Risk Analysis of Goods Accumulation at The Port During The Shipping Process of Wirerod Cargo Using The House Of Risk (HOR) Method

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ABSTRACT
PT. Berlian Jaya Maritim (BJM) is a stevedoring company operating in the Jamrud Terminal area at Tanjung Perak Port, Surabaya. In 2018, PT. BJM experienced an accumulation of wirerod cargo reaching 65,698 tons, resulting in storage costs amounting to IDR 147,820,500. This study aims to analyze the risks causing cargo accumulation and determine the most effective mitigation strategies using the House of Risk (HOR) method. The research identified 17 risk events and 30 risk agents related to cargo accumulation activities. The identified risks were processed using HOR Phase 1 to determine dominant risk causes through Aggregate Risk Potential (ARP) calculations and Pareto analysis. The results showed 14 dominant risk causes contributing significantly to cargo accumulation. Furthermore, HOR Phase 2 produced 16 mitigation actions to address these dominant risks. Effectiveness-to-difficulty ratio calculations indicated that the most effective mitigation strategy was establishing communication with cargo owners to prioritize the unloading and delivery process of goods originating from the port. The implementation of appropriate mitigation strategies is expected to reduce cargo accumulation and improve operational efficiency at the port.

Keywords: *Stevedoring Company, Cargo Accumulation, House of Risk, Risk Mitigation, Port Logistics*

1. INTRODUCTION

Ports play a strategic role in supporting national and international trade activities because they function as gateways for the distribution of goods and logistics services. According to Van der Baan (2015), ports serve as logistics centers that facilitate the movement of goods between regions and countries while supporting economic growth and industrial development. In Indonesia, ports are not only used as transportation hubs but also play an important role in supporting national logistics connectivity and supply chain activities. One of the major ports contributing significantly to logistics distribution in Eastern Indonesia is Tanjung Perak Port in Surabaya. Along with the increasing demand for logistics services and cargo transportation, port operational activities have become more complex and require efficient management systems. However, the rapid growth of logistics activities is often accompanied by operational problems that can disrupt the smooth flow of cargo handling processes. According to Heizer and Render, operational disruptions in logistics activities may reduce efficiency, increase operational costs, and negatively affect supply chain performance. One of the most common operational issues occurring at ports is cargo accumulation in storage areas. Cargo accumulation can reduce operational efficiency, increase storage costs, create congestion in warehouse areas, and delay cargo distribution to consignees.

This problem also occurred at PT. Berlian Jaya Maritim (BJM), a stevedoring company operating at Jamrud Terminal, Tanjung Perak Port. PT. BJM is responsible for handling cargo loading and unloading activities as well as supporting the distribution process of goods arriving at the port. During operational activities, especially in the shipment process of wirerod cargo from the dock to the consignee's factory, several operational disruptions were frequently encountered. These disruptions prevented goods from being immediately delivered after unloading activities were completed, resulting in cargo accumulation within the port area. Based on company operational data in 2018, wirerod cargo experienced the highest accumulation level compared to other cargo types, reaching 65,698 tons. This condition caused additional operational burdens for the company because accumulated cargo occupied storage areas for an extended period and generated stacking costs amounting to IDR 147,820,500. In addition, cargo accumulation also affected operational productivity and slowed down loading and unloading activities at the port.

The occurrence of cargo accumulation indicates that there are operational risks within the cargo handling process that need to be identified and controlled properly. Risk management is therefore required to analyze the factors causing cargo accumulation and to determine appropriate mitigation strategies. According to Pujawan and Geraldin (2009), risk

management in logistics activities is important because it helps organizations identify dominant operational risks and prioritize preventive actions systematically. One method that can be used to manage operational risks systematically is the House of Risk (HOR) method. The HOR method integrates the concepts of Failure Mode and Effect Analysis (FMEA) and House of Quality (HOQ) to identify dominant risk agents and prioritize mitigation actions effectively (Pujawan & Geraldin, 2009). This method is considered suitable for this study because it not only identifies operational risks but also determines the most critical risk agents and recommends mitigation strategies based on effectiveness and implementation difficulty. By applying the HOR method, companies can focus on controlling the most significant risk causes that contribute to cargo accumulation. Therefore, this study aims to analyze the risks causing cargo accumulation during the shipment process of wirerod cargo at PT. Berlian Jaya Maritim using the House of Risk method. Specifically, this research aims to identify risk events and risk agents, determine dominant operational risks, develop mitigation strategies, and recommend the most effective actions to minimize cargo accumulation and improve operational efficiency at the port.

2. RESEARCH METHODOLOGY

2.1 Research Design

This study applied a descriptive quantitative approach to analyze operational risks causing cargo accumulation during the shipment process of wirerod cargo at PT. Berlian Jaya Maritim. According to Sugiyono (2017), quantitative research is used to evaluate measurable variables through systematic data collection and analysis. The study identified operational activities involved in cargo handling and analyzed the associated risks using the House of Risk (HOR) method. The research stages included problem identification, data collection, risk identification, risk assessment, HOR Phase 1 analysis, HOR Phase 2 analysis, and mitigation strategy prioritization.

2.2 Data Collection

The data used in this study consisted of primary and secondary data obtained from PT. Berlian Jaya Maritim operational activities. Primary data were collected through observations, interviews, and questionnaires distributed to operational personnel involved in cargo handling activities. According to Nazir (2014), observation and interviews are important methods for obtaining detailed operational information directly from the research object. Observations were conducted to understand the operational flow of wirerod cargo handling processes, while interviews were used to obtain information regarding operational disruptions, transportation readiness, warehouse conditions, and stakeholder coordination. In addition, questionnaires were distributed to evaluate the severity and occurrence levels of identified risks. Secondary data such as operational reports, cargo accumulation records, and supporting literature were also used to support the analysis.

2.3 Research Variables

The variables analyzed in this study consisted of risk events and risk agents related to cargo accumulation activities. Risk events refer to operational disruptions occurring during cargo handling processes, while risk agents refer to the factors causing those disruptions. According to Pujawan and Geraldin (2009), identifying risk events and risk agents is an important stage in the House of Risk method because it helps determine the root causes of operational problems. Based on the identification process, the study identified 17 risk events and 30 risk agents associated with cargo accumulation activities. The identified risk events included delays in cargo delivery, warehouse congestion, and transportation limitations, while the risk agents included human error, poor coordination, inaccurate scheduling systems, and delays in document processing.

2.4 Data Analysis Method

The data analysis process in this study was conducted using the House of Risk (HOR) method because it allows researchers to identify dominant risk agents systematically and determine mitigation priorities. According to Pujawan and Geraldin (2009), the HOR method integrates Failure Mode and Effect Analysis (FMEA) and House of Quality (HOQ) concepts to evaluate operational risks and prioritize mitigation strategies. The analysis began by identifying all risk events and risk agents related to cargo accumulation activities. Severity and occurrence values were then determined to evaluate the impact and frequency of operational risks. Correlation values between risk events and risk agents were used in the Aggregate Risk Potential (ARP) calculation during HOR Phase 1 analysis. Furthermore, HOR Phase 2 was conducted to evaluate mitigation actions based on effectiveness and implementation difficulty in order to determine priority mitigation strategies.

3. RESULTS AND DISCUSSION

3.1 Risk Identification

The risk identification process was conducted by observing operational activities related to the shipment and handling of wirerod cargo at PT. Berlian Jaya Maritim. Based on observations, interviews, and questionnaire results obtained from operational personnel, the study successfully identified 17 risk events that potentially caused cargo accumulation at the port area. According to Pujawan and Geraldin (2009), risk identification is an important stage in risk management because it determines the operational disruptions that may significantly affect organizational performance. Several operational problems were frequently encountered during the cargo handling process, such as delays in cargo delivery, limited transportation availability, weather disturbances, administrative processing delays, and miscommunication between stakeholders involved in port operations.

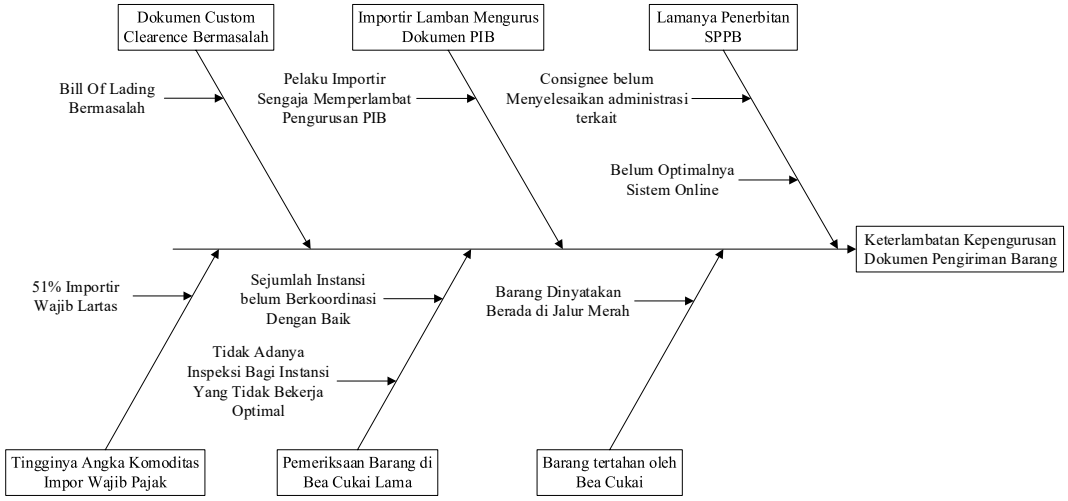

Figure 1. Fishbone of Delays in Handling Goods Delivery Documents

In addition, warehouse overcapacity also became one of the critical operational issues because accumulated cargo occupied storage areas for an extended period and reduced the efficiency of loading and unloading activities. Besides identifying risk events, the study also identified 30 risk agents considered the main causes of operational disruptions. These risk agents originated from internal and external operational factors, including poor coordination between parties, inaccurate scheduling systems, human error, insufficient transportation support, and delays in document completion. The identification of these risk agents became an important step because they formed the basis for further analysis in the HOR Phase 1 process.

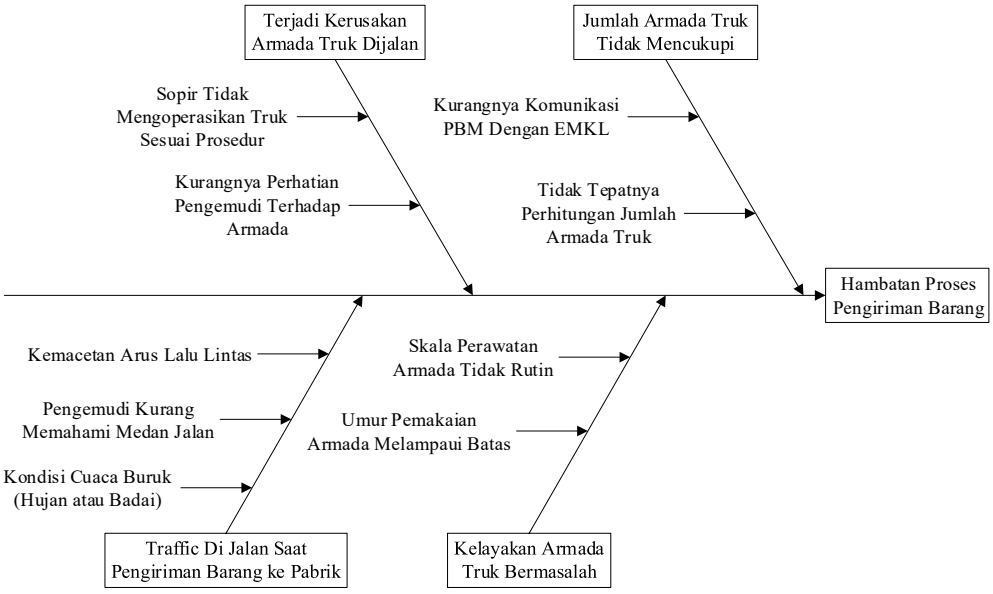

Figure 2. Fishbone Diagram of Obstacles in the Goods Delivery Process

The identification results indicate that cargo accumulation at the port was not caused by a single factor, but rather by interconnected operational problems involving communication, transportation readiness, administrative systems, and warehouse management. Therefore, a structured risk management approach was required to determine which risk agents had the most significant impact on cargo accumulation. The risk identification process was conducted by observing operational activities related to the shipment and handling of wirerod cargo at PT. Berlian Jaya Maritim. Based on observations, interviews, and questionnaire results obtained from operational personnel, the study successfully identified 17 risk events that potentially caused cargo accumulation at the port area. These risk events occurred throughout the logistics process, starting from unloading activities at the dock until the cargo delivery process to the consignee. Several operational problems were frequently encountered during the cargo handling process, such as delays in cargo delivery, limited transportation availability, weather disturbances, administrative processing delays, and miscommunication between stakeholders involved in port operations. In addition, warehouse overcapacity also became one of the critical operational issues because accumulated cargo occupied storage areas for an extended period and reduced the efficiency of loading and unloading activities.

Besides identifying risk events, the study also identified 30 risk agents considered the main causes of operational disruptions. These risk agents originated from internal and external operational factors, including poor coordination between parties, inaccurate scheduling systems, human error, insufficient transportation support, and delays in document completion. The identification of these risk agents became an important step because they formed the basis for further analysis in the HOR Phase 1 process. The identification results indicate that cargo accumulation at the port was not caused by a single factor, but rather by interconnected operational problems involving communication, transportation readiness, administrative systems, and warehouse management. Therefore, a structured risk management approach was required to determine which risk agents had the most significant impact on cargo accumulation.

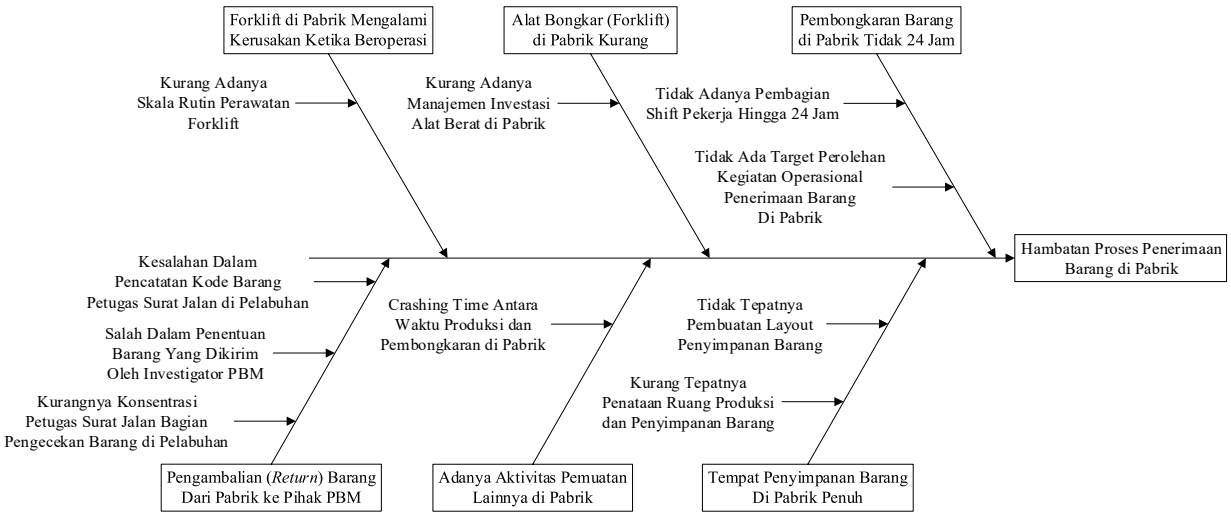

Figure 3. Fishbone Diagram of Obstacles in the Goods Receiving Process at the Factory

3.2 HOR Phase 1 Analysis

The HOR Phase 1 analysis was conducted to determine the dominant risk agents contributing most significantly to cargo accumulation problems at PT. Berlian Jaya Maritim. In this phase, the relationship between identified risk events and risk agents was analyzed using severity, occurrence, and correlation values obtained from questionnaires and interviews with operational personnel. According to Pujawan and Geraldin (2009), HOR Phase 1 aims to identify dominant risk agents through Aggregate Risk Potential (ARP) calculations. The severity assessment was used to measure how significant the impact of each risk event was on operational performance, while the occurrence assessment measured the frequency or likelihood of each risk agent occurring during operational activities. After the scoring process was completed, Aggregate Risk Potential (ARP) values were calculated to determine the priority level of each risk agent.

The analysis results showed that several risk agents had considerably higher ARP values compared to others. These dominant risk agents were identified as the main contributors to cargo accumulation problems and therefore required immediate mitigation attention. The Pareto analysis further demonstrated that 14 dominant risk agents contributed to the majority of operational disruptions occurring during cargo handling activities. Among the dominant risk agents identified were poor coordination with cargo owners, limited transportation fleet availability, delayed document

processing, inaccurate shipment scheduling, warehouse congestion, and human error during operational activities. These factors significantly affected the smooth flow of cargo distribution from the port to the consignee.

The findings from HOR Phase 1 indicate that operational inefficiencies in cargo handling activities were strongly influenced by communication and coordination issues among stakeholders, as well as limitations in transportation and administrative systems. Therefore, identifying dominant risk agents became a crucial step before determining the most appropriate mitigation strategies in the next analysis phase. The HOR Phase 1 analysis was conducted to determine the dominant risk agents contributing most significantly to cargo accumulation problems at PT. Berlian Jaya Maritim. In this phase, the relationship between identified risk events and risk agents was analyzed using severity, occurrence, and correlation values obtained from questionnaires and interviews with operational personnel. The severity assessment was used to measure how significant the impact of each risk event was on operational performance, while the occurrence assessment measured the frequency or likelihood of each risk agent occurring during operational activities. After the scoring process was completed, Aggregate Risk Potential (ARP) values were calculated to determine the priority level of each risk agent.

Table 1. HOR Phase 1 Framework for Cargo Accumulation

Risk Event (Ei)	*Risk Agent (Aj)*																													*Severity Risk Event*
	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	
E1	9	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	7,00
E2	0	0	9	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3,83
E3	1	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,67
E4	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3,33
E5	0	3	0	0	0	9	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4,33
E6	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,17
E7	0	0	0	0	0	0	0	0	3	9	0	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	6,17
E8	0	0	0	0	0	0	0	0	0	0	1	3	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,17
E9	0	0	0	0	0	0	0	0	0	0	1	0	9	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,83
E10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	6,83
E11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	3	0	0	0	0	0	0	0	0	0	0	0	7,50
E12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	6,33
E13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	3	0	0	0	0	0	0	0	0	5,00
E14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	3	0	0	0	0	0	0	5,83
E15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	5,83
E16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	9	9	0	0	2,50
E17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1,83
Occurrence Risk Agent j	4,50	5,33	2,00	2,50	6,00	4,17	3,33	2,50	4,67	7,33	4,83	3,50	3,83	6,00	7,33	4,00	5,83	7,67	6,83	5,50	4,17	5,67	3,67	5,00	6,33	3,17	2,83	2,50	2,33	1,67	
Aggregate risk potentials j	309,02	181,17	68,94	127,58	179,82	207,67	43,26	116,33	86,44	407,03	48,30	54,29	344,70	366,12	495,80	46,64	227,37	517,73	153,68	313,34	187,65	85,05	192,56	87,45	332,14	23,78	63,68	56,25	29,50	26,97	
Priority rank of agent j	8	13	21	16	14	10	27	17	19	3	25	24	5	4	2	26	9	1	15	7	12	20	11	18	6	30	22	23	28	29	

Sumber : Pengolahan Data, 2019

The analysis results showed that several risk agents had considerably higher ARP values compared to others. These dominant risk agents were identified as the main contributors to cargo accumulation problems and therefore required immediate mitigation attention. The Pareto analysis further demonstrated that 14 dominant risk agents contributed to the majority of operational disruptions occurring during cargo handling activities. Among the dominant risk agents identified were poor coordination with cargo owners, limited transportation fleet availability, delayed document processing, inaccurate shipment scheduling, warehouse congestion, and human error during operational activities. These factors significantly affected the smooth flow of cargo distribution from the port to the consignee. The findings from HOR Phase 1 indicate that operational inefficiencies in cargo handling activities were strongly influenced by communication and coordination issues among stakeholders, as well as limitations in transportation and administrative systems. Therefore, identifying dominant risk agents became a crucial step before determining the most appropriate mitigation strategies in the next analysis phase.

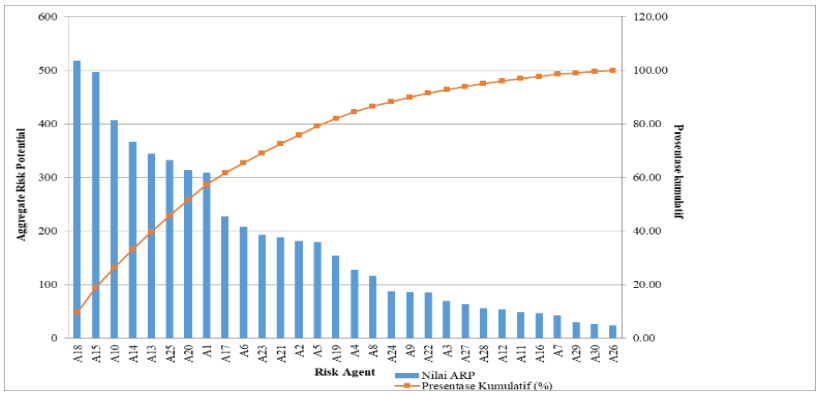

Figure 4. Pareto Diagram of Cargo Accumulation Risks

3.3 HOR Phase 2 Analysis

After identifying the dominant risk agents through HOR Phase 1 analysis, the study continued with HOR Phase 2 to determine the most effective mitigation strategies for minimizing cargo accumulation risks. According to Pujawan and Geraldin (2009), HOR Phase 2 is used to determine mitigation priorities by evaluating the effectiveness and implementation difficulty of mitigation actions. A total of 16 mitigation actions were proposed to address the dominant risk agents. These mitigation strategies focused on improving operational coordination, increasing transportation readiness, optimizing scheduling systems, enhancing employee competency, and improving monitoring processes during cargo handling activities. Several mitigation actions proposed in this study included improving communication with cargo owners, enhancing shipment scheduling systems, increasing transportation fleet readiness, improving coordination between operational divisions, conducting regular employee training, implementing operational monitoring systems, and optimizing warehouse management systems. Each mitigation action was then evaluated using effectiveness and difficulty calculations. The effectiveness assessment measured how far a mitigation strategy could reduce operational risks, while the difficulty assessment evaluated the level of complexity, cost, and implementation challenges associated with each mitigation action.

The HOR Phase 2 analysis results indicate that not all mitigation actions have the same implementation priority. Some mitigation strategies provide significant operational improvements with relatively lower implementation difficulty, making them more suitable for immediate execution. Therefore, the effectiveness-to-difficulty ratio became an important indicator in determining which mitigation strategies should be prioritized by the company. After identifying the dominant risk agents through HOR Phase 1 analysis, the study continued with HOR Phase 2 to determine the most effective mitigation strategies for minimizing cargo accumulation risks. In this phase, mitigation actions were designed based on the dominant operational problems identified in the previous analysis. A total of 16 mitigation actions were proposed to address the dominant risk agents. These mitigation strategies focused on improving operational coordination, increasing transportation readiness, optimizing scheduling systems, enhancing employee competency, and improving monitoring processes during cargo handling activities.

Several mitigation actions proposed in this study included improving communication with cargo owners, enhancing shipment scheduling systems, increasing transportation fleet readiness, improving coordination between operational divisions, conducting regular employee training, implementing operational monitoring systems, and optimizing warehouse management systems. Each mitigation action was then evaluated using effectiveness and difficulty calculations. The effectiveness assessment measured how far a mitigation strategy could reduce operational risks, while the difficulty assessment evaluated the level of complexity, cost, and implementation challenges associated with each mitigation action. The HOR Phase 2 analysis results indicate that not all mitigation actions have the same implementation priority. Some mitigation strategies provide significant operational improvements with relatively lower implementation difficulty, making them more suitable for immediate execution. Therefore, the effectiveness-to-difficulty ratio became an important indicator in determining which mitigation strategies should be prioritized by the company.

Table 2. HOR Phase 2 Framework for Cargo Accumulation

Risk Agent	*Preventive Action*																*ARP Risk Agent*
	PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	PA9	PA10	PA11	PA12	PA13	PA14	PA15	PA16	
A18	9	9	0	0	0	0	0	9	0	0	0	0	0	0	0	0	517,73
A15	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	495,80
A10	0	0	0	9	3	0	0	0	0	0	0	0	0	0	0	0	407,03
A14	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	366,12
A13	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	344,70
A25	0	1	0	0	0	0	0	9	0	0	0	0	0	0	0	0	332,14
A20	0	0	0	0	0	0	0	0	9	0	0	0	0	9	0	0	313,34
A1	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	309,02
A17	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	227,37
A6	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	207,67
A23	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	192,56
A21	0	0	0	0	0	0	0	0	3	0	0	0	0	9	0	0	187,65
A2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	181,17
A5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	179,82
Total Effectiveness of proactive action k (TEk)	4659,57	4991,71	4462,2	3663,27	1221,09	3295,08	3102,3	7648,83	3383,01	2781,18	2046,33	1869,03	1733,04	4508,91	1630,53	1618,38	
Difficulty of peroforming action k (Dk)	3	3	5	3	5	5	4	3	4	4	3	3	3	4	4	3	
Effectiveness to difficulty ratio of action (ETDk)	1553,19	1663,90	892,44	1221,09	244,21	659,02	775,57	2549,61	845,75	695,29	682,11	623,01	577,68	1127,23	407,63	539,46	
Rank of proactive action k (Rk)	3	2	6	4	16	11	8	1	7	9	10	12	13	5	15	14	

3.4 Priority Mitigation Actions

Based on the effectiveness-to-difficulty ratio calculations conducted in HOR Phase 2, several mitigation strategies were identified as priority actions for reducing cargo accumulation risks at PT. Berlian Jaya Maritim. These mitigation strategies were prioritized because they provided the highest operational impact while requiring relatively manageable implementation efforts. Among all proposed mitigation actions, establishing communication with cargo owners to prioritize the unloading and delivery process of goods from the port was identified as the most effective strategy. This mitigation action achieved the highest priority score because it directly addressed one of the major causes of cargo accumulation, namely delays in cargo distribution after unloading activities were completed.

Improved communication between the company and cargo owners is expected to accelerate decision-making processes regarding cargo pickup schedules and transportation readiness. Better coordination can also minimize delays caused by administrative problems, scheduling conflicts, and warehouse congestion. As a result, the duration of cargo storage at the port can be significantly reduced. In addition to communication improvement, other mitigation strategies such as enhancing transportation readiness, improving scheduling systems, and conducting regular operational monitoring also showed positive contributions toward operational efficiency. These strategies support the company in reducing operational disruptions and improving the overall cargo handling process. Overall, the mitigation prioritization results indicate that operational coordination and communication play a very important role in minimizing cargo accumulation at the port. Therefore, the implementation of integrated mitigation strategies is expected to improve operational efficiency, reduce logistics costs, and support smoother cargo distribution activities in the future.

4. CONCLUSION

Based on the research conducted at PT. Berlian Jaya Maritim, several conclusions can be drawn:

- The study identified 17 risk events and 30 risk agents related to cargo accumulation activities.
- HOR Phase 1 analysis determined 14 dominant risk agents contributing significantly to cargo accumulation.
- HOR Phase 2 analysis generated 16 mitigation strategies to reduce operational risks.
- The most effective mitigation action is improving communication with cargo owners to prioritize cargo unloading and distribution.
- The implementation of risk mitigation strategies can reduce cargo accumulation and improve operational efficiency.

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