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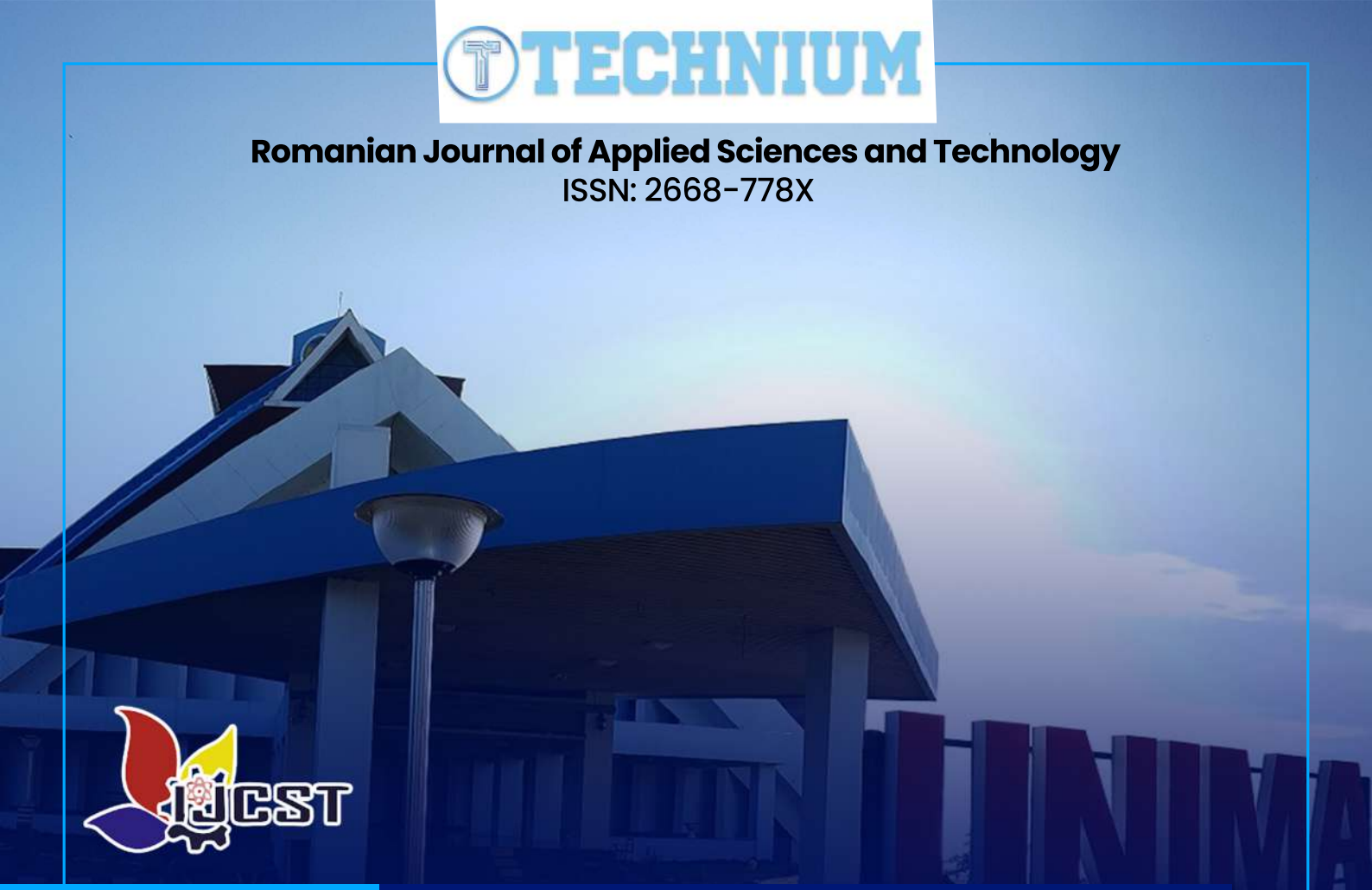

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Designing Supply Chain Resilience with a Quality Function Deployment Approach: A Case Study in a Shipping Line Company

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Abstract. Supply chain resilience is needed for companies to be able to reduce the impact of risks that can occur to the company. The purpose of this study is to analyze supply chain resilience in a shipping line company, which is one of the players in the maritime logistics industry. This research adopts a Quality Function Deployment (QFD) approach that considers customer needs and maritime risks. The results of this study identified 15 customer needs and obtained 3 priority customer needs, namely no errors on invoices and B/L, professional shipping services and easy and realtime tracking of goods shipments. 18 risks have been identified and 3 risk priorities have been obtained, namely damage to communication devices, handling errors and delays in handling documents or goods by EMKL. 26 causes of risk have been identified and 3 priority causes of risk have been identified, namely lack of skill and accuracy of employees, server disruption and lack of work motivation in employees. Based on the analysis that has been carried out in the previous sections, there are 18 resilience measures as risk mitigation that can be carried out by companies. The following are the top-ranked resilience measures, including providing training on sending and receiving goods, establishing good communication with customers and providing training on how to communicate well.

1 Introduction

A stable supply chain is closely related to transportation, now companies prefer integrated transportation so that it can be checked easily [1]. Water transportation is part of maritime logistics. The more complex the supply chain, the more difficult it is to manage it according to customer needs. Every business activity has unexpected risks that can disrupt and even cause losses. Designing supply chain resilience can help reduce and overcome vulnerabilities [2]. Through the development of strategies that enable the supply chain to return to its original state or a more desirable functional state after a disturbance. Supply chain resilience empowers a company's proactive response to changes in market demand and disruption ahead of their competitors [3].

The company used as the research object this time is PT. Tanto Intim Line, is a company engaged in the shipping line. Activities carried out are the same as water transportation but augmented by packing and unloading of containers, storage, warehousing, offering distribution centers, quality control, testing, assembly, packaging, repackaging and inland connection. Loading and unloading services are carried out at its subsidiary, namely PT. Tanto Karya Utama which also provides trucking services which are shipping services from or to the port. As another supporting service, the company also provides warehousing services to serve its customers who need temporary storage.

As previously stated, the shipping line is one of the main key holders of the maritime logistics system [3]. If the shipping line experiences problems in its work process, other elements integrated into the system will also be disrupted. For example, in the previous case, there was an unplanned incident, such as a ship colliding with another ship which caused several falling container boxes to be lost and scattered. This situation can slow down the work process of the shipping line. So that consumers who use their services also experience delays in service [4]. This condition is a risk that can disrupt the state of the supply chain, after receiving a disturbance, its performance is threatened, in terms of profitability, including cost and inventory structure [5][6]. This situation also affects the level of overall satisfaction from downstream to end-customers [7].

The existence of several risks including maritime risk is one of the causes of disruption of the company's efforts to increase customer satisfaction [8]. So it is possible that the supply chain will also be damaged, or customers will change shipping line services to other companies. There have been many studies on customer satisfaction in the previous study by [9] on the analysis of the effect of shipping service quality on customer satisfaction at shipping line companies using multiple

linear regression and simple linear regression. Meanwhile, research by [10] on supply chain resilience in freight forwarders uses the QFD approach. Another research on tourism supply chain resilience, where this research creates a resilience framework for the religious tourism supply chain to mitigate post-pandemic risks, in this study uses qualitative methods in the form of risk analysis and developing appropriate resilience measures according to risks [11]. So this research adopts the Quality Function Deployment approach because it can prioritize corporate resilience measures by considering consumer needs and maritime risks [12]. To build supply chain resilience what is needed is an understanding of the needs of customers and risks [13]. Quality Function Deployment (QFD) is a method that is said to be able to find out customer needs by connecting them with potential risks [14]. The tool used in this study is the House of Quality (HOQ).

This research is able to provide an overview to the company regarding the supply chain resilience that will be carried out, in which the design can identify potential maritime risks that can disrupt the company's work processes. This input is obtained from the ranking results based on resilience measures. The results of resilience measures in the form of mitigation measures are proposed to improve the supply chain. With these recommendations the company can increase customer satisfaction so that competitiveness also increases.

2 Literature Review

2.1 Supply Chain Management

According to [15] Supply chain is a series of relationships between companies or activities that carry out the distribution of goods or services from the place of origin to the buyer or customer. In the supply chain involves a continuous relationship regarding goods, money and information [16]. Viewed horizontally, there are five main components or actors in the supply chain, namely: suppliers, manufacturers, distributors, retailers and customers. Vertically there are several main components of the supply chain, namely: buyers (buyers), transporters (transporters), warehouses (storage), and sellers (sellers).

Supply chain management is the integration of the activities of purchasing materials and services, transforming them into final product items and sending them to customers [17]. These supply chain management activities include purchasing and outsourcing, and many other functions that are essential to linking them to suppliers and distributors [18]. In detail, it can be stated that supply chain management is the management of the activities of purchasing materials and services, transforming them into final products, and shipping products into a distribution system.

On the other hand, according to [19] explains that in a supply chain there are usually 3 (three) types of flow that must be managed, namely:

1. The first is the flow of goods flowing from upstream to downstream.
2. The second is the flow of money and the like that flows from downstream to upstream.
3. The third is the flow of information that can occur from upstream to downstream or reversed.

2.2 Supply Chain Resilience and Resilience Measures

According to [20], supply chain resilience is the ability of the supply chain to resist disruptions and restore operational capabilities after disruptions occur. As noted above, seen from this perspective, resilience consists of two important but complementary system components: the capacity for resistance and the capacity for recovery [21]. Here are the elements:

1. Resistance capacity is the ability of a system to minimize the impact of a disturbance by avoiding it completely (avoidance) or by minimizing the time between the disturbance occurring and the start of recovery from the disturbance (containment).
2. Recovery capacity is the ability of the system to return to its function after a disturbance occurs. The system recovery process is characterized by a (hopefully berief) stabilization phase after which a return to a stable state of performance can be pursued. The final achieved steady-state performance may or may not require a return to the original performance level, and is dependent on many interference and competitor factors.

Resilience is the ability to overcome unexpected disruptions in the supply chain [22]. According to [10] resilience needs to be designed so that by building collaboration, flexibility and visibility can create bonds between suppliers and customers. Collaboration that can be done is by sharing information in the supply chain [23]. The development of resilience measures will depend on the nature of the supply chain [24]. According to [10], in general there are several main steps to increase resilience in the supply chain. These steps are grouped into nine as follows:

1. Assist the development of a risk management culture
2. Risk mitigation in production and internal system logistics
3. Strengthen supply chain collaboration
4. Sharing information about risks to supply chain partners
5. Increase supply chain agility
6. Increase redundancy/supply at critical junctures
7. Monitor and analyze errors
8. Implement a stress-test system regularly
9. Insure against supply chain risks

Many companies currently do not have the awareness to consider their supply chain resilience as part of their approach to risk and business continuity management [25].

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2.3 Quality Function Deployment (QFD) and House Of Quality (HOQ)

According to [26] Quality Function Deployment (QFD) is a systematic approach that determines consumer demands or requests and then translates these demands accurately into technical design, manufacturing, and production planning that are appropriate. QFD enables organizations to consider customer needs, find innovative responses to customer needs and improve processes to achieve maximum effectiveness [17]. QFD is also a practice towards process improvement that enables organizations to exceed consumer expectations [27]. QFD consists of several activities which include:

1. Description of consumer requirements
2. Description of measurable quality characteristics
3. Determination of the relationship between quality requirements and quality characteristics.
4. Determination of values based on certain numbers for each quality characteristic
5. Determination of quality characteristics into the product
6. Product design, production and quality control

QFD is used early in the design process to help determine what will satisfy the customer and provide quality in what is needed [28]. So it can be concluded that QFD's position in supply chain management is between suppliers and manufacturers, because it is in this stage that products are designed and developed according to customer needs.

The QFD model is a model for translating customer requirements into design requirements [29]. According to [30] the advantage of using this model is its ability to build resilience by connecting requests from customers. According to [3], there are several steps in building an HOQ. The following are the steps in the HOQ.

1. Customer requirements (CR)

The main step in making an HOQ is to identify customer needs or "voice of customer". The list of customer requirements is placed on the left side of the HOQ. This identification was carried out through literature studies and interviews with the company and customers.

2. Prioritizing CR

Conduct a Relative Importance assessment of the CR that has been identified using a rating scale. This section determines the importance rating and weighting of customer needs. Each customer need is rated for customer interest or Absolute Importance (AI) and Weight (W). Interest rating can use a nominal scale such as the Likert scale which starts from the numbers 1 to 5. For weight calculations use formula 1. This assessment is carried out by the company and also the customer.

$$W_i = \frac{I_i}{\sum_{i=1}^{n} I_i}, \quad i = 1, n \qquad \text{.....(1)}$$

Note:
W : Weight
I : Respondents (customers)

3. Design Requirements (DR)

This section contains the identification of any risks that can occur in maritime logistics. Identification can be done by conducting literature studies and interviews with the company.

4. Relationship Matrix

This section is located in the middle of the HOQ. This section contains an evaluation of the relationship between customer needs which is located on the left, with Design Requirements which is at the top.

5. Technical Matrix

This section is located at the bottom of the HOQ which aims to determine the relationship between CR and DR, so AI and Relative Importance (RI) calculations are performed. If previously AI was a calculation for CR only, in this section AIj is a total calculation of the relationship between each company's attributes and consumer needs. The AIj value is shown below the Relationship Matrix. AI for each maritime risk is calculated using formula 2.

$$AI_j = \sum_{i=1}^{n} W_i R_{ij}, \qquad j = 1, \ldots m. \qquad \text{.....(2)}$$

Note:
AI : Absolute Importance
W : Weight
RI : Relative Importance

Whereas RIj for each maritime risk comes from AI with formula 3. According to [3] shows that Design Requirements are usually ranked based on RI rather than AI. So that the research uses the RI value.

$$RI_j = \frac{AI_j}{\sum_{j=1}^{m} AI_j}, \qquad j = 1, \ldots m. \qquad \text{.....(3)}$$

Note:
RI : Relative Importance
AI : Absolute Importance

3 Methodology

The type of data used in this study is primary data, namely the results of interviews with the company and customers. In addition, it also uses secondary data in the form of the results of literature studies. The interview method was carried out through in-depth interviews. As for data collection, data that requires measurement or assessment is carried out using structured interviews.

QFD method used in this study refers to the method used in [3]. The informants in this study were from the company, namely the director and manager of export-import. In addition, there are sources from the customer as well. Research conducted at PT. Tanto Intim Line at the Prapat Kurung Selatan Nomor 17, Perak Utara, Pabean Cantian, Surabaya. The time for carrying out the research is in February 2019 until the data is sufficient.

In this research, 3 HOQs were made. HOQ 1 contains the relationship between customer needs and potential risks. The purpose of HOQ 1 is to identify maritime risk linkages that can affect the company's competitiveness according to customer needs. HOQ 2

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is a continuation of HOQ 1. HOQ 2 contains the relationship between risk and the causes of risk. Then HOQ 3 contains the relationship between the causes of risk and resilience measures which are expected to mitigate the risks that have been identified.

4 Discussio

4.1 Data Collection

Based on research conducted by [10] there are 16 attributes about customer needs. Brainstorming conducted with the company contained 1 attribute that was not in accordance with the company's conditions, namely being able to overcome overweight shipments. So that the number of attributes obtained is 15 as follows:

Table 1. Customer Needs

Attribute	Customer Requirements
KP 1	Easy and timely delivery
KP 2	Easy and realtime tracking of goods shipments
KP 3	Professional delivery service
KP 4	Fast service
KP 5	Safe delivery
KP 6	There is no mistake on the invoice and B/L
KP 7	No delay on invoice and B/L
KP 8	Secure warehousing services
KP 9	Sharing information
KP 10	Can handle document discrepancies
KP 11	There is no delay on document delivery
KP 12	Easy to contact
KP 13	Prices are in accordance with the services provided
KP 14	Cleanliness and completeness of equipment
KP 15	Availability of equipment used

From the attribute data above, presampling was carried out with 30 customers who were sampled in this study. Where 100% of customers agree with the attributes of customer needs above. Based on these considerations, the next stage can be carried out.

The final results of the customer needs questionnaire validity test show that all variables have an r value above the critical r. Thus all the variables in the customer perception questionnaire are declared valid.

Table 2. Test the Validity of Customer Needs

No	Variable	r_{count}	r_{Table}	Conclusion
1	KP 1	0.532	0,296	Valid
2	KP 2	0,367	0,296	Valid
3	KP 3	0,342	0,296	Valid
4	KP 4	0,395	0,296	Valid
5	KP 5	0,499	0,296	Valid
6	KP 6	0,356	0,296	Valid
7	KP 7	0,595	0,296	Valid
8	KP 8	0,421	0,296	Valid
9	KP 9	0,465	0,296	Valid
10	KP 10	0,513	0,296	Valid
11	KP 11	0,571	0,296	Valid
12	KP 12	0,647	0,296	Valid
13	KP 13	0,432	0,296	Valid
14	KP 14	0,386	0,296	Valid
15	KP 15	0,408	0,296	Valid

Source: Processed data

Cronbach's Alpha results for the respondent's perception questionnaire show a number of 0.729 where > 0.70, it can be concluded that the respondent's perception questionnaire is reliable as a data collection tool.

Table 3. Respondent Perception Reliability Test

Reliability Statistics

Cronbach's Alpha	N of Items
.729	15

4.2 Data Processing

The first thing to do is to identify and assess customer needs. After the previous questionnaire results were valid and reliable in the validity and reliability test. So the next step is to calculate the average value of the importance level of all respondents. The following is the result of identification and assessment of customer needs shown in Table 4.

Table 4. Average Value of Customer Needs

Attribute	Customer Requirements	Average
KP 1	Easy and timely delivery	3,67
KP 2	Easy and realtime tracking of goods shipments	4,20
KP 3	Professional delivery service	4,30
KP 4	Fast service	3,87
KP 5	Safe delivery	3,70
KP 6	There is no mistake on the invoice and B/L	4,83
KP 7	No delay on invoice and B/L	3,93
KP 8	Secure warehousing services	3,70
KP 9	Sharing information	3,57
KP 10	Can handle document discrepancies	3,83
KP 11	There is no delay on document delivery	3,73
KP 12	Easy to contact	3,60
KP 13	Prices are in accordance with the services provided	3,63
KP 14	Cleanliness and completeness of equipment	3,37
KP 15	Availability of equipment used	3,43

From the table above it can be seen that customer needs with the lowest value is 3.43, namely cleanliness and completeness of equipment. Meanwhile, customer needs with the highest average value are 4.83, namely there are no errors on invoices or B/L.

4.3 Calculation of HOQ 1

The following is the result of the HOQ 1 calculation shown in Table 5.

Table 5. Ranking Results Based on HOQ 1 Calculations

Attribute	Risk Potential	RI_j	Rank
PR 1	Natural disasters	4.62	8
PR 2	Traffic jams, breakdowns and road closure regulations	3.87	10
PR 3	Delays in handling documents or goods by EMKL	13.03	3
PR 4	Lack of complete documents	5.84	4

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Attribute	Risk Potential	RI_j	Rank
PR 5	Document incompatibility	5.18	5
PR 6	Harbor congestion	1.70	17
PR 7	Delayed ship docking	2.10	14
PR 8	IT system down	4.86	7
PR 9	Labor strike at the port	1.38	18
PR 10	Damage to ship cranes	3.28	11
PR 11	Damage to ground cranes	3.28	12
PR 12	Trucking is not available	4.97	6
PR 13	Trucking damage and accidents	4.14	9
PR 14	Reach stackers damage	1.99	15
PR 15	Warehouse theft	2.84	13
PR 16	Ship schedule discrepancies with customers	1.71	16
PR 17	Error in handling	15.65	2
PR 18	Damage to the communication device	19.55	1

Source: Processed data

Based on the table above, the potential risks with the top 5 rankings include:

1. Damage to the communication device
2. Error in handling
3. Delays in handling documents or goods by EMKL
4. Lack of complete documents
5. Document discrepancies

4.4 Calculation of HOQ 2

After making HOQ 1, then proceed with making HOQ 2. In forming HOQ 2, AIj and RIj data are used for potential risks from HOQ 1. The following are the results of HOQ 2 calculations shown in Table 6.

Table 6. Ranking Results Based on HOQ 2 Calculations

Attribute	Causes of Risk	RI_k	Rank
PY 1	Bad weather	7.56	4
PY 2	Dense queues for bulk carriers	0.48	24
PY 3	Changes in regulations that add to the burden on port workers	0.49	23
PY 4	Bad economic factor	1.19	17
PY 5	Increasing market demand for trucking	1.50	16
PY 6	There are road damage, accidents, broken bridges and density in certain areas	4.42	6
PY 7	There are rules regarding the prohibition of operating for the transportation of goods	2.55	13
PY 8	There was an error on the server	12.85	2
PY 9	Hacker attack	7.22	5
PY 10	Lack of maintenance on communication equipment	3.93	7
PY 11	There is no performance appraisal system	0.58	22
PY 12	Lack of monitoring	1.54	15
PY 13	Lack of maintenance on cranes	0.71	20
PY 14	Lack of skills of ship crane employees	1.69	14
PY 15	Lack of ship crane parts vendor skills	0.26	25
PY 16	Less than optimal security system	1.01	18
PY 17	Lack of maintenance on trucking	0.25	26
PY 18	Lack of skills and accuracy of employees	19.60	1
PY 19	Lack of work motivation in employees	11.55	3
PY 20	Lack of employee skills in the vendor trucking section	0.72	19
PY 21	Lack of employee skills in the warehouse	0.67	21
PY 22	The process of handling documents and goods by EMKL is not fast enough	3.77	12
PY 23	There was an error in filling in data and checking data by EMKL	3.93	8
PY 24	There is an error in filling in the data and checking by the supplier	3.79	11
PY 25	Damage to the trucking machine	3.85	10
PY 26	Absence of office leadership	3.90	9

Source: Processed data

Based on the table above, the potential risks with the top 5 rankings include:

1. Lack of skills and accuracy of employees
2. There was an error on the server
3. Lack of work motivation on employees
4. Bad Weather
5. Hacker attacks

The cause of the risk that gets the highest rating is the lack of employee skills. This is because the causes of this risk have a relationship or have a significant impact on the occurrence of previously identified risks. This lack of employee skills can be in the form of lack of thoroughness, lack of responsiveness, lack of speed, lack of ability to communicate and so on.

The cause of the risk that gets the second rank is an error on the server. Disruption to the server can certainly hinder the process of sending and receiving documents with Customs and Excise. While the cause of the risk that gets the third rank is the lack of employee motivation. Much of the literature states that there is a relationship between employee motivation and employee performance. The higher the motivation of employees, it will affect the increase in employee performance.

4.5 Calculation of HOQ 3

After making HOQ 2, then proceed with making HOQ 3. In forming HOQ 3, AI_l and RI_l data are used for potential risks from HOQ 2. The following are the results of HOQ 3 calculations shown in Table 7.

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Table 7. Ranking Results Based on HOQ 3 Calculations

Attribute	Resilience Measures	RI_I	Rank
RM 1	Provide training on the delivery and receipt of goods	0.17	1
RM 2	Provide training on how to communicate well	0.14	3
RM 3	Using an employee performance appraisal system with KPIs every month	0.12	5
RM 4	Make maintenance on communication equipment on a regular basis	0.04	8
RM 5	Updating the latest information regarding weather forecasting	0.01	14
RM 6	Carry out good control and communication with all related parties	0.13	4
RM 7	Choose to work with a professional crane vendor	0.00	17
RM 8	Provide training on how to operate ship cranes according to standards	0.01	13
RM 9	Make regular maintenance on cranes	0.01	12
RM 10	Monitor directly matters related to the delivery and receipt of goods	0.11	6
RM 11	Provide training to warehouse employees on how to work	0.00	16
RM 12	Predict how many ships will sail	0.00	18
RM 13	Repair and replace damaged equipment	0.02	9
RM 14	Choose to work with a professional trucking vendor	0.01	10
RM 15	Add trucking vendors	0.01	11
RM 16	Order trucking long before the D-day	0.01	15
RM 17	Sharing the latest information about shipping and receiving goods, traffic, etc	0.05	7
RM 18	Maintain good communication with customers	0.15	2

Source: Processed data

From the table above it can be seen that the top 5 ranked resilience measures include the following:

1. Provide training on the delivery and receipt of goods

Training regarding the delivery and receipt of goods is needed by employees so that they can work better in fulfilling customer demands. This can be done by holding training on the delivery and receipt of goods which is attended by all employees in the work process.

2. Establish good communication with customers

As a company engaged in services, good communication with customers is necessary. This is important because customers will feel valued because the company is very informative with its customers. Customers will easily understand if there are problems in their work process

3. Provide training on how to communicate well

Training on how to communicate well is also needed to minimize the causes of risks that occur. If each employee can communicate well then the error rate in workmanship and processing will be reduced. This is because the delivery of information is good and correct.

4. Carry out good control and communication with all related parties

It is important to control and communicate well with all related parties. This means that the elements related to the sending and receiving processes must control each other so that errors in processing are minimal. For example, marketing controls whether the EMKL has done the stuffing on time, because the delay in stuffing time will also make the next process too late.

5. Using an employee performance appraisal system with KPIs every month

An employee performance appraisal system needs to be carried out because employees will be motivated to work better. This employee performance appraisal can also improve the accuracy and quality of the performance of each employee..

5 CONCLUSION

The results of the research have identified 15 customer needs and obtained 3 priority customer needs, namely There are no mistake on the invoice and B/L; professional delivery service; Easy and realtime tracking of goods shipments. 18 risks have been identified and 3 priority risks have been obtained, namely damage to the communication device; error in handling; and delays in handling documents or goods by EMKL. 26 causes of risk have been identified and 3 priority causes of risk have been identified, namely lack of skills and accuracy of employees; there is a server error; and lack of work motivation in employees. Based on the analysis that has been carried out in the previous sections, there are 18 resilience measures as risk mitigation that can be carried out by companies. The following are the top-ranked resilience measures, including:

1. Provide training on the delivery and receipt of goods
2. Establish good communication with customers
3. Provide training on how to communicate well
4. Carry out good control and communication with all related parties
5. Using an employee performance appraisal system with KPIs every month

Based on the research results, there are several suggestions for companies and further research. Based on the results obtained from this study, each entity in the shipping line supply chain can make improvement efforts based on the resulting priority order. However, it is also possible to do it in a different order if during implementation it is found that there are various changes in circumstances and conditions. Companies should be able to carry out mitigation to avoid or reduce the impact of potential risks. Companies should

better understand customer needs in order to compete with competitors.

Further research using the Quality Function Deployment (QFD) method is suggested to continue up to a more complex Probabilistic Language QFD Level using Sustainable Supply Chain Continuity Management and to be able to conduct research on a more macro supply chain shipping line with the aim of building a good national logistics system.

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