The supply chain risk assessment for tuna during the Covid-19 pandemic in Ambon by using the House of Risk Method

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Abstract. This study aims to mitigate risks in supply chain activities in tuna products during the Covid-19 pandemic. Method used in this research is House of Risk (HOR) approach by identifying each business process activity based on the Supply Chain Operation Reference (SCOR) model. House of Risk (HOR) offers a framework for controlling risk effectively in managing risk from risk agents. Aggregate Risk Potential (ARP) is used to determine the priority of risk sources that need to be done in designing a mitigation strategy. The results of the study identified 32 risk events and 52 risk agents. House of Risk (HOR) phase 1 shows that 11 Risk Agents will be prioritized for handling based on the highest ARP value, which further proposes 16 possible mitigation strategies. Based on the value of Effectiveness to Difficulty (ETD) from the House of Risk (HOR) phase 2, 12 mitigation strategy measures were taken from 16 proposed strategies that would be used to prevent risk causes.

1. Introduction

The Covid-19 pandemic affected all sectors, including the fisheries sector from upstream to downstream of the supply chain. PT. Harta Samudera as one of many companies engaged in the fishing industry has also been impacted by this Covid-19 pandemic which affected fish market activity. Target countries for tuna products, such as Vietnam, Japan, and USA, were affected by this outbreak, resulting in a decrease in exporting tuna products from this company. Besides, there are about 6 containers of tuna products that are still stored in cold storage [1].

There was a temporary suspension of purchasing tuna products, which affected the selling price of fish from fishermen to companies/cooperatives/fish collectors. There was a decrease of around 33.33% in the price of tuna size 30 kg from Rp. 39,000 to Rp. 26,000 which resulted in the decreasing of fishermen’s income. Indonesian Fisheries and Society Foundation (known in Indonesia as MDPI) in May 2020 [2] reported that during the pandemic, the average number of fishing activity by fishermen decreased by 19% which simultaneously affected fish catches to 6-10%, as a result of the implementation of the Social Restriction policy in large scale (known in Indonesia as PSBB) which limiting port operations.

Supply Chain Risk Management (SCRM) is defined as the risk that occurs due to the process of moving material from suppliers to the last consumers [3]. During the current Covid-19 pandemic, the risks involved in the company are quite high which is needed to carry out SCRM to manage all activities related to the business chain and also need to prepare and implement SCRM as a tuna fish business sustainability strategy. Based on the description above, the problem in this study is "what mitigation strategy must be done to prevent the risk of tuna fish commodity during the Covid-19 pandemic?".

Risk is a potential loss which can bring a negative impact on company goals [4] so that need to be identified to map the characteristics of the risks that will impact the overall supply chain performance [5] and [6]. [7] and [8] identified risks using the supply chain operation reference (SCOR) method based on supply chain (SC) process activities such as Plan, Source, Make, Deliver and Return. The identified risks were then assessed by using the House of Risk (HOR) method. [9] developed the HOR model by integrating the Failure Modes and Effects Analysis (FMEA) model and the House of Quality (HOQ)
model on the Quality Functions Diagram (QFD). [10] and [11] also use HOR by modifying it into a multi-stakeholder HOR in risk management for tuna commodity in Bitung and southern part of East Java. HOR is a method that focuses on the formulation of strategies for prevention, reduction, and treatment of several risk factors that can potentially cause more than one risk.

However, this research has an element of novelty in terms of risk management for fish commodities for special situations such as the current Covid-19 pandemic.

By implementing the SCRM, the company can plan, implement, and control the process of supply chain management which will not interfere the SC and the sustainability of the fishery industry.

2. Method
This study discusses the SCRM of PT. Harta Samudera using HOR method. There are several stages in this research referring to risk management. First, the initial mapping of all SC activities using the SCOR model which is divided into five core processes which are Plan, Source, Make, Deliver, and Return. Second, identifying risk events and risk agents by conducting brainstorming and direct observation which are then validated through focus group discussions (FGD) or interviews with the company’s internal stakeholders. Then, an assessment of the risk impact (severity), the level of probability of risk occurrence (occurrence), the correlation between risk events and risk agents, and mitigation strategies using HOR are carried out. The HOR model consists of two stages [11].

2.1. HOR1
HOR1 to explain the ranking of each risk cause based on the potential aggregate risk. The steps for the HOR 1 model can be seen as follows:
1. Identifying the risks that may occur in the business process by mapping the supply chain process and identifying risk events in each process. \( E_i \) in Table 1 shows the risk event that occurred.

| Business Process | Risk Event \( (E_i) \) | Risk Agent \( (A_j) \) | Severity of Risk Event \( (S_i) \) |
|------------------|-------------------------|------------------------|-------------------------------|
|                  | \( E_1 \)  | \( R_{11} \)  | \( R_{12} \)  | \( S_1 \) |
|                  | \( E_2 \)  | \( R_{21} \)  | \( R_{22} \)  | \( S_2 \) |
|                  | \( E_3 \)  | \( R_{31} \)  | \( S_3 \) |
|                  | \( E_4 \)  | \( R_{41} \)  | \( S_4 \) |
|                  | \( E_5 \)  | \( R_{51} \)  | \( S_5 \) |
| Occurrence of Agent j \( (O_j) \) | \( O_1 \)  | \( O_2 \)  | \( O_{n+1} \) |
| Agregat Risk Potential \( (ARP_j) \) | \( ARP_1 \)  | \( ARP_2 \)  | \( ARP_{n+1} \) |
| Priority Rank of Agent j | |

2. Conducting an impact assessment due to the risk that occurs (severity) in each risk event. The assessment is carried out with a value range of 1-10, where the value 10 represents an extreme impact. The impact value for each risk that occurs is described by \( S_i \).
3. Identifying risk agents and assessing them using a scale of 1-10 on the probability of occurrence for each risk cause, a score of 10 representing the most common risk causes. The causes for the risk are explained by \( A_j \) and the possible events that cause the risks are described by \( O_j \).
4. Assessing the relationship between risk agent and risk events described by \( R_{ij} \) with a scale of 0,1,3,9 where 0 indicates no relationship and 1, 3, 9 indicates a low, medium and high relationship.
5. Implementing \( ARP_j \) calculation which is the result of the multiplication of occurrence \( (O_j) \) and the aggregate impact of risk events caused by risk causes, with the following formula: \( ARP_j = O_j \Sigma_i S_i R_{ij} \)
6. Ranking the causes of risk based on the largest to the smallest ARP values.
2.2. HOR2

HOR2 to prioritize proactive actions to minimize costs and prevent risks. The steps in making the HOR 2 model can be seen as follows:

|   |   |   |
|---|---|---|
| 1. | Selection of priority risk causes; selection of risk causes can use the Pareto analysis of ARPj |   |
| 2. | Identify the relevant mitigation for prevention. The mitigation measures in Table 2 are described with the sign PAk |   |

### Table 2. Model of House of Risk 2

| Priority Risk (A_j) | Preventive Action (PA_k) | ARP_j |
|---------------------|--------------------------|-------|
| A_1                 | E_{11}                   | ARP_1 |
| A_2                 |ARP_2                     |
| A_3                 |ARP_3                     |
| A_{(n+1)}           |ARP_{n+1}                 |

3. Assessing the relationship between each mitigation action and the risk agent, which in Table of HOR 2 is explained by E_{jk}. The assessment is carried out on a scale of 0,1,3,9 where 0 indicates no linkage and the value of 1, 3, 9 indicates a low, medium, high linkage.

4. Calculating the total value of effectiveness for each mitigation measure, using the following formula:

\[ TE_k = \Sigma_i ARP_i E_{jk}, \forall k \]

5. Conducting an assessment of the difficulty level measurement in implementing mitigation described by D_k. Assessment can use a Likert scale approach (1-5). Assessment of the difficulty of implementing mitigation measures by considering the costs required and the number of resources required.

6. Calculating the ratio of mitigation effectiveness with the difficulty level of mitigation by using the formula:

\[ ETD_k = \frac{TE_k}{D_k} \]

7. Finding the priority ranking for the mitigation, the first rank is the mitigation with the highest ETD_k value.

### 3. Results and Discussion

#### 3.1. Activity mapping based on the SCOR Method

There are four main entities, which are suppliers, logistics providers, fishing companies, and final consumers. The following is the figure of SC Structure in the Company (Figure 1).
Mapping through the SCOR model is used for easier identifying each activity in the supply chain. Data were collected through direct observation, interviews, and literature review. Based on the SCOR Model, SC activities are divided into plan, source, make, deliver, and return which can be seen in Table 3.

**Table 3.** Mapping of supply chain activities of PT. Harta Samudera based on the SCOR Model

| Major Process                     | Activity                      | Detail Activity                                                                 |
|----------------------------------|-------------------------------|---------------------------------------------------------------------------------|
| Amount of Accepted Order         | a. Limitation for customer order |
|                                  | b. Procurement of customer order quantities |
|                                  | c. Order checking              |
|                                  | d. Collection and calculation of customer orders |
| Delivery Schedule Plan           | a. Confirmation for customer product delivery |
| Supplies Calculation and Planning| a. Checking for raw material stock |
|                                  | b. Planning orders for raw material supplies from suppliers |
|                                  | c. Suppliers Selection         |
| Production Planning              | a. Planning for production quantity |
|                                  | b. Planning for deadline production |
|                                  | c. Submitting plan for purchasing raw materials to the marketing division |
3.2. Risk identification and risk assessment

The process of identifying risks in the company's supply chain is carried out by brainstorming the company about the risks that occur, the sources of risk, and where the risks occur. The process of risk identification using brainstorming is carried out with experts in each process in the supply chain who are then verified with each other to obtain a statement agreed upon by all parties in the company. 32 risk events may occur in the activities of each SC process of PT. Harta Samudra which are shown in the Table 4 below.
Table 4. Identification of risk events and value of severity

| Code | Risk Event | Severity | Code | Risk Event | Severity |
|------|------------|----------|------|------------|----------|
| E1   | Lost customer | 5        | E17  | Error in the production process | 6        |
| E2   | Incorrect number of orders | 6        | E18  | Error in labeling product | 5        |
| E3   | Insufficient raw material order with order | 4        | E19  | The buildup of finished products | 6        |
| E4   | Error in accepting the specifications towards customer needs | 6        | E20  | Product damaged in cold storage | 6        |
| E5   | Uncertainty customer order | 5        | E21  | Product contaminated | 6        |
| E6   | Insufficient data stock with physique data | 6        | E22  | Packaging contaminated with covid 19 pathogens | 6        |
| E7   | The raw material out of stock/limited | 5        | E23  | Product process stopped/Company temporarily closed | 6        |
| E8   | Order for supplier reduce | 6        | E24  | Error in recording shipping documents | 6        |
| E9   | High cost for raw material | 4        | E25  | Late in goods delivery for the customer | 5        |
| E10  | Slow response for raw material purchases | 4        | E26  | Damaged raw material (return to supplier) | 5        |
| E11  | Buy too many raw materials | 4        | E27  | Damaged product (return from the customer) | 6        |
| E12  | Inspection error when receiving incoming material | 6        | E28  | Late in receiving raw material | 5        |
| E13  | Fish quality does not match the company's needs | 6        | E29  | Lack of raw material | 6        |
| E14  | The fish weight does not match the company's needs | 5        | E30  | Sudden change in the number of orders | 6        |
| E15  | Delay in-process production process | 5        | E31  | Late in receiving raw material from the supplier | 6        |
| E16  | Production not on time | 6        | E32  | Damaged raw material/defect raw material | 6        |

Furthermore, identification of risk agents from existing risk events is carried out, and there are 52 risk agents shown in the Table 5 below.

Table 5. Identification of risk agent and occurrence value

| Code | Risk Agent | Occurrence | Code | Risk Agent | Occurrence |
|------|------------|------------|------|------------|------------|
| A1   | Target Lockdown/PSBB in a region | 7         | A27  | Differences in employee cultural background | 4         |
| A2   | The poor communication system in an internal company | 3         | A28  | Limited human resources in production | 2         |
| A3   | Error in delivery data order | 2         | A29  | The increasing number of orders received from customers | 5         |
| A4   | Increasing the number of impromptu orders | 4         | A30  | Employee negligence | 3         |
| A5   | Order changes from customer | 3         | A31  | Negligence handling | 2         |
| A6   | Damaged raw material | 2         | A32  | The employee does not comply with SOP | 2         |
HOR1 is a stage for identifying risks that will be prioritized to be handled. This is obtained from the value of each risk such as severity, occurrence, and correlation value. From there, it can be seen the ARP value for each risk agent. This ARP value is used as a reference for determining the priority of risk agents that need to be addressed first (Table 6).
### Table 6. HOR1 Matrix

| Risk Event | Risk Agent | Severity |
|------------|------------|----------|
| 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      |
| A37        | A38        | A39      |
| A40        | A41        | A42      |
| A43        | A44        | A45      |
| A46        | A47        | A48      |
| A49        | A50        | A51      |
| A52        | A53        | A54      |

The HOR1 Matrix shows the ranking of 52 risk agents. The first rank shows the most influential risk agent on the risk event, and the last rank shows the smallest risk agent that influences the risk event. Treatment measures are only for priority risks, while to determine priority risks, the Pareto Diagram is used. The following figure is a Diagram of Pareto for Agent Risk.
The Pareto diagram shows the priority risk agent to handle, and the 80:20 principle is used evaluating this risk. In this study, 21.15% risk agent are taken to design handling strategies that were expected to influence the improvement of 78.85% of other risk agents. Table 7 lists the 11 risk agents that cause risk events from fish supply chain flows and 16 risk mitigation strategies.

**Table 7. Mitigation strategy**

| No | Risk Agent                                                                 | Mitigation Strategies                                                                                     | Code |
|----|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|------|
| 1  | A1 (Lockdown of Target Countries or PSBB of a Region)                     | Seeking for new countries for marketing                                                                     | PA1  |
| 2  | A21 (Error in tally sheet calculation)                                    | Implementing barcode-based/computer-based calculation technology                                           | PA2  |
|    |                                                                           | Persuading other customers to buy more fish                                                              | PA3  |
| 3  | A5 (Sudden change of customer)                                            | Giving penalty, or clarifying about the order change in the PO agreement                                  | PA4  |
| 4  | A20 (Limitation in port operation time, fisherman does not sail)         | Investing in other fish storage facilities to ensure safety stock at times when fishermen do not go for fishing | PA5  |
|    |                                                                           | Implementing strict raw material quality control                                                        | PA6  |
| 5  | A6 (Damaged raw material)                                                 | Initiating resale of damaged raw materials and / or offering fishery product processing with appropriate quality standards for industry | PA7  |
| 6  | A24 (Disaster/bad weather at supplier’s location)                         | Exploring new supplier from other region                                                                  | PA8  |
| 7  | A15 (Error in planning calculation)                                       | Planning for synchronization                                                                               | PA9  |
| 8  | A19 (Workers contaminated with Covid-19)                                   | Freelance recruitment                                                                                     | PA10 |
| 9  | A29 (Increasing number of orders received from customers)                 | Enforcing strict health protocol in working area                                                          | PA11 |
| 10 | A17 (Lack in quality control)                                             | Analyzing maximum dan minimum level of stock                                                              | PA12 |
| 11 | A14 (Duration for waiting the approval of the director / branch Meeting for proposing the best flow for procedures manager) | Conducting periodic training for workers                                                                  | PA13 |
|    |                                                                           | Regular audits in production and reception floor                                                          | PA14 |
|    |                                                                           | Designing work scenarios for employee remotely                                                            | PA15 |

The next stage is HOR2 or the risk management phase. In this HOR2, several risk agent handling strategies will be prioritized to be handled. The stages in HOR phase 2 are designing the handling strategy, assessing the level of the relationship between the handling strategy and existing risk agents,
calculating the value of Total Effectiveness ($TE_k$) and Degree of Difficulty ($D_k$), and calculating the Effectiveness to Difficulty ($ETD_k$) that rank, as shown in Table 8 below.

### Table 8. HOR2 matrix

| Risk Agent | PA1 | PA2 | PA3 | PA4 | PA5 | PA6 | PA7 | PA8 | PA9 | PA10 | PA11 | PA12 | PA13 | PA14 | PA15 | PA16 | ARP |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|-----|-----|
| A1         | 9   | 3   | 1   | 1   | 3   | 3   |     |     |     |      |      |      |      |      |      |      |     |
| A21        | 9   |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |     |
| A5         | 1   | 9   | 9   | 3   |     |     |     |     |     |      |      |      |      |      |      |      |     |
| A20        | 9   |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |     |
| A6         |     | 9   | 9   |     |     |     |     |     |     |      |      |      |      |      |      |      |     |
| A24        |     |     |     | 9   | 9   |     |     |     |     |      |      |      |      |      |      |      |     |
| A15        | 1   |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |     |
| A19        |     |     |     |     |     |     |     | 9   | 9   |      |      |      |      |      |      |      |     |
| A29        |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |     |
| A17        |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |     |
| A14        |     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |     |
| TEk        | 27027 | 23853 | 17037 | 17037 | 35598 | 26892 | 15444 | 15513 | 35598 | 26892 | 15444 | 15513 | 35598 | 26892 | 15444 | 15513 | 35598 |
| ETD        | 8900 | 8519 | 8154 | 305  | 8582 | 8582 | 8582 | 8582 | 8582 | 8582 | 8582 | 8582 | 8582 | 8582 | 8582 | 8582 | 8582 |
| Rank       | 4   | 10  | 13  | 8   | 5   | 1   | 14  | 11  | 12  | 15   | 2    | 3    | 9    | 16   | 6    | 6    |     |

The largest ETD value is an indicator that the handling strategy has the highest effectiveness to be implemented. To make it easier to find out the implemented handling strategies, a Pareto diagram is made as seen in Figure 3:

![Diagram of Pareto for mitigation strategies](image)

**Figure 3.** Diagram of Pareto for mitigation strategies

With consideration for the effectiveness of the implemented mitigation strategies, only 80% of the total cumulative value of ETD will be taken. Then, the top 12 strategies are recommended to be carried out. The first possible treatment strategy is the implementation of strict quality control of raw materials (PA6), strict enforcement of health protocols in the work area (PA1), conducting a min-max stock analysis (PA12), seeking new regions/counties for marketing (PA1), investment in new fish storage facilities to ensure stock are safe at times when fisherman does not go fishing (PA5), meeting to propose best flow procedures (PA15), designing work scenarios for remote workers (PA16); provide sanctions, and clarify about changes of orders in the PO agreement (PA4), periodic training for workers (PA13); applying barcode / computer-based calculation technology (PA2), exploring new supplier from other regions (PA8), and synchronizing planning (PA9).
4. Conclusion
Supply chain risk assessment has been carried out using the House of Risk method, so several conclusions can be drawn, which are; a total of 32 identified risk events and 52 risk agents. By using HOR1, the ARP value of each risk agent is obtained which will be a priority for the proposed handling strategy. Based on the Pareto diagram with the 80:20 rule, 11 risk agents are prioritized to be handled. HOR2 is a step to get a mitigation strategy that can be done to reduce the possibility of a risk agent. Based on 11 risk agents from HOR 1, 16 possible mitigation strategies were proposed and after calculating the ETD value, 12 mitigation strategies were obtained with the highest effectiveness value.

This research can be developed for further research by adding the interests of the stakeholders involved in the fish supply chain, such as fishermen, government, and transportation service providers. Besides, further research also needs comprehensive handling for the implementation of the proposed handling strategy.

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