Risk Analysis in the Supply Chain of Cane Sugar Industry in Sidoarjo

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Abstract. Fluctuating demand conditions will cause a lot of uncertainty that can pose risks. In this condition, the company must have the right strategy to minimize the risks that occur to increase competitiveness. The sugar industry is an industry that has a complex supply chain flow, and of course, every process is inseparable from risks. The purpose of this study is to identify and analyze the potential risks in the company's supply chain as a basis for preparing the right strategy for the company. The Supply chain Operation Reference (SCOR) and House Of Risk (HOR) methods were used in this study to identify possible processes and risks. House Of Risk Phase 1 results in 30 risk events and 44 risk agents. And of the 44 selected risk agents, 13 priority risk agents have the highest probability of occurrence. The 13 risk agents come from the plan, source, make, and delivery processes, but the dominant risk agents appear in the make and source processes.

Keywords. SCRM, SCOR, HOR

1 Introduction

Fluctuating demand conditions will have many uncertainties that can pose risks. In this condition, the company must have the right strategy to minimize the chances of becoming more competitive. The study raised in this case is a manufacturing company that produces cane sugar in Sidoarjo. The sugar company has a complex supply chain flow; every process is inseparable from risks. So it is necessary to identify and analyze the risks that have the potential to occur in the company's supply chain as a basis for preparing the right strategy for the company.

The House Of Risk (HOR) method was used in this study to identify risks that may arise in the supply chain process and their causes while obtaining priority risk mitigation strategies to minimize existing risks [1]. House Of Risk is a supply chain risk management (SCRM) model that develops a framework for managing supply chain risk. The HOR method is used because of the risk assessment of the HOR method through the calculation of Aggregrate Risk Potential (ARP) [2] so that it can be known directly the potential risk that must be the primary concern. In addition to HOR, mapping business activities based on the Supply chain Operations Reference (SCOR) model, which includes the plan, source, make, delivery, and return, is also used to determine the flow of processes in the supply chain. These processes can represent all SCM activities in the company. This study aims to identify and analyze the risk along the supply chain of the cane sugar industry to determine the potential risk agents so that it can be the basis for preparing strategies for handling and preventing appropriate risks and increasing the company's competitiveness.

2 Literature Review

2.1 Supply Chain Risk Management (SCRM)

Risk management and supply chain management are two things that cannot be separated because of their interrelationships. Supply chain risk management (SCRM) is an effort to manage the risks that can occur in a supply chain activity to obtain an optimal supply chain and prevent disruptions internally and externally. SCRM is essential and requires serious attention due to the frequent impact of risks and the potential for significant effects on the performance of supply chain members [3]. Meanwhile, according to Ridwan [4], SCRM is defined as a coordinated approach between supply chain members to carry out a series of activities to identify and manage supply chain risks. It aims to reduce overall supply chain disruption. In Rostamzadeh et.al. [5], risk management in the supply chain functions to identify, analyze, suggest problem-solving on accountability, control, and observe risks in economic and production circles. Risk management was developed to create a sustainable supply chain system framework. In general, the SCRM process consists of 4

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processes: risk identification, risk analysis, risk evaluation, and mitigation [6].

2.2 Supply chain Operations Reference (SCOR)

The supply chain performance measurement's result helps in making improvements. In the process approach, mapping the current process and modeling the ideal or desired process is usually carried out. The Supply chain Operation Reference (SCOR) is one kind of supply chain performance measurement system [6].

The SCOR model is developed by the Supply chain Council (SCC). The SCOR model serves to measure and improve the total performance of the company's supply chain [4]. Another definition put forward by Nadhira et.al. [3] is the SCOR method is an approach method for measuring supply chain performance. In another sense, this method is used to perform supply chain management. The SCOR method used is level 1, which defines the scope and content of the supply chain. At this level, the performance of the supply chain will be seen. Supply chain management using the SCOR method is divided into five processes, namely Planning, Procurement (Source), Making, Delivery, and Return.

2.3 House Of Risk (HOR)

House Of Risk (HOR) is a model based on risk management needs and focuses on preventive action to determine the risks that occur and the causes of risks that are priorities so that mitigation and countermeasures can be proposed. This HOR method is a modification method between FMEA (Failure Modes and Effect of Analysis) and House of Quality (HOQ) models. HOR method prioritizes the sources of risk and the most effective mitigation action to reduce the potential risk from the origins [7].

The earliest stage of the HOR method is to identify risk events and agents. Adapting from the FMEA method, the risk assessment applied is the Risk Priority Number (RPN), which consists of 3 factors: occurrence, severity, and correlation. However, the HOR method only establishes the probability for the risk agent (severity) and the severity of the risk event [1]. Cahyani [2] applied HOR risk assessment using Aggregate Risk Potentials (ARP). In this case, a high ARP value means that the risk agent has a high probability of occurrence and causes many risk events with the impact. (1) is the formula used to calculate ARP.

$$ARP_j = O_j \Sigma S_i R_{ij} \quad (1)$$

3 Research Methods

This study was conducted in several steps, including mapping risk events, risk agents, and calculation of the ARP.

3.1 Identification of Risk Events and Risk Agent

The risk analysis that has the opportunity to emerge in the supply chain process of the cane sugar industry begins with field observations to map the supply chain and the details of its production system. The business activities were mapped based on the SCOR model in three levels: level 1/ primary process (PP), level 2/ configuration level/sub-process (SP), and level 3/ detailed activities. Business activities are mapped through brainstorming with relevant departments to determine business activities in the supply chain. The business activities mapping is present in Table 1. After elaborating supply chain activities based on the SCOR model, the next step is identifying risk events. In this case, the risk in question is the possibility of something happening that can negatively impact the achievement of company goals due to an ongoing process or future event. This risk is identified based on interviews, employee brainstorming, and past documents. This identification resulted in 30 risk events that often occur and cause disruptions in supply chain activities, as listed in Table 2.

The next step determines a list of risk causes/ agents based on each risk event. The causes of this risk are identified based on the results of interviews, brainstorming, and past documents. Forty-four risk agents were obtained that caused the company to experience several problems, as seen in Table 3.

Table 1. The Business Activities Mapping of Cane Sugar Industry Based on SCOR.

Level 1 (PP)	Level 2 (SP)	Level 3 (Detail Activity/ DA)
Plan (P)	Capacity Planning (P1)	Planning the grinding capacity to be carried out (P1a)
	Financial planning(P2)	Adjusting the supply chain to the financial planning of the enterprise (P2a)
	Production planning (P3)	Planning the production process(P3a)
Source (S)	Raw material procurement process(S1)	Scheduling and delivery of raw materials(S1a)
		Checking the quality of raw materials sent by suppliers before entering the factory (S1b)
		Acceptance & Weighing of Raw Materials(S1c)
		Storing in the raw material warehouse/emplacement (S1d)
	Supplier (S2)	Supplier Evaluation(S2a)
Make (M)	The process of producing sugar cane into sugar (M1)	Sugarcane milling process(St Gilingan) (M1a)
		The process of separating saplings with pulp (Kettel station) (M1b)
		Purification process (M1c)
		Purification process (M1d)
		Crystallization and turning process (M1e)
	Finished products(M2)	Checking product quality from the results of the production process (M2a)
		Product packaging (M2b)
		Storage of products in the warehouse of finished products (M2c)
Delivery (D)		Product availability updates (D1a)

	Checking product availability *updates* (D1)	Checking the vehicle to be used (D1b)
		Product Delivery (D1c)
Return (R)	Product Return *Reject*(R1)	Returns and handling products returned from consumers (R1a)

Table 2. Risk Events Identification.

DA	Ei	Kejadian Risiko	DA	Ei	Kejadian Risiko
P1a	E1	Grinding capacity is not achieved	M1b	E16	Damage to the heater
	E2	Grinding capacity is not achieved		E17	Corrosion of screen pipes
P2a	E3	The mismatch between supply chain and financial planning	M1c	E18	Turbidity of diluted nira above the provisions
P3a	E4	Sudden changes in the production process	M1d	E19	Evaporator performance is less than optimal
S1a	E5	Delay in the receipt of raw materials	M1e	E20	Uneven crystals and sugar are still brown
S1b	E6	Raw materials that do not comply with standards	M2a	E21	Deterioration of product quality during production
	E7	The quantity of raw materials ordered is not appropriate	M2b	E22	Plastic sacks are easily torn
S1c	E8	There was a long queue during sugarcane weighing		E23	An error occurred during the packaging process
	E9	Inaccurate scale results	M2c	E24	Sugar products in the warehouse are spoiled
S1d	E10	Sugarcane queue buildup in emplacements		E25	Product damage occurs when moving to the warehouse
S1f	E11	Damage to raw materials at the time of storage is inflamed	D1a	E26	Physical incompatibility of goods with documents
S2a	E12	Not evaluating supplier performance	D1b	E27	Vehicle damage during delivery of goods
M1a	E13	Sugarcane milling error (the grind setting is too high)	D1c	E28	Delay in product delivery
	E14	The occurrence of work accidents	R1a	E29	Product returns are not accepted
M1b	E15	Fuel interference at the boiler station		E30	Delay in handling returning products

Table 3. Risk Agent Identification.

Ei	Ai	Risk Agent	Ei	Ai	Risk Agent
E1	A1	Competition for the acquisition of raw materials is not dominated	E14	A23	Lack of discipline of employees using full PPE
E2	A2	Lack of coordination		A24	Lack of socialization of the importance of K3
	A3	Significant increase in demand	E15	A25	lack of direction from the management of the enterprise
E3	A4	Less accurate pricing reference	E16	A26	Heater used in excess capacity
	A5	Falling sales prices in the market	E17	A27	Preventive maintenance is less than optimal
E4	A6	The occurrence of engine breakdown	E18	A28	There is still unfiltered bagasse
E5	A7	Interruptions during the shipping process	E19	A29	The cleanliness of the evaporator is not maintained
	A8	Limited human resources to cut down transportation	E20	A30	Contaminated raw materials (not BSM)
E6	A9	Lack of logging supervision		A31	Damage to the sugar turning tool
	A10	A less thorough inspection of raw material receipts		A32	Less skilled workers
E7	A11	Availability of raw materials at suppliers is small	E21	A33	Raw materials damaged by the production process
	A12	There was a miscommunication with the supplier	E22	A34	The process of sewing sacks is not done correctly
E8	A13	The occurrence of tool damage	E23	A35	Negligence of workers
E9	A14	Have not done under the applicable SOP	E24	A36	Arrangement and storage in the warehouse are not good
	A15	Absence of a crosscheck mechanism		A37	Old unsold products
E10	A16	Unplanned grinding stops	E25	A38	The occurrence of an accident during the placement or transfer of products to the warehouse

E11	A17	Absence of SOPs for routine checking from the company	E26	A39	Product logging and identity errors
	A18	Inadequate storage warehouse facilities	E27	A40	Rarely performed routine service
	A19	Storage too long		A41	The age of the vehicle is old
E12	A20	No explicit provisions in determining supplier criteria	E28	A42	Limitations of shipping conveyances
E13	A21	No regular machine checks are carried out	E29	A43	Return products do not fall into the defect category
	A22	Incorrect labor in the operation of the machine	E30	A44	Hampered communication between companies and consumers

Calculation of Aggregate Risk Potential (ARP)

After the risk identification, an analysis will be carried out using the House Of Risk (HOR) phase 1 method, including assessment of severity, occurrence, correlation, and also the calculation of the Value of Aggregate Risk Potential (ARP). Aggregate Risk Potentials (ARP) is used to sort risk agents based on their potential occurrence. Before calculating the ARP, it is necessary to develop questionnaires to determine risk event weighting, risk agent occurrence, and correlation between risk event and risk agent. The questionnaires were addressed to managers and several heads of sections related to supply chain activities. The questionnaires will obtain the severity impact of the risk event (weighting), the chance of the occurrence of the risk agent, and the value of the correlation between the risk event and the risk agent. The weighting and occurrence questionnaires are assessed by the head of each department related to activities mapping, i.e., departemen of plant, departemen of installation, departemen of fabrication, and departemen of the warehouse. Especially for the correlation questionnaire, the assessment is carried out by the general manager.

The example of ARP calculation is carried out using (1) and data collection results from questionnaires before present below:

$ARP_j = O_j \sum S_i R_{ij}$

ARP_2 = *Occurrence* A2 X $((S_{E1} \text{ X } C_{1,2}) + (S_{E2} \text{ X } C_{2,2}) + (S_{E3} \text{ X } C_{3,2}) + (S_{E30} \text{ X } C_{30,2}))$

$ARP_2 = 8 \text{ x } ((9 \text{ x } 3) + (9 \text{ x } 9) + (3 \text{ x } 3) + (3 \text{ x } 3))$

$ARP_2 = 8 \text{ X } (27+81+9+9) = 1008$

Those calculations show that ARP2 is the value of the risk agent 2 (A2), which is a lack of coordination. A2 has an occurrence value of 8 and has a correlation with risk events from E1 (Milling capacity is not achieved), E2 (Capacity planning is not appropriate), E3 (Discrepancies between supply chains and financial planning), and E30 (Delay in handling returning products) with the final value of 1008. The calculation was carried out for the rest of the risk agents and then plotted in a Pareto diagram.

According to [1], under the principle of the Pareto diagram, the priority of the problem that must be addressed is the problem with a percentage of up to 80%. The risk agent is to be mitigated based on the ARP value using the Pareto diagram shown in Figure 1. There are 13 risk agents in the top 80% of ARP listed in Table 4.

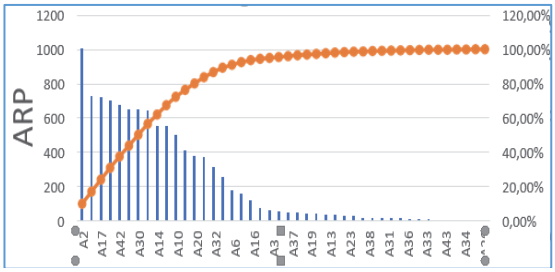

Fig. 1. Pareto Diagram of ARP.

Table 4. Cumulative ARP.

Ai	Risk Agent	Rank	ARP	% ARP	Cumulative ARP
A2	Lack of coordination	1	1008	9,86%	9,86%
A1	Competition for the acquisition of raw materials is not dominated	2	729	7,13%	16,98%
A17	Absence of SOPs for routine checking from the company	3	720	7,04%	24,02%
A35	Negligence of workers	4	702	6,86%	30,89%
A42	Limitations of shipping conveyances	5	675	6,60%	37,49%
A8	Limited human resources to cut down transportation	6	651	6,36%	43,85%
A30	Contaminated raw materials (not BSM)	7	648	6,34%	50,19%
A21	No regular machine checks are carried out	8	645	6,31%	56,49%
A14	Have not done in accordance with the applicable SOP	9	555	5,43%	61,92%
A27	Preventive maintenance is less than optimal	10	555	5,43%	67,34%
A10	A less thorough inspection of raw material receipts	11	504	4,93%	72,27%
A22	Incorrect labor in the operation of the machine	12	414	4,05%	76,32%
A20	Absence of clear provisions in determining supplier criteria	13	378	3,70%	80,02%

4 Result and Discussion

From the results of risk identification with SCOR, various risks that occurred in the company were obtained. There were 30 risk events caused by 44 agents of risk of the plan, source, make, delivery, and return processes. Based on the Pareto diagram, there are 13 priority risk agents that need to be mitigated, namely lack of coordination (A2), competition for the acquisition of raw materials not controlled (A1), absence of SOPs for routine checking from the company (A17), negligence of workers (A35), limited delivery transportation equipment (A42), limited human resources for logging transportation (A8), contaminated raw materials (A30), no regular machine checks (A21), has not carried out in accordance with the applicable SOP (A14), preventive maintenance is less than optimal (A27), the inspection of raw material receipts is less thorough (A10), labor is wrong in the operation of the machine (A22), and there are no explicit provisions in determining supplier criteria (A20). If traced back to level 1, the risk agent comes from nearly all processes in the supply chain, i.e., plan, source, make, and delivery process, but the dominant risk agent is in the make and source process, where each of these processes appears five risk agents.

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