

## Supply Chain Risk Mapping at ABC Cement Plant in Aceh, Indonesia

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**Abstract** – Supply Chain Risk Management is an industry collaboration that works with partners in the supply chain system to implement a risk management process in dealing with the emergence of risks and uncertainties caused by logistics activities or other resources in the supply chain. Every industry deals with risk. This study aims to identify, classify, and map supply chain activities and their risks. In the initial stage, supply chain events are identified through interviews and brainstorming. Then, these events are portrayed in the supply chain map. Then, the risk identification stage used a rating scale to determine the level of likelihood and consequence based on three SCOR elements. There are 40 risk events in this study which are 13 risk events in the source section, 19 risk events in the make section, and eight risk events in the delivery section. Finally, it is necessary to calculate the value of the Risk Priority Index. The Risk Priority Index is the basis of the risk mapping stage. The risk map shows the urgency to treat each risk event.

**Keywords:** Supply Chain Management, Supply Chain Risk Map, SCOR, Risk Priority Index, Cement Plant.

### Introduction

Supply Chain Management is a management activity that converts materials and services into good final products and then distributes them (Heizer and Berry, 2014). A good supply chain is a solid and trusted cooperation between each supply chain element. It is necessary to integrate all partners in the supply chain, such as suppliers, manufacturers, distributors, and retailers, effectively and efficiently to obtain the best supply chain (Putra *et al.*, 2020). The supply chain covers all actors, starting from upstream to downstream. Therefore, the supply chain is a unified whole, and if one of these elements does not exist, refuses to work together, or has a problem, it will affect all the processes.

The company should conduct careful consideration before implementing a supply chain. The supply chain has many unavoidable risks. Although these risks are hard to avoid, we can reduce their impact with several strategies. Therefore, a company must have a risk management system. Risk management, commonly known as Supply Chain Risk Management (SCRM), is “an inter-organizational collaborative endeavor utilizing quantitative and qualitative risk management methodologies to identify, evaluate, mitigate, and monitor unexpected macro and micro level events or conditions, which might adversely impact any part of a supply chain” (Ho *et al.*, 2015). On the other hand, the company must figure out the latest trend. It is possible to identify business trends in the literature and other reasons that could make the chain more vulnerable, such as opportunities to compete globally, increase chain exposure, and add new dimensions of risk (Dias *et al.*, 2020).

Risk is the possibility and implication of loss to individuals and organizations. The company must have proactive and reactive risk planning (Chaudhuri *et al.*, 2020). Every company must have risks that accompany the course of the production process. However, the difference is the level of risk itself. There are risks that, if they occur, will have little effect on the production process, while others may have severe consequences and may even stop the production process. The supply chain risks are obstacles to initiatives taken in moving products from their place of production to the final customer (Eleck Son, 2018). The risks can directly affect the whole production activity. That is because supply chain risk is defined as an unplanned and undesirable situation that can result in the production process (Revilla *et al.*, 2017). Supply chain management often consists of several

suppliers on the upstream and several retailers and distributions on the downstream, known as a branching supply chain (Murdapa, 2021). This condition raises the complexity of supply chain networks and the risk within its chain. Therefore, it is necessary to plan risk management to minimize or even eliminate these risks.

The steps to manage risk are mapping the supply chain activities: identification, assessment, treatment, and monitoring (Fan and Stevenson, 2020). The steps are identified using the Supply Chain Operations Reference (SCOR) level, analysis of risks and causes of risk using severity categories for risk and occurrence, and transformation of the data to the risk map (Millaty *et al.*, 2014). Therefore, these steps are necessary for conducting this research. After mapping, determine the Risk Priority Index (RPI) to identify the correlation between the causal factor (risk agent) and each risk event (risk event) using the House of Risk (HOR) tool (Utama, 2009).

ABC Cement Plant is one company that applies supply chain management in carrying out the company's production process. The ABC Cement Plant supply chain elements are supplier, manufacturer, distributor, and retailer. The company should also implement supply chain risk management to improve the existing supply chain results. Aceh is a disaster-prone area located in the far west of Indonesia. The risks include natural disasters, economic and political issues, and other things that directly or indirectly impact all existing sectors. Therefore, it is necessary to prepare a strategy to deal with risks for the ABC Cement plant can survive and not hamper the production process.

## **Materials and Methods**

### **Data collection**

The data used in this study were collected by questionnaire. There are two types of questionnaires which are the Likelihood and Consequences. There are five respondents from the company who are from the production department. Each respondent filled out both questionnaires. The questionnaire consists of 40 risks. The results for each question are calculated to find each item's average value.

### **Methods**

Supply Chain Risk Management (SCRM) describes the steps for risk management: identification, evaluation, mitigation, and control (Dias *et al.*, 2020). The research process involves a four-step stage that begins with mapping the company's supply chain activities, aiming to identify the parties involved in the company's supply chain activities (Lufika *et al.*, 2022). The next step is identifying the risk events in the supply chain using the Supply Chain Operation Reference (SCOR) level 1 model category: plan, source, make, deliver, and return. The risk events are obtained by collecting information from the company and data from previous research. After that, it is crucial to measure the risk events by calculating the Risk Priority Index (RPI) based on the calculation of likelihood and consequence values (Lufika *et al.*, 2022). Likelihood and Consequences values range from one to five, and these values are the questionnaire results filled by the managers and workers at the production department in the company. The Risk Priority Index (RPI) will be used to determine the ranking of risk events. Finally, we map the risk events in the Risk Map. This mapping will determine the selected risk events and identify the risk agent (Lufika *et al.*, 2022). The mapping will show the level of risk needed for improvement based on the combination of likelihood and consequence values.

### **Supply Chain Mapping**

Figure 1 shows the Supply Chain Activities of the ABC Cement Plant. The ABC Cement Plant has a production target based on historical data to estimate the plant capacity. Then, the company calculates the raw material requirements and orders them to the suppliers, which are mostly part of the company. To fulfill the demand, the production planning is carried out according to the production target. Quality inspection of raw materials is carried out at the beginning of the production process to ensure that all materials meet the quality standard. ABC Cement Plant also applies a quality inspection at every stage of the production process, aiming to minimize final product defects.

There are two distribution types at the company, individual packaging, and bulk. The research focuses on the packaging terminal's cement distribution section in this case. The method for mapping the supply chain activities is SCOR method level 1. At level 1 SCOR, the supply chain elements that become the focus are Plan, Source,

Make, Deliver, and Return. However, this study only covers Source, Make, and Deliver because these three elements are the main elements in the supply chain network.

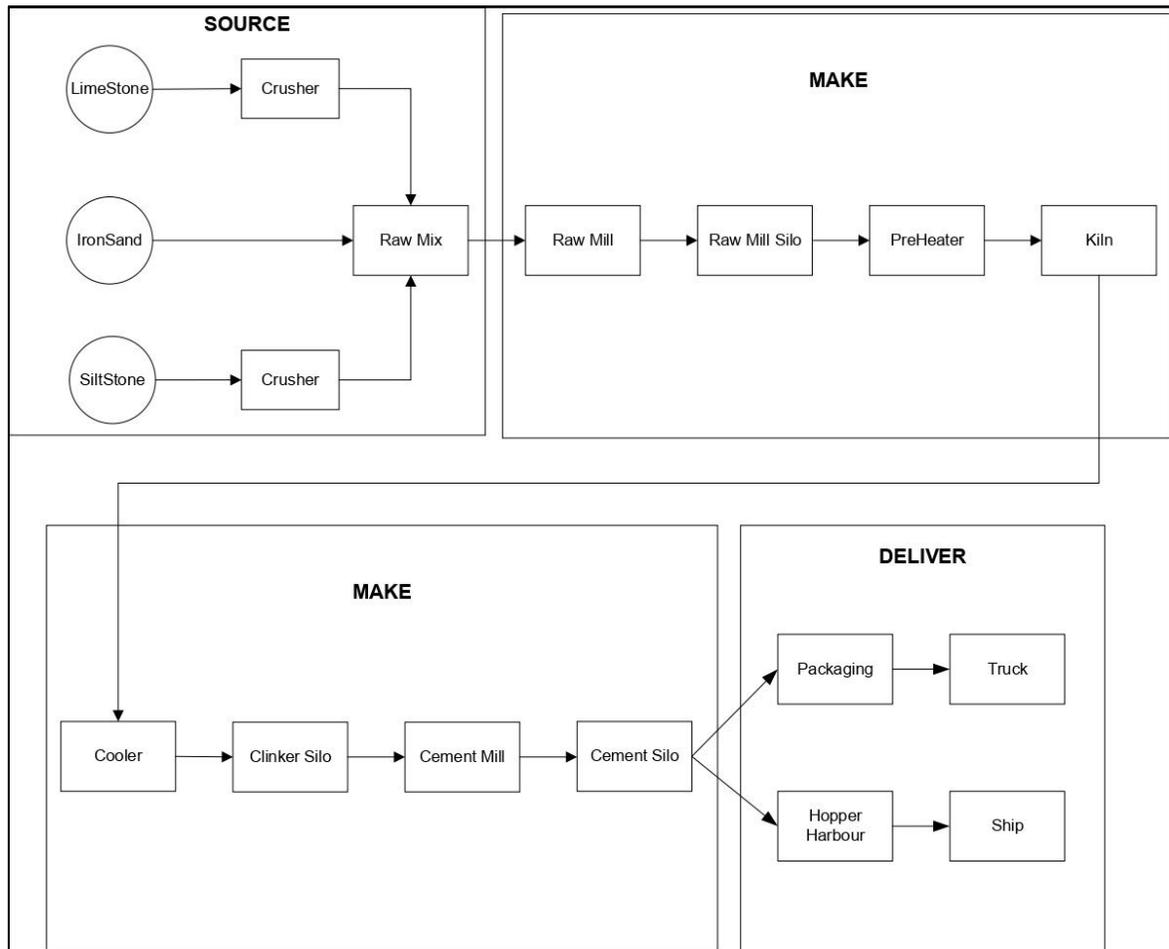


Figure 1. Supply Chain Map

### Risk Analysis

The next step is to inspect the Likelihood and Consequences. The inspection involves a brainstorming session with management people from ABC Cement Plant. This brainstorming aims to adjust the category to the level of likelihood and consequence described by Waters (2007). Table 1 below shows the results of categorizing the likelihood level and describes the results of the consequence level.

### Risk Identification

This step helps identify potential inherent supply chain risks. This includes being aware of all associated risks. Data sources consist of primary and secondary data from interviews with experts and historical data of the target companies (Wachyudi et al., 2018). At this stage, the risk events identification is focused on SCOR elements, namely Plan, Source, Make, Deliver, and Return. Each element may contain similar risks. It is necessary to treat these risks differently because they occur in different situations and involve different stakeholders. Table 2 below shows the results of risk identification at ABC Cement Plant.

**Table 1.** Likelihood and Consequence Category

Level	Likelihood		Consequence	
	Criteria	Description	Criteria	Description
1	Very Unlikely	An event that almost never happens	Negligible	It has an effect that does not significantly affect the supply chain
2	Rare	A rare occurrence, but several times it has happened	Minor	It causes unpleasant effects but does not affect most production processes
3	Occasional	Occasional events that can also be considered not to occur due to irregular timing of events	Moderate	Disrupt supply chain elements, but the primary function can still run
4	Frequent	Events that often occur with quite a lot of frequency	Serious	Disruption to essential supply chain elements, resulting in severe delays, and high price increases
5	Very Likely	Events that occur so often that they are often considered normal	Critical	Disruption of all elements of the supply chain for an indefinite period, requiring a large amount of money and effort to restore the production process

**Table 2.** Risk List based on SCOR Level 1

No	SCOR		
	Source	Make	Deliver
1	Inadequate equipment	Imperfect Material	Worker fatigue
2	Insufficient transportation	Drought Level	Final product sort error
3	Quality does not match quality standards	Ball Mill is not in optimal condition	The net weight of the product is not up to standard
4	Dependence on a single supplier	The separator is not in optimal condition	Sudden demand from consumers
5	Price fluctuation	Worker fatigue	Identification error
6	Order error	Contaminated product	Product packaging is not perfect
7	Raw material not available	Maintenance	Inadequate transportation
8	The supplier does not fulfill the order	Limited HR operators	Delivery schedule mismatch
9	Raw material delay	Product completion delay	-
10	SiltStone mixed with water	Lack of adequate transportation	-
11	Maintenance	Water and carbon dioxide contamination	-
12	Raw materials are not mixed perfectly	Insufficient energy	-
13	The quality of mixed raw materials	Insufficient fuel	-
14	-	Incomplete combustion	-
15	-	Fire Breaker is not in optimal condition	-
16	-	Broken material	-
17	-	Material sorting error	-
18	-	The product does not meet standard dimensions	-
19	-	Overtime	-
	-	Element stacking	-

**Table 3.** Risk Priority Index

No	Code	Risk Event	Likelihood	Consequence	RPI	Rank
1	SRC01	Inadequate equipment	1	4	4	8
2	SRC02	Insufficient transportation	2	4	8	5
3	SRC03	Quality does not match quality standards	2	5	10	3
4	SRC04	Dependence on a single supplier	2	4	8	5
5	SRC05	Price fluctuation	3	5	15	1
6	SRC06	Order error	1	5	5	7
7	SRC07	Raw material not available	1	5	5	7
8	SRC08	The supplier does not fulfill the order	3	5	15	1
9	SRC09	Raw material delay	3	4	12	2
10	SRC10	SiltStone mixed with water	1	5	5	7
11	SRC11	Maintenance	3	5	15	1
12	SRC12	Raw materials are not mixed perfectly	1	5	5	7
13	SRC13	The quality of mixed raw materials	1	5	5	7
14	MK01	Imperfect Material Drought Level	3	4	12	2
15	MK02	Ball Mill is not in optimal condition	2	4	8	5
16	MK03	The separator is not in optimal condition	2	4	8	5
17	MK04	Worker fatigue	2	4	8	5
18	MK05	Contaminated product	2	5	10	3
19	MK06	Maintenance	3	5	15	1
20	MK07	Limited HR operators	1	4	4	8
21	MK08	Product completion delay	1	4	4	8
22	MK09	Lack of adequate transportation	1	4	4	8
23	MK10	Water and carbon dioxide contamination	1	4	4	8
24	MK11	Insufficient energy	2	5	10	3
25	MK12	Insufficient fuel	1	5	5	7
26	MK13	Incomplete combustion	1	5	5	7
27	MK14	Fire Breaker is not in optimal condition	2	4	8	5
28	MK15	Broken material	2	4	8	5
29	MK16	Material sorting error	1	4	4	8
30	MK17	The product does not meet standard dimensions	1	5	5	7
31	MK18	Overtime	3	4	12	2
32	MK19	Element stacking	1	5	5	7
33	DLV01	Worker fatigue	2	3	6	6
34	DLV02	Final product sort error	1	5	5	7
35	DLV03	The net weight of the product is not up to standard	1	5	5	7
36	DLV04	Sudden demand from consumers	3	3	9	4
37	DLV05	Identification error	1	5	5	7
38	DLV06	Product packaging is not perfect	1	4	4	8
39	DLV07	Inadequate transportation	1	5	5	7
40	DLV08	Delivery schedule mismatch	3	5	15	1

## Results

### Risk Identification

The next step is to assess the likelihood and consequences of the risk events before. This assessment involves an interview and questionnaire approach. The purpose is to identify the highest risk factors in transportation/distribution routes (Mullai, 2009). Then we need to evaluate the consequences as well. This evaluation aims to estimate side effects if a risk occurs by estimating various factors and conditions (Mullai, 2009). Based on the Likelihood and Consequence assessment, we need to conduct the multiplication between these two values. The multiplication of values is a basis for the Risk Priority Index (RPI). Table 4 shows the likelihood, consequences, RPI, and ranking.

## Risk Priority Index

The research process involves a six-step chain that begins with (1) mapping the company's supply chain activities aimed at identifying the parts involved in the company's supply chain activities; (2) identification of risk events in the supply chain using the Supply Chain Operation Reference (SCOR) level 1 model which is grouped based on the level 1 SCOR category: plan, source, make, deliver, and return; (3) measurement of risk events by calculating the Risk Priority Index (RPI) based on the calculation of likelihood and consequence values. Likelihood and Consequences values range from one to five by concentrating on information on the level of likelihood of risk. The two values are then multiplied to produce the Risk Priority Index (RPI); this value will be used as a reference to determine the ranking of risk events; (4). mapping of risk events in the Risk Map. This mapping will determine the selected risk events and identify the risk agent. The mapping will show the level of risk needed for improvement based on comparing likelihood and consequence values.

**Table 4.** Colour Description for Risk Map

No	Colour	Description
1		No Corrective Action Required
2		Corrective Action Needs to be Considered
3		Corrective Action Highly Recommended
4		Corrective Action Must Be Take

C/L	1	2	3	4	5
5					
4					
3			DLV04	SRC09 MK01 MK18	SRC05 SRC08 SRC11 MK06 DLV08
2			DLV01	SRC02 SRC04 MK02 MK03 MK04 MK14 MK15	SRC03 MK05 MK11
1				SRC01 MK07 MK08 MK09 MK10 MK16 DLV06	SRC06 SRC07 SRC10 SRC12 SRC13 MK12 MK13 MK17 MK19 DLV02 DLV03 DLV05 DLV07

**Figure 2.** Risk Map

## Risk Map

Based on table 4. above, there are groups of risks in each rank. Five, three, three, one, seven, one, thirteen, and seven risks ranked first to eighth, respectively. The value of the RPI for each risk is fifteen, twelve, ten, nine, eight, six, five, and four, respectively. The next step is mapping the risk in the risk map with the rank information. The map will represent which risk is more urgent than others. The Risk Map consists of four areas. The green area indicates that corrective action is not required. The yellow part shows that the company should consider planning preventive action. Treating the risk if it is part of the orange area is strongly recommended. The red area tells that company should immediately conduct the corrective action. Table 4 describes the color description of the Risk Map. Figure 2 shows the Risk Map.

The table above shows the risk map. There are eight risk events in the green area, 21 risk events in the yellow part, eleven risks in the orange part, and no risk in the red part. In this study, risk events that will be followed up are risk events in the orange area, namely SRC09 (Raw Materials Delay), MK01 (Imperfect Material Drought)

Level), MK18 (Overtime), SRC05 (Price Fluctuations), SRC08 (The supplier does not fulfill the order), SRC11 (Maintenance), MK06 (Maintenance), DLV08 (Delivery schedule mismatch), SRC03 (Quality does not match quality standards), MK05 (Contaminated Products), and MK11 (Insufficient energy).

## **Discussion**

The result above shows that the company has sufficient risk management. Out of forty risks, there is no risk in the red area. It shows that the risk is under control and has no damage to the production system (Lufika *et al.*, 2022). The risks in the green and yellow areas can be ignored because they provide no threat to manufacturing activities, although the company should be aware of the risks. These risks are usually minor and provide small to mild effects on the production process. However, the risks in the orange part are the ones that should get attention. The risk may not be dangerous at the moment, but it can develop into a threat soon. All of these risks require attention and strategy to prevent the risks disturb the whole production process. The chosen strategy for managing the supply chain risks depends on the firm's nature and external parties (Faizal and Palaniappan, 2014). Therefore, the following research should focus on risk management to treat these risks. There are several steps to manage these risks. The first one is to choose the risk priority for treatment.

## **Conclusion**

Based on the research, there are several conclusions available. First, there are 40 risk events. The events are 13, 19, and 8 risks in the source, make and deliver sections. Second, the Risk Priority Index (RPI) groups the risks into eight ranks. Five risks in the first rank, three risks in the second rank, three risks in the third rank, one risk in the fourth rank, seven risks in the fifth rank, one risk in the sixth rank, thirteen risks in the seventh rank, and seven risks in the eighth rank. Third, the Risk Map shows the details of 11 risks in the orange area, 21 in the yellow, eight in the green, and no in the red. Then the risk in the orange section is the selected risk event, namely, SRC09 (Raw Materials Delay), MK01 (Imperfect Material Drought Level), MK18 (Overtime), SRC05 (Price Fluctuations), SRC08 (The supplier does not fulfill the order), SRC11 (Maintenance), MK06 (Maintenance), DLV08 (Delivery schedule mismatch), SRC03 (Quality does not match quality standards), MK05 (Contaminated Products), and MK11 (Insufficient energy).

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