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Risk Control in Supply Chain Tobacco Processing Unit Using House of Risk Method (A Case of Indonesia)

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***Abstract*— There is a tobacco processing factory located in Maesan, Bondowoso, Indonesia that has been facing a problem of high demand but a lack of raw materials to meet it. Unfortunately, the demand for their product is decreasing every year. Therefore, the company needs to conduct a study of risk control within their supply network to identify potential risks and agents involved. The HOR method is employed to identify and analyze risks as well as the agents present within the supply chain of the tobacco processing facility. The company also needs strategies to manage the identified risks. The HOR method comprises two stages: the initial phase entails identifying risks and risk agents emerging within the factory's supply chain utilizing the Supply Chain Reference Operation (SCOR) approach. Phase two is the stage of determining the priority order of mitigation strategies that can be implemented at the factory. In the initial phase of HOR, 46 instances of risk events were identified within the supply chain, while the second phase involved selecting 27 risk agents for mitigation strategies. The results of phase two of HOR yielded 12 mitigation strategies that were implemented in the factory. These mitigation strategies were then ranked based on their ability to handle the existing risk agents.**

Keywords*— *risk agent, risk identification risk event, House of Risk (HOR), Supply Chain Operation Reference (SCOR)

I. INTRODUCTION

Companies are increasingly striving to implement the most effective strategies to remain competitive. A pivotal approach to realize this goal is through efficient management of the company's supply chain. The supply chain constitutes a complex network comprising entities, individuals, tasks, information, and assets collaborating to deliver products to consumers [11]. The supply chain is something that businesses must pay attention to in order to meet customer demand [18]. Risk is defined as the potential for an event to occur within a specific time frame, which could lead to financial loss [5]. Drawing from domestic and international shipping risk cases, a model for the risk identification process was developed to uncover innovative approaches to risk management [10]. Implementing the right supply chain strategy can yield multiple benefits to the company, including improvements in pricing, quality, product offerings, delivery times, and customer service. The implementation of supply chain risk management is very important because it can recognize risks from the beginning, so that the impact that may arise can be anticipated and the flow of products is smooth from upstream to downstream [14].

The sources of risk include human resources (workers), technology, nature, environment, and facilities [27]. Risk mitigation refers to the steps taken to lessen the impact of potential risks, while risk evaluation is used to assess how effectively the mitigation measures have been implemented [19]. Mitigation action refers to actions taken to reduce the impact of a risk before it occurs [19].

The company is engaged in the tobacco processing industry, using various types of tobacco such as Lombok, Madura, Virgin, and Temanggung. The supply chain activities in the factory include raw material procurement, production planning and processes, storage in warehouses, distribution, transportation systems, and working with distributors. In the context of supply chain systems, information asymmetry phenomena exist [21]. Based on interviews with current employees, it has been found that the state of supply chain activities in this company is poor, which could lead to problems for the company. Furthermore, the company has experienced notable repercussions from the enduring Covid-19 pandemic, leading to a decline in sales. Demand data from 2021 to 2023 shows a decline in the demand for cigarettes. In 2021, the factory had a demand for 164,000 rolls, which decreased to 16,000 rolls in 2022 and 10,000 rolls in 2023. As a result, cigarette production in the company has decreased. Furthermore, based on interviews and existing data, it has been revealed that the company did not produce regularly in 2023 due to inadequate raw materials. The limited stock in the warehouse has led to an inability to meet market demand and has hindered the distribution process, causing delays in product delivery. All companies must maintain good inventory, especially with changes in product demand and existing policies, such as the reorder level [8].

Supply chain risk management allows each party to make integrated coordination, thus creating effectiveness and efficiency of each actor [16]. Currently, supply chain performance evaluation (SCPM) involves developing a

measurement system that includes both financial and non-financial aspects [23]. Uncertainty in the availability of raw material supplies poses risks to a company's supply chain operations and can hinder customer satisfaction. Therefore, ensuring an adequate supply of raw materials is crucial for maintaining smooth production processes [30]. A research project will be undertaken to address risk within the raw material supply chain. The House of Risk (HOR) approach will be utilized to examine and tackle supply chain risks within the factory. This method aims to identify risks and formulate strategies to decrease the probability of risk events by implementing preventive measures [3]. HOR is a modified result of the FMEA (Failure Modes and Effect Analysis) method and the model of House of Quality (HOQ) [26].

Risk management shows a tendency to recognize threats, taking manageable risks, making contributions valuable resources carefully, and schedule comprehensive tasks before allocating cash to an organizationproject [7]. The HOR methodology is a risk management strategy designed to minimize the occurrence of risk agents. To achieve this, an action strategy is developed to minimize the risk, and prevent it from recurring [15]. HOR proves to be especially valuable in agricultural commodity supply chains, where a singular risk source can trigger multiple risk events [4]. The purpose of the effort is to propose risk mitigation actions using the House of Risk approach to minimize risk events in the company by identifying, analyzing, evaluating all risks that arise in the company, in this case the HOR approach is grouped into 2 phases, namely risk identification, risk evaluation [6]. One significant advantage of the HOR approach is its capacity to account for the potential occurrence of risk events stemming from diverse risk agents, including those capable of inducing multiple risk events. This is not always taken into account by other risk mapping methods [24]. The risk identification phase is where risk events and risk agents are identified and measured. While the risk handling phase is the stage where risk agents that have been selected from the identification phase are classified based on the handling methods or mitigation measures applied [1].

II. Materials And Methods

The following research was conducted at a factory located at Jalan Raya Bondowoso - Jember KM. 7 No. 16, Pakuniran Village RT 07 RW 04, Maesan Sub-district, Bondowoso District, East Java Province. The data for this research was collected through interviews and questionnaires, which were directed towards respondents who are experts in their respective fields. Additionally, secondary data were obtained through a literature review.

A. House of Risk 1 (HOR 1) (Heading 2)

HOR 1 represents the starting phase of the risk management process, focusing on identifying risks and establishing priority for risk agents or sources. The stages in HOR 1 are outlined as follows:

1. Recognize risk occurrences through activity mapping within the supply chain. The SCOR approach was employed to delineate the supply chain, encompassing five activities: plan, source, make, deliver, and return.
2. Identifying risk factors within the factory's supply chain.
3. Assessment of risk occurrence or severity of risk impact. According to [31], severity assessment is conducted on a Likert scale, which ranges from 1 to 5, with a score of 5 indicating an extreme impact.
4. In evaluating the probability of a potential risk, a Likert scale ranging from 1 to 5 is employed. A score of 1 suggests the risk is improbable, whereas a score of 5 suggests the risk is highly probable. This evaluation follows the methodology outlined by [31].
5. Assessing the correlation between risk events and risk agents entails utilizing a scale of 0, 1, 3, and 9 to signify absence of correlation, minimal correlation, moderate correlation, and significant correlation, respectively.
6. Determination of Aggregate Risk Potential (ARP) for Risk Agents, utilizing the equation proposed by [28].

   $$ARPj = Oj \sum i\, Si\, Rij \quad \text{.....(1)}$$

   where,

   Oj = Probability of the occurrence of risk agent j

   Si = Impact of the risk event i

   Rij = Degree of correlation between risk source j and risk event

   Perform a risk ranking assessment to prioritize the risk factors that require control measures.
7. To prioritize the risk sources, generate a Pareto chart based on the ranking of ARP values. The Pareto principle of 80/20 is employed as a guideline, indicating that 80% of risk events stem from 20% of the risk sources responsible for them.

B. House of Risk 2 (HOR 2) (Heading 2)

HOR 2 is a phase dedicated to establishing the sequence of risk mitigation strategies based on their efficacy. The process encompasses several steps, including identifying control measures to manage the emergence of risks.

1. Determine the association between control measures and risk agents.
2. Calculate the Total Effectiveness (TEK) of each risk control measure.

   $$TEK = \sum ARPj\, Ejk\, ak \quad \text{.....(2)}$$

   where,

   ARPj = Aggregate Risk Potential at risk agent, j= 1,2,3,...,n

   Ejk = correlation level of the jth risk agent

   jth risk agent and kth mitigation, j=1,2,. . .,n and

   k=1,2,. . .,n
3. Recognize the connection between control measures and risk agents.

4. Calculate the Effectiveness to Difficulty (ETDk) ratio value to demonstrate the effectiveness of risk control implementation relative to the difficulty level.

$$ETDK = \frac{TEk}{Dk} \quad \text{.....(3)}$$

where,

Tek = Total Effectiveness (TEk),

on the kth mitigation k=1,2,3,...n

Dk = Degree of Difficulty, at the

kth mitigation k=1,2,3, ...,n

5. Perform ranking based on the value of ETDK to determine the control strategy to be used
6. Perform risk control strategy selection.

III. Results And Discussion

A. Supply Chain Activity Mapping

Activity mapping in the supply chain is applied using the SCOR approach, with an emphasis on the role of suppliers as providers of tobacco raw materials and factories as production and marketing actors. The supply chain activities at the factory are illustrated in (Figure 1).

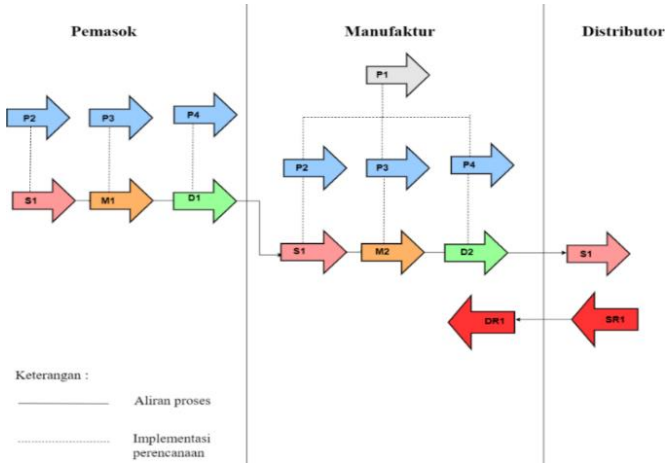


Fig 1. Mapping Supply Chain Activities with SCOR

B. Supply Chain Analysis

Supply chain risk analysis begins with mapping supply chain activities and classifying supply chain activities based on the SCOR model, namely plan, source, make, deliver, return [2]. Then identify risk events and risk agents based on the results of interviews that have been conducted.

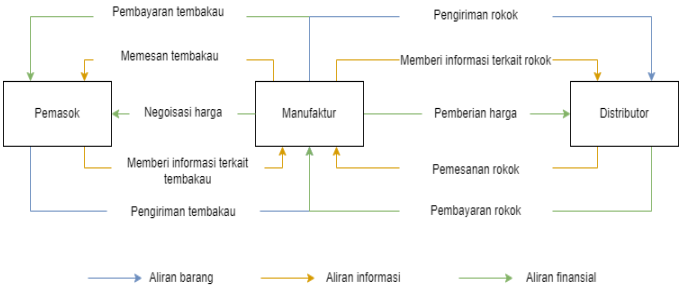


Fig 2. Supply Chain Activities

The explanation of each stakeholder and supply chain activities is as follows:

1. Suppliers
   Suppliers are suppliers of tobacco raw materials. Suppliers are key elements in the supply chain that have a major impact on the development of a company [12]. Furthermore, the supplier conducts the tobacco harvesting process, including weighing, shredding, and drying. Before delivering the goods to the Factory, the supplier provides information on the quantity of tobacco to be delivered. Next, the supplier and the Factory negotiate the price. After the supplier receives a decision on the price, the supplier provides information on the shipment of tobacco. Finally, the Factory makes payment to the supplier.
2. Manufacture
   A factory or manufacturer is a party that processes raw materials into a product [25]. The factory processes tobacco according to the quantity of raw materials. The cigarette processing process starts with receiving raw materials, sorting the quality of raw materials, mixing using additional ingredients, rolling, and packaging.
3. Distributor
   Distribution is a process or activity that involves channeling products, both goods and services, from producers or suppliers to consumers or end users [32]. In supply chain activities, distributors have relationships with factories, retailers, and consumers.

C. House of Risk 1

HOR 1 is a procedure designed to pinpoint potential risks and their origins within the supply chain at the factory. This process involved a series of interviews to identify risk events, resulting in a total of 54 events being identified. Following this, respondents assessed the severity of the identified risks.

Risk agents are identified based on risk events and literature studies. These agents are responsible for causing risks that need to be controlled to minimize their impact. The severity and occurrence values are utilized in computing the Aggregate Risk Potential (ARP) value, aiding in prioritizing the risk agents requiring control measures. Through the identification process, it was found that there are 17 risks at the supplier level, 19 risks at the factory level, and 10 risks at the distributor level. The outcomes of the risk identification and risk agents can be observed in (Table 1).

Following the assessment of severity for each risk and event associated with each risk agent, the subsequent step involves evaluating the correlation between the risk event and the risk agent. This evaluation process aims to comprehend the connection between the occurring risk and its underlying cause, the risk agent. A score of 0 signifies no correlation between the risk event and the risk agent, a score of 1 suggests a weak correlation, a score of 3 indicates a moderate correlation, and a score of 9 represents a strong correlation.

The next step involves risk mapping or determining priority risk agents by using a Pareto diagram, which is a graphical representation with data sorted from left to right in descending order. To create the Pareto diagram, we sort the ARP values from highest to lowest. This helps us identify risk agents using the 80/20 Pareto principle.

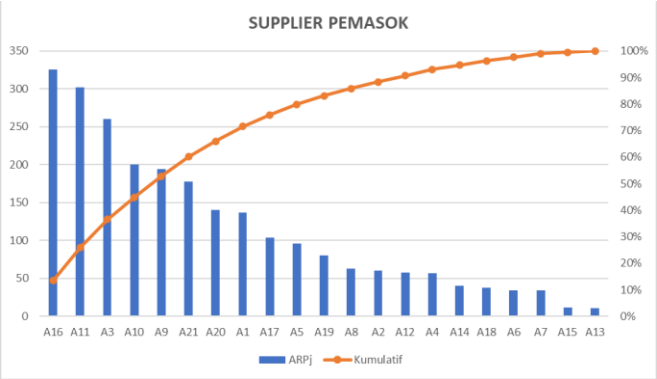


Fig 3. Pareto Diagram at Supplier Level

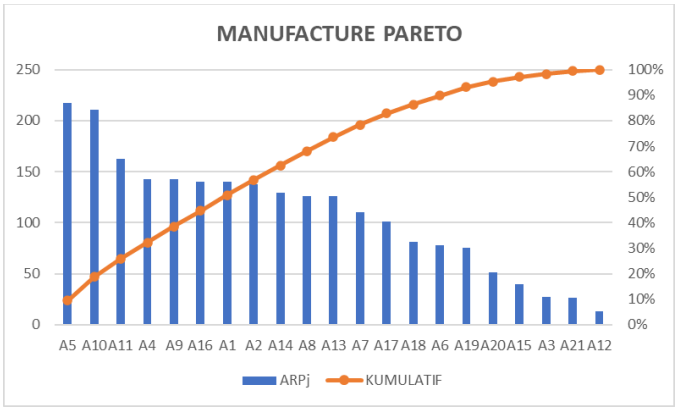


Fig 4. Pareto Diagram at Manufacture Level

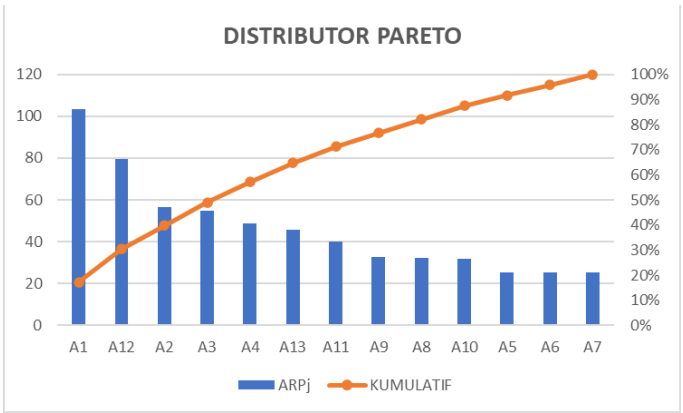


Fig 5. Pareto Diagram at Distributor Level

The decision to use 80% as the threshold for addressing concerns flagged by the ARP assessment is based on the fact that these risks are classified as high priority. These concerns relate to raw materials, production processes, and marketing activities. (Figure 2) displays a Pareto chart of the ARP values, which identifies 10 high-priority risks at the supplier level (A16 to A5), 12 at the factory level (A5 to A7), and 8 at the distributor level (A1 to A9).

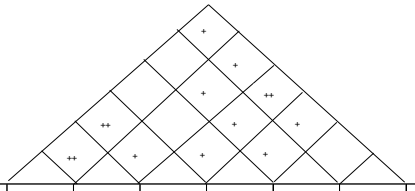
D. House of Risk 2

Then the research uses the House of Risk approach, namely "Implementation of supply chain risk management at PR. Black Crow" with the problem of the production supply chain system that affects supply chain performance, using the HOR method based on the ARP value. Conclusions were drawn in the form of priority mitigation actions to minimize risks and potential risk events [13].

HOR 2 involves determining control actions against prioritized risk agents to manage supply chain risks. This assessment utilizes a questionnaire to calculate TEK, Dk, and ETDk, resulting in a ranking to prioritize control measures. The calculation of the Effectiveness to Difficulty (ETDk) value aims to determine which preventive actions can be implemented first [22]. The higher the ETD value of a mitigation strategy, the higher its percentage value (Melly et al., 2019). The ETD value and percentage of a strategy serve as references for selecting which mitigation strategy the company should prioritize (Prasetyo et al., 2022). Each designed mitigation strategy is evaluated using Degree of Difficulty (Dk) to assess its implementation challenges in the factory. The Degree of Difficulty assessment is conducted through a questionnaire.

E. Risk Control Strategy for Cigarette Product Supply Chain

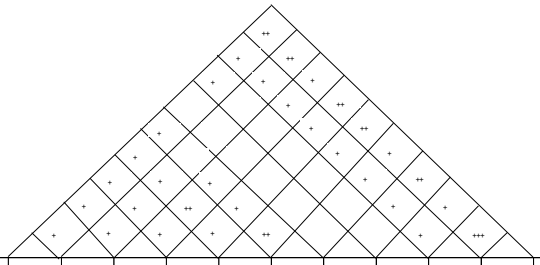
The design of the phase 2 risk handling strategy house is a continuation of the previous phase, phase 1 risk house, according to Suryaningrat et al. (2023). The identified predominant risk agents outcomes will be addressed by formulating preventive actions for the risk agent mitigation process. At the supplier level, there are 6 strategies for controlling supply chain risks at the factory. The strategies formulated are (1) Creating an SOP (operational standard) for good maintenance management of production and storage facilities (2) Checking transportation equipment before and after product delivery (3) Repeatedly checking the condition of tobacco in the warehouse (4) Expanding the scope of relationships or involvement with customers or consumers (5) Looking for tobacco sellers who have good characteristics (6) Creating an SOP (operational standard) for the production process. The supplier-level HOR 2 analysis can be shown in (Figure 5).



Keterangan :
(+) : Positive
(++) : Strong Positive

Risk Causes \ Risk Mitigation Strategy	M1	M2	M3	M4	M5	M6	ARP
Humid warehouse temperature	9					9	352.2
Delay in delivery	1	9	3		1		301.55
Raw material condition	1			3	3		260.1
High soaring prices				3	3		200.26
Raw material quality is not	3		1	3	3	1	194.22
The material used by the supplier is not good	1						177.54
Checking of transportation equipment is not thorough	3	9					140.4
Company errors in inventory							136.59
Warehouse cleanliness is not paid attention to	3					3	103.7
Material supplies are scarce			3				95.76
Changes in manufacturing production planning							80.64
Tek	5223.95	3977.55	1386.15	1963.74	2265.29	3675.12	
Dk	4	4	4	4	4	4	
Etd	1306.0	994.4	346.5	490.9	566.3	918.8	
Rank	1	2	6	5	4	3	

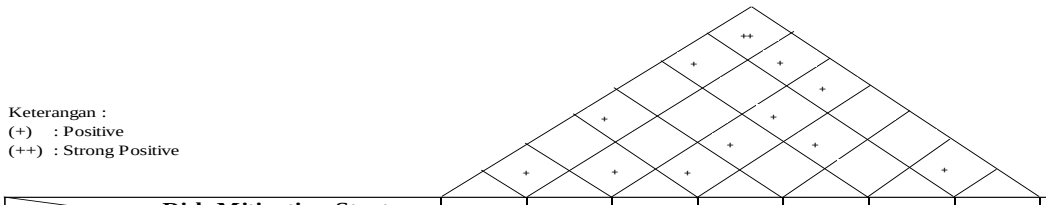
Fig 6. HOR 2 Supplier Level



Keterangan :
(+) : Positive
(++) : Strong Positive

Risk Causes \ Risk Mitigation Strategy	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	ARP
Communication and information errors between PPIC and the production	3	1		1						3	217.6
Worker negligence in the production process	3	3	9	1	3	3				1	210.9
Worker error in taking packaging	1	3	9	1	1	3					162.8
Sudden change in demand	3						9	1	9		142.8
Lack of planning when the production process will be carried out	1			3	3		3		3	9	142.7
Worker negligence in picking up products from the warehouse		1				3					140.4
Workers' inaccuracy in making records				3							140.1
The demand information obtained is not clear											137.6
Lack of coordination with consumers								3	1		137.6
Inadequate storage facilities					1						129.6
Workers neglect to make payments						3					126.4
The delivery party's inaccuracy in recording shipping documents				1				3			126
The checking method is still based on the assumptions of each worker		3	1	3							110.1
Product packaging is not tight enough											101
The number of products does not meet the number of shipments							1		3	3	81
Tek	2019.4	1809.4	3473.4	1896	1353.2	1921.5	1794.3	933.6	2093.9	2391	
Dk	4	4	4	4	4	5	4	4	4	4	
Etd	504.9	452.4	868.4	474.0	338.3	384.3	448.6	233.4	523.5	597.8	
Rank	2	4	1	3	9	8	7	10	6	5	

Fig 7. HOR 2 Factory Level



Risk Mitigation Strategy / Risk Causes	M1	M2	M3	M4	M5	M6	M7	ARP
Error in providing delivery schedule information to manufacturers	3		3	3		1	1	103.53
Insufficient number of replacement products		9	1		1	1		79.56
Tek	310.59	716.04	390.15	310.59	79.56	183.09	103.53	
Dk	4	4	4	4	3	4	3	
Etd	77.6	179.0	97.5	77.6	26.5	45.8	34.5	
Rank	2	1	3	4	7	5	6	

Fig 8. HOR 2 Distributor Level

Furthermore, at the factory level, 10 strategies are obtained, namely 1) There are clear work instructions in processing (2) Enhance the productivity of he production planning and inventory management divisions (3) Conduct briefings to workers before work begins according to the section (4) Checking and supervision at every stage and equipment of the production process (5) Implement production planning carefully, based on raw material requirements, production capacity, and production schedules (6) Increase product availability (strategic stock) (7) Make terms / conditions of orders (8) Record stock regularly (9) Make SOPs (operational standards) for good production facility maintenance management (10) Improved coordination between sections and consumers. Factory-level HOR 2 can be shown in (Figure 6).

For the distributor level, 7 strategies are needed, namely (1) Increasing product availability (strategic stock) (2) Monitoring product availability at agents (3) Carrying out performance evaluations (4) Keeping regular records (5) Checking and supervising warehouse workers (6) Creating backup stock (7) Checking transportation equipment before and after sending products. HOR 2 Supplier level can be shown in (Figure 7).

IV. Conclusions

In the factory's supply chain analysis, the highest priority risk is the humidity level in the warehouse. The improper temperature and humidity levels, as well as less thorough employee mitigation, are prioritized risk factors at the factory. The priority control strategy that needs to be carried out is to create a standard operating procedure (SOP) for the proper maintenance management of production and storage facilities.

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