Service Supply Chain Risk Analysis and Control of Port using the HOR Approach

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Abstract

Ports have an important role in the maritime transportation system, but also face various obstacles and threats to different types of risks. Economic conditions and activities that tend to be complex and uncertain, such as the threat of the COVID-19 pandemic, climate change, and geopolitics, cause port development and operations to face various challenges and uncertainties. The ASDP port of the Juata Tarakan ferry has become one of the important parts of community activities to travel from Tarakan island to the surrounding islands such as Tana Tidung and Nunukan. Various studies have been conducted to learn about the operational phases of ports, but not about the overall life cycle. In addition to operational factors, there are environmental factors that still need to be explored in order to avoid failure to distinguish the causes and consequences of risks from risk events. In this study, the process of identification, analysis, and risk mitigation was carried out using a house of risk approach to be able to identify risk events and risk causative agents. This study seeks to explore the risk that is a key component by looking for the relationship between one risk agent and another risk agent and its impact on port companies. Risk prevention actions are discussed in this study in order to provide an insight into rethinking port risks and designing strategic management. The purpose of this study is to help port authorities, especially ASDP ferry, develop an understanding and management approach to risk from all aspects of the life cycle of the port. This study identified 33 potential failure scenarios, six of which had a cumulative ARP of 75%. One of the most significant factors is strong winds, which can be anticipated by updating the weather around the port and monitoring port equipment during docking, both day and night. Port operators and captains calculate tidal levels before docking to determine safe speeds and ropes.

Keywords: *Risk Management, House of Risk, Port, Supply Chain, Service*

1. Introduction

To improve performance and resilience to risk, risk prevention activities need to be developed both in terms of risk identification and assessment that could disrupt the supply chain of services in port companies based on the flow of logistics, information, and capital through the adaptation of the score service model to be able to control the risks. Risk events will be identified based on the core business activities in the SCOR model, along with the agents that cause the risks.

Port supply chain activities require all parties to be closely involved, leading to integration activities where one risk occurs; it can trigger other issues, and the situation becomes more complex. Additionally, since several organisations are involved simultaneously in supply chain activities, a problem within one group can trigger another within another group.

Risk is a function of uncertainty and the impact of an event. [1]. Risk can also be defined as an occurrence with uncertain impacts. The process within supply chain risk management refers to the supply chain processes based on the SCOR (Supply Chain Operations Reference) model, which consists of five important processes: planning, sourcing, making, delivering, and returning. However, there are some adjustments to the SCOR model at ports, such as the absence of a sourcing process, the return process being associated with disconnection from supply chain members, and the addition of two extra processes, namely the financial and external environment. Port risk can be defined as uncertain events occurring throughout the port's cycle that may lead to negative impacts [2]. The life cycle of a port can be divided into two phases: the development phase and the operational phase[3].

Juata Port is a place that connects service consumers of maritime transportation with ferry owners, serving as a location for ticketing services, loading and unloading activities, as well as non-loading and unloading activities. Based on the literature study that has been conducted, port companies face various types of risks that can cause damage or reduce the functionality of port activities involving the flow of logistics, information, and capital.

2. Literature Review

Supply chain operations management is conducted by utilizing resources, information, and financing to maximize profits while minimizing risks [4]. Ports, as organizations, play a crucial role in integrating their operations with the supply chain, and need to adapt to changes in the business environment [5].

Port activities are carried out in accordance with current needs without causing adverse side effects for the related stakeholders [6]. The port implements business strategies and activities that align with the current and future needs of the port and its stakeholders and must be able to protect and sustain human beings and natural resources [7]. The social dimension has also become a part that is considered in the stakeholder relationship perspective of the port, such as relationships between stakeholders, culture, accessibility, workers, health, safety, and security, to minimize risks that disrupt port activities. [8], [9].

Ports operate due to the presence of stakeholders who play a role in the port supply chain activities and are crucial to the development of the national economy business continues to run [10]. Ports in Indonesia have a crucial role in maintaining the efficiency and quality of logistics in line with their role in trade between the two regions [11]. Stakeholders, also known as stakeholders, are groups or individuals who are affected by or influence the goals of the organization [12]. Stakeholders are divided into external and internal [13]. Internal stakeholders consist of the employee staff and the middle managers. Local communities, governments, suppliers, competitors, and consumers are external stakeholders. The corporate board is an interface stakeholder. Stakeholders can also be differentiated into two types, namely primary and secondary stakeholders. The difference between them lies in the economic impact, where primary stakeholders have a direct economic impact, while secondary stakeholders have an impact on the company, but are not directly involved in the company's transactions, and are not essential parties to the survival of the port [14].

The concept of ports has evolved as described in the generation concept, consisting of five types of port generation, namely city ports, industrial ports, container ports, cooperative ports, and digital ports. [15]. The concept of port development does not imply higher performance [16].

Supply chain risk management is an effort by the company to identify, evaluate risks along with their impacts, and determine the necessary actions to reduce losses incurred by collaborating with business partners [17]. Supply chain risk management can be classified into two categories based on the source of its causes, namely, risks arising from the internal supply chain itself and risks generated from the external environment [18]. Risk management can be used to identify and manage threats and opportunities to society, such as stricter social and environmental legislation, changing customer demands, national and global litigation, effects on brand and reputation, the ability to attract employees and investors, and the availability and cost of resources, waste, and emissions[19].

The framework used in this research is the house of risk, which combines two types of research tools, namely the house of quality and FMEA (failure mode effect and analysis). FMEA was first introduced by the US Department of Defense as a risk-based tool that functions to identify, assess, and manage potential failures of a product or system in a structured manner [20]. HOR consists of two stages, namely HOR1, which is used to rank risk agents based on potential risk, and HOR2, which is used to prioritise proactive actions taken by the company to maximize cost-effectiveness against the risk agents selected in HOR1 [21].

Risks not only impact financial losses, but also affect the operational aspects of social and environmental sustainability, where sustainability aspects are also studied to ensure that operational activities and port projects do not endanger the surrounding life [22], [23], [24]. The port should focus not only on the environment, but also on social and economic aspects, because it involves many strategically responsible stakeholders, such as local service users and fishermen.[25].

3. Method

The research was conducted by compiling the HOR, consisting of HOR1 and HOR2 can be shown in Table 1 and Figure 1. HOR1 is used to list the risk events and risk agents that occur during the supply chain process in the port, while HOR2 is used to determine risk mitigation to address the risk agents that will be acted upon according to the calculations made in the HOR1 stage. The compilation of HOR1 is based on the SCOR model for ports, which consists of planning, service, distribution, relationship, finance, and external environment processes.

Table 1 Research steps

Number	**Steps**	**Explanation**
0	System identification	Ferry port of Juata Tarakan
1	Risk identification	Risk that can cause failure or reduce the function or capability of Port (HOR1)
2	Risk assessment	Investigation or quantification of important port risk (HOR1)
3	Risk mitigation option	Measuring risk mitigation activities to repair port function or capabilities (HOR2)
4	Decision	Recommendation of risk mitigation (HOR2)

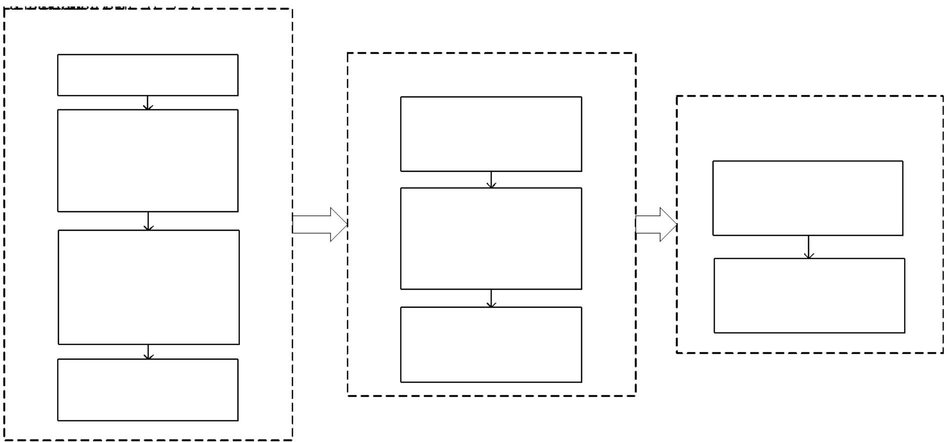

Figure 1 House of Risk Steps

4. Result and discussion

There are three types of supply chain flows at Juata Port, namely capital flow, information flow, and logistics flow, and there are at least three supply chain agents involved, such as port officials, shipowners, and passengers can be shown in Figure 2. Supply chain information will be used as a guideline for arranging the activities of the port service supply chain, which will then be arranged into risk events, as shown in Table 2.

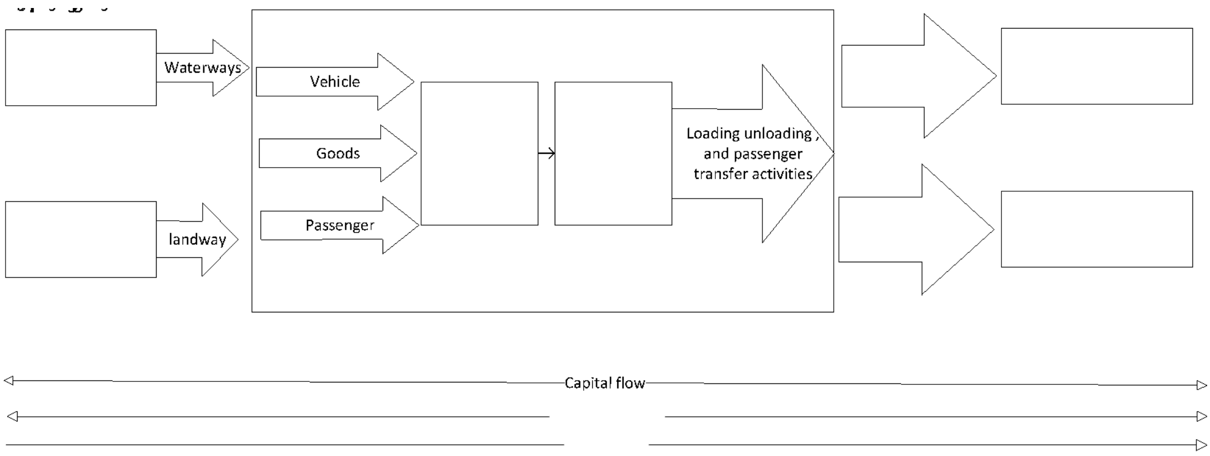

Figure 2 supply chain of Juata Port

The business process based on the SCOR service model in port companies consists of planning, services, distribution, relationships, finance, and external environments. Risk identification is carried out starting from the business process, which is then traced back to its root causes for risk mitigation. The risk identification process is carried out based on the business processes that have been developed in the previous subchapter. After identifying risks, the next step is to assess the severity of risks according to Table 3 And, as a reference, to evaluate the severity based on the risk events found in Table 5.

Table 2 Business Process

Business process	Description
Planning process [26]	Include the process of determining service delivery (route determination and vessel size)
Service process [27]	Loading activities
	Service activities
	Berthing activities
	Distribution activities
Distribution process [28], [29]	Activities related to other ports (delay, berthing / unberthing, destination selection)
Relation process [26]	Relationships process among supply chain members. Risk associated with this process includes a decline in participation of supply chain members.
financial [30], [31]	Capital flow process that occurs during the port service process between ship owners, port companies, and service users.
External environment process [3], [26], [32]	The process of risk events caused by disruptions from external parties that can interfere with the operational flow of the port

Table 3 Risk Events

Business process	*Risk event*	*Code*	*Severity*
Planning process	Reduction of ship capacity	E1	3
	Sudden increase in demand	E2	3
Services	Deficiency of loading and unloading equipment	E3	5

	Insufficient storage capacity	E4	4
	Damage to the dock area	E5	5
	The reduction in the queue area	E6	4
Distribution process	Delay of ship arrival	E7	4
	Unreadiness cargo owner	E8	3
	Unreadiness port for berthing	E9	5
	Travel safety issues	E10	5
	Unreadiness ship to berthing	E11	5
Relation process	Work accident	E12	4
	Ticketing error	E13	4
	Labor problem	E14	1
Financial Process	Administration and financing difficulties	E15	1
	Financial crisis	E16	1
External environment process	Transportation change route	E17	1
	Inspection by security personnel concerned	E18	5
	Riot in the dock area	E19	5

Business process risks can arise from several factors, including natural conditions, operational errors, IT system failures, management mistakes, distribution disruptions, financial issues, and external environments. To differentiate between risks that often occur and those that rarely occur, an assessment of the likelihood of these risks being triggered is conducted, with the descriptions shown in the identified risk as risk agents, as shown in Table 4, while risk assessment is conducted by calculating the aggregate risk potential (ARP) by multiplying severity, occurrence probability and the correlation between risk agents and risk events. Thus, mitigation action will be constructed based on risk agents with an ARP value of 80% cumulative percentage value.

Table 6 serves as a reference for assessing the frequency levels of each risk.

Table 4 Risk Agents

No	Category	Code	Risk Agent	Occurence
1	Nature condition	A1	Rain	4
		A2	Heavy wind	4
		A3	Natural disaster	2
		A4	Species invasion	1
2	Operational	A5	Pilotage error	3
		A6	Navigasi error	3
		A7	Collision	2
		A8	Hit by an object	2
		A9	Electrical error	3
		A10	Human error	4
		A11	Inadequate safety management	4
		A12	Inadequate timing management	4
		A13	Fire and explosion	2
3	IT system	A14	IT maintenance	2
		A15	Cyber attack	1
4	Distribution	A16	Visibility problem	4
		A17	Tide condition	4
		A18	Operational location	1
		A19	Ship type	4

		A20	Night/day operation	4
5	Management	A21	Not wearing PPE	2
		A22	Stowage planning problem	2
		A23	Labour protest	2
6	Financial	A24	Financing and documentation problem	1
		A26	inflation	1
		A27	Inaccurate demand forecast	2
7	External environment	A28	Illegal trade	3
		A29	Gang problem	3
		A30	Market disruption	1
		A31	Public opposition	2
		A32	Holiday season	2
		A33	Pandemic	1

Table 5 Severity Assessment Scale for Risk Event

SI	*Severity*	*Human safety*	*Financial*	*Delays*
1	*Insignificant*	No injuries	No financial loss	No delay, little disturbance
2	*Minor*	Single or minor injuries	Very low financial loss	No delay, disturbance
3	*Significant*	Multiple severe injuries	Intermediate financial loss	Slightly delay
4	*Severe*	Single fatality or multiple severe injuries	High financial loss	Delay less than 1 hour
5	*Catastrophic*	Multiple fatalities	Financial loss is very high	Delay 1-3 hours
Reference		[3]	[30]	[29]

Risk assessment was conducted by calculating the aggregate risk potential (ARP) by multiplying severity, occurrence probability, and the correlation between risk agents and risk events. Thus, mitigation action will be constructed based on risk agents with an 80% cumulative percentage value of the ARP.

Based on data obtained from the respondents' opinions, risks due to weather conditions and distribution disruptions are the most significant causes of disruptions, while disruptions due to social factors do not significantly impact business processes. The minimal influence of social factors is affected by the low frequency of triggers, so if social disruptions can provoke risks to business processes, port activities can be affected. To address this, related risk mitigation, such as preparing security and workers to face those demands, is still needed.

Heavy wind risk will affect planning, service, and distribution process risks, and is one of the unavoidable risks. Heavy wind can cause disturbances within the port activities, such as passenger transfer and loading unloading accidents. It can also cause disturbance to the shipper, such as a ship crashing into the dock, difficulty with the ship's control and maneuvering, a rope break, inability of the movable bridge to stay balanced. The risk of strong winds can be exacerbated by the presence of rain, making the anticipation of slippery floors a part that needs to be cautious on.

Tide condition risk can cause difficulties for the shipper to perform berthing. Low tide will cause grounding and insufficient seawater drawn to the machine that can withdraw sludge, while high tide will cause drawing garbage from the seawater to the land surface.

Loading, unloading, and non-loading unloading risk usually have a correlation with human error. There is a wide variety of severe injuries, such as minor injuries, multiple injuries, to fatalities. The port needs to perform an emergency response, including clearing the area and medical parties if needed. Inadequate safety work management can also be the reason human errors occur. Warn workers who are undisciplined when not wearing PPE (Personal protective equipment) can be used to mitigate human error risk.

The risk event with the highest severity is the unreadiness of ships caused by the engine being off. This risk event can cause delays of up to three hours. To mitigate the engine off risk, the port needs to perform an engine check periodically and conduct preventive maintenance and corrective maintenance.

There is a 20% increase in demand every holiday season, and with this number, there will be slight delays due to the preparation process of passengers and shippers. This sudden increase can be mitigated by identifying seasonal factors when service users increase, including annual holiday dates, to increase handling and service readiness.

Worker fatigue and visibility problems usually occur during night/day operations. To handle this risk, the port has to provide good lighting around the maneuver area, conduct security surveillance within the port, and update the conditions in case of disturbance (public security, species invasion, etc.). Adequate working time management will be needed to perform mitigation activities.

Table 6 Frequency Assessment Scale of Risk Agents Occur

Probability Scale (*Occurrence*)		
Scale	**Description**	***Occurrence (likely)***
1	*Rare*	Happens once in a lifetime
2	*Unlikely*	May occur once time in a year
3	*Possible*	May occur once time in a month
4	*Likely*	Can occur more than once in each month
5	*Almost certain*	Can occur one time every three days or less

Table 7 Risk agent contribution 80% RPN

rank	***Code***	***Risk agent***	**ARP**	***Percentage***	***Cumulative Percentage***
1	A2	Heavy wind	972	46%	46%
2	A17	Tide condition	192	9%	55%
3	A10	Human error	180	9%	64%
4	A19	Ship condition	144	7%	71%
5	A31	Holiday season	108	5%	76%
6	A20	Night/day operation	96	5%	80%

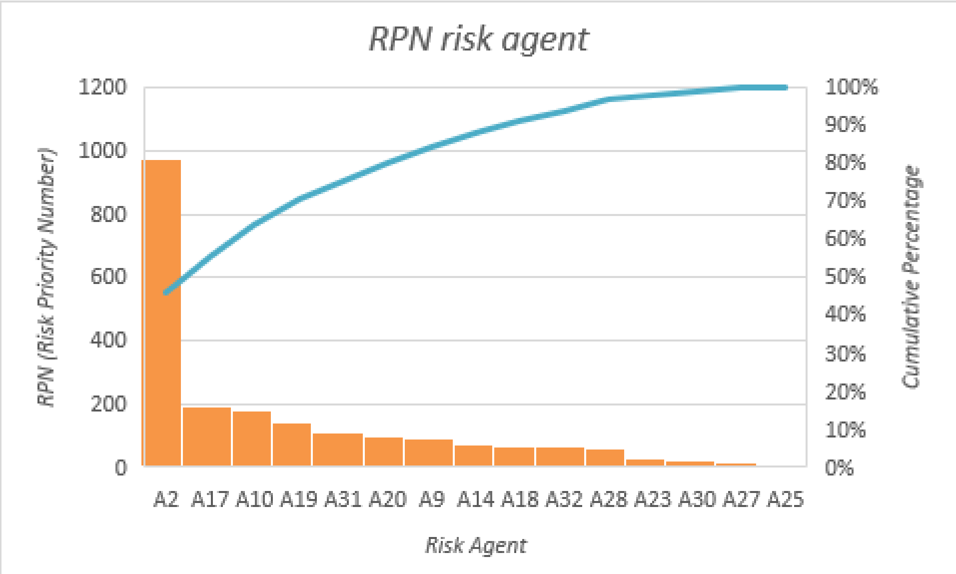

Figure 3 Pareto chart of CARP

Mitigation is formulated based on the risks that trigger failures in the port business processes outlined in the previous subsection. Each mitigation action or activity has its own level of difficulty, influenced by financial aspects, management, or execution, depending on external parties. The scale of difficulty can be seen in Table 8, which forms the basis for assessing the difficulty level of implementing risk mitigation displayed in Table 9, and mitigation activities are shown in Table 10.

Table 8 Difficulty Scale of Mitigation Level Assessment

Scale	Description	Implementation indicator
1	Very easy to implement	Mitigation activities require a very low cost and a short time
2	Easy to implemented	Mitigation activities require low cost and a long time
3	Neutral	Neutral
4	Difficult to implemented	Mitigation activities require a high cost and a short time
5	Very difficult to implement	Mitigation activities require a high cost and a long time

Table 9 Mitigation and Risk Agent Related

rank	*RA code*	*Risk agent*	ARP	Mitigation code
1	A2	Heavy wind	972	M1,M2
2	A17	Tide condition	192	M2,M3,M4
3	A10	Human error	180	M2, M5
4	A19	Ship condition	144	M3
5	A31	Holiday season	108	M6
6	A20	Night/day operation	96	M2,M3

Table 10 Mitigation activities list

No.	Mitigation	Risk agent correlated	Difficulty Scale
M1	Updating the weather conditions at the port and coordinating with related parties to forecast the weather changes	Heavy wind	2
M2	Conducting security surveillance within the port and updating the conditions in case of disturbance (public security, species invasion, etc.)	Heavy wind, tide conditions, and human error	2
M3	Conducting protective maintenance and corrective maintenance	Tide condition, ship type	1
M4	Calculating tides and regularly checking tidal information with personnel	Tide condition	2
M5	Warn workers who are undisciplined when not wearing PPE (personal protective equipment)	Human error	1
M6	Identifying seasonal factors when service users increase, including annual holiday dates	Holiday season	3

5. Conclusion

The Ferry Port acts as a supply chain and logistics agent connecting Tarakan Island with the surrounding islands. The port has six business processes (planning, service, operations, relationships, finance, and environmental conditions), which are then evaluated for risk in each of these business processes using the HOR model to measure the level of risk priority, which is then designed to mitigate as an effort to improve port supply chain management. A total of 19 risk events and 33 risk causes were successfully identified in seven business processes. Based on the assessment of the level of severity and risk occurrence, six priority risks were successfully identified. Mitigation actions were taken to address priority risks that can reduce the frequency and severity based on delays, financial and human security.

Weather and human factors pose challenges in ferry operations, making early risk detection and human capacity building crucial for addressing the ever-changing work environment. This study identified 33 potential failure scenarios, six of which had a cumulative ARP of 75%. One of the most significant factors is strong winds, which can be anticipated by updating the weather around the port and monitoring port equipment during docking, both day and night. Port operators and captains calculate tidal levels before docking to determine safe speeds and ropes. Another recommended mitigation measure is the use of personal protective equipment (PPE), which is expected to reduce human error.

In addition to weather and human factors, this study also considers the holiday season. Holiday season factors are related to passenger queues, which refer to increased preparation time for passengers to enter and exit, and the level of traffic density within the port, which has the potential to increase delays. The implementation of the ferry port service business process in the HOR attempts to demonstrate the port's challenges, both in terms of weather, humans, and external aspects (holiday season and administration), and how to address these business process risks. Further research can be conducted by developing a new business process framework for port stakeholders in the supply chain network based on the risk mitigation that has been formulated.

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