: 10.14254/2071-8330.2023/16.

[2] A. Saman, L. Laksmi, and S. Hadi, "The potential of shrimp farming in Indonesia: Opportunities and challenges," 2021.

[3] H. Suhendang and H. Kurniawan, "Sustainable shrimp aquaculture practices in Indonesia: A review," *International Journal of Aquaculture and Marine Biology*, vol. 7, no. 3, pp. 190–207, 2022.

[4] R. S. Dhiwangkara, H. Asrori, and S. Hidayat, "Marine shrimp resources and their management in Indonesia," *J Fish Aquat Sci*, vol. 13, no. 2, pp. 45–59, 2018.

[5] M. Christopher, *Logistics and Supply Chain Management*, 5th ed. Financial Times Publishing, 2016.

[6] M. Christopher, *Logistics and Supply Chain Management*, 5th ed. Financial Times Publishing, 2016.

[7] D. Ivanov, A. Tsipoulanidis, and J. Schönberger, *Global supply chain and operations management*. Springer, 2019.

[8] J. T. Mentzer *et al.*, "Defining supply chain management," *Journal of Business Logistics*, vol. 22, no. 2, pp. 1–25, 2001.

[9] M. Fadli, A. Baihaqi, and S. Kasimin, "Analisis Kinerja Manajemen Rantai Pasok Perusahaan Kebun Kurma Barbate Analysis of Supply Chain Management Performance of Company Barbate Dates Plantation," *Jurnal Ilmiah Mahasiswa*, vol. 6, pp. 23–30, 2021, [Online]. Available: www.jim.unsyiah.ac.id/JFP

[10] A. Ghadge, S. Dani, and R. Kalawsky, "Supply chain risk management: Present and future scope," Nov. 02, 2012. doi: 10.1108/09574091211289200.

[11] C. S. Tang, "Perspectives in supply chain risk management," Oct. 2006. doi: 10.1016/j.ijpe.2005.12.006.

[12] M. Giannakis and T. Papadopoulos, "Supply chain risk management: A literature review," *Int J Prod Econ*, vol. 171, pp. 207–220, 2016.

[13] U. Jüttner, "Supply chain risk management," *International Journal of Logistics Management*, vol. 16, no. 1, pp. 120–141, 2005.
[14] S. Nahmias and T. L. Olsen, *Production and Operations Analysis*. Waveland Press, 2013.
[15] G. Soni and V. Jain, "House of Risk (HOR) approach for risk assessment and mitigation in supply chain management: A literature review and case study," *J Risk Res*, vol. 22, no. 7, pp. 918–944, 2019.
[16] C. Bode and S. M. Wagner, "Structural dynamics and the role of information in managing supply chain risk," *Journal of Operations Management*, vol. 36, pp. 134–148, 2015.
[17] P. Ahi and C. Searcy, "A comparative literature analysis of definitions for green and sustainable supply chain management," *J Clean Prod*, vol. 86, pp. 360–377, 2015.
[18] A. Nalhadi and A. Rizaal, *Identifikasi Bahaya Dan Penilaian Risiko K3 Pada Tindakan Perawatan & Perbaikan Menggunakan Metode Hirarc (Hazard Identification And Risk Assesment Risk Control) Pada PT. X*, vol. 12. 2015.
[19] I. Nyoman Pujawan and L. H. Geraldin, "House of risk: a model for proactive supply chain risk management," *Business Process Management Journal*, vol. 15, no. 6, pp. 953–967, Jan. 2009, doi: 10.1108/14637150911003801.
[20] N. F. Syah, "The Impact of Supply Chain Management Practices and Supply Chain Integration on Company Performance Mediated by Competitive Advantage (Empirical Study on Cabbage Agribusiness in Bandungrejo Village, Magelang Regency)," *Jurnal UII*, 2018.
[21] P. Ghasemi, R. Haji, and A. Sadeghi, "An integrated approach for risk assessment and prioritization in supply chain management," *J Risk Res*, vol. 21, no. 8, pp. 1042–1060, 2018.
[22] M. Moradi and M. Jafari, "Risk identification and assessment in supply chains using House of Risk approach," *Int J Prod Econ*, vol. 220, pp. 107–119, 2020.
[23] A. Z. Zeng, Y. Li, and C. Lin, "A review of risk management in supply chains: House of Risk approach and other methodologies," *J Clean Prod*, vol. 275, p. 124087, 2021.
[24] H. , L. X. Cheng and L. Liang, "Prioritizing risk events and agents in supply chain management using the House of Risk approach," *Int J Prod Econ*, vol. 195, pp. 134–146, 2018.
[25] T. M. Choi, T. C. E. Cheng, and H. Yan, "Risk management in supply chains: The impact of cost and effect on risk treatment decisions," *Journal of Supply Chain Management*, vol. 55, no. 1, pp. 24–41, 2019.
[26] J. Wang, Q. Chen, and X. Zhang, "Evaluating and prioritizing risk factors in supply chain management: A House of Risk approach," *Journal of Operations Management*, vol. 66, no. 4, pp. 123–137, 2020.