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Designing Supply Chain Resilience With a Quality Function Deployment (QFD) Approach

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Abstract

PT. XYZ is a leading company in the palm oil industry, but there are still problems that need to be addressed in its supply chain management. The problems include 3% product returns from cooking oil shipments to distributors under the brands Sania cooking oil, Fortune cooking oil, Sovia cooking oil, and Siip cooking oil. In addition, there are fluctuations in demand, an increase in demand of 170% with a demand of 20,774 tons and a decrease in demand of 59% with a demand of 7,225 tons at an average monthly production of 12,195 tons. This research aims to design Supply Chain Resilience with a Quality Function Deployment (QFD) approach. This QFD approach uses a 3-level HOQ. HOQ 1 assesses the relationship between customer needs and potential risks, resulting in risk prioritization. HOQ 2 assesses the relationship between potential risks and risk causes, resulting in the prioritization of risk causes. HOQ 3 assesses the relationship between risk causes and resilience measures, resulting in the prioritization of resilience measures. From the research results, 20 resilience measures were obtained and the 5 highest ranks were obtained as priority resilience measures, namely insurance, marketing quick response, product quality, customer relations, preventive maintenance and repair. The results of the resilience measure design are expected to be used as risk mitigation for the company.

A. Introduction

In a rapidly evolving business era, resilience and efficiency in the supply chain are key to a company's sustainability [1]. Supply Chain Resilience refers to the ability of a supply chain system to withstand and recover quickly from disruptions or unexpected changes [2]. In an ever-changing business environment, supply chain resilience is crucial to ensure smooth operations and customer satisfaction [3]. The reason it is important to design for Supply Chain Resilience is to understand and improve the resilience of the system to the risks that occur [4]. By understanding the dynamics in the supply chain, companies can design supply chain strategies to mitigate risks so that they can recover quickly and efficiently after a disruption [5].

The Quality Function Deployment (QFD) technique was developed in the 1970s by Akao in Japan. QFD as a comprehensive and widely recognized quality management tool, was developed to translate customer requirements into process or product characteristics. This is achieved by building a House of Quality (HOQ). Needs can be identified through the help of past literature and questionnaire surveys of managers and employees. QFD has proven to be a systematic process to solve the major problems involved in any process. Lately, QFD has been widely used for strategy selection, risk, supplier selection while using weights derived from decision-making tools [6].

PT. XYZ is a leading company in the palm oil industry and has become a major player in the production, processing, and distribution of palm oil products globally. Established in 1991, PT. XYZ also strives to improve efficiency and product quality, and upholds the values of integrity. PT. XYZ has several products that it produces, namely palm oil refining, palm kernel and copra crushing, flour, soap, fertilizer, animal feed, soybeans, rice, special fats and oleochemicals. Examples of its products are Sania Premium cooking oil, Sania Royale cooking oil, and Fortune cooking oil.

Although PT. XYZ has achieved a leading position in the industry, there are still issues that need to be addressed in its supply chain management. PT. XYZ has identified several crucial issues in their supply chain. The problems include 3% product returns from cooking oil shipments to distributors under the brands Sania cooking oil, Fortune cooking oil, Sovia cooking oil, and Siip cooking oil. The company said that in 1 month there were about 3-4 product returns by distributors with an average monthly return of 342 tons with each return averaging 68 tons. In September, there was the largest return of 5% with a return of 408 tons from a demand of 8,910 tons. In addition, there are fluctuations in demand, an increase in demand of 170% with a demand of 20,774 tons and a decrease in demand of 59% with a demand of 7,225 tons at an average monthly production of 12,195 tons. Therefore, it is necessary to conduct an in-depth analysis to design an effective and sustainable Supply Chain Resilience.

In an effort to overcome these problems, the proposed method is to apply Quality Function Deployment (QFD). QFD is a systematic method that enables companies to transform customer needs into specific product and process characteristics, thereby integrating customer needs in the service stage [7]. According to [8] QFD can be used as an analytical tool to identify critical criteria in maintaining supply chain resilience, by ensuring that customer priorities and market needs are met [9].

By conducting this research through the application of Quality Function Deployment (QFD) on Supply Chain Resilience analysis, it is expected to identify critical criteria in maintaining their supply chain resilience, as well as ensuring that customer priorities and market needs are still met. By combining the concept of Supply Chain Resilience and the QFD method, this research is expected to provide deep insights for PT. XYZ to increase flexibility and resilience in the supply network based on customer needs. Through this analysis, it is expected that improvements in risk management, production planning, distribution, and collaboration with business partners will be identified, focusing on increasing resilience and responsiveness in the face of unforeseen changes.

B. Research Method

Identification and Operational of Variables

In conducting a study, it is necessary to identify its variables. The related variables for the study are listed below about the study's title.

1. Dependent Variable

The dependent variable is the variable that is affected or that is the result of the independent variable [10]. The dependent variable in this study is resilience measures.

2. Independent Variable

Independent variables are variables that affect or cause the dependent variable [11]. The independent variables of this study are customer needs that will be inputted in Quality Function Deployment (QFD), including: On-time delivery of products, Timely procurement of documents, No loss of products in transit/warehouse, Fast in service, Loading and unloading process runs smoothly, No errors on invoices and B/L, Availability of facilities to obtain information and convey criticism/suggestions, The company is responsive to questions/complaints, Invoices and B/Ls are not delayed, Ability to handle document discrepancies, The price of the product is in accordance with its quality, Warranty guarantee against damage to goods, The company is easy to contact, Consistency of cooking oil quality, Continuous supply of cooking oil, Demand that is fulfilled

Data Collection Methods

Primary data used in this research comes from interviews conducted with the company, namely the marketing department, while secondary data is obtained from literature studies. Interviews were conducted in depth, and data collection that required measurement or assessment was done through structured interviews. This research applies the Quality Function Deployment (QFD) method which has been adapted from research by Lee & Bai [12]. Quality Function Deployment (QFD) is a method used to focus attention on things that become the needs and desires of consumers in the preparation of design standards [13]. Information was obtained from stakeholders in the company, including production, PPIC, logistics, operations, purchasing. The research location is at PT. XYZ which is located at Jalan Kapten Darmo Sugondo 56, Gresik, East Java. The research was conducted from February 2024 until sufficient data was collected.

The data processing technique in this study is to apply the Quality Function Deployment (QFD) method by determining the Voice of Customer (VOC) in identifying customer needs (what's) [14], identifying and assessing potential risks (how's), Relation Matrix assessment illustrates the relationship between consumer needs (What's) and technical responses (How's). Using the numbers 9 (Strong), 3 (Moderate), and 1 (Weak) [15], Technical Correlation identifies the relationship or technical correlation between all the "How's" attributes (on the roof quality house), assessment of the relationship between customer needs and risk (Technical Matrix), Planning Matrix illustrates the relationship between customer requirements and proposed technical characteristics [16].

In this study, three House of Quality (HOQ) were developed. The first HOQ focuses on the relationship between customer needs (what's) and potential risks (how's). The purpose of the first HOQ is to identify risk linkages that can affect the competitiveness of the company according to customer needs [17]. The second HOQ is a continuation of the first HOQ. The second HOQ contains the relationship between the potential risk (what's) and the cause of the risk (how's). Then the third HOQ is a continuation of the second HOQ containing the relationship between risk causes (what's) and resilience measures (how's) that are expected to reduce the risks that have been identified [18].

C. Result and Discussion

Data Collection

Based on research conducted by Isti'anah et al (2021) [7] and Ernawati et al (2023) [8], 16 attributes of customer needs were obtained. Brainstroming was conducted with department heads and marketing staff at PT. XYZ who had a deep understanding of the needs commonly requested by customers and said they agreed with the given customer requirement attributes. So these 16 attributes are used as follows.

Table 1. Customer Needs

Variable	Attributes
K1	On-time delivery of products
K2	Timely procurement of documents
K3	No loss of products in transit/warehouse.
K4	Fast in service
K5	Loading and unloading process runs smoothly
K6	No errors on invoices and B/L
K7	Availability of facilities to obtain information and convey criticism / suggestions
K8	The company is responsive to questions/complaints
K9	Invoices and B/Ls are not delayed
K10	Ability to handle document discrepancies
K11	The price of the product is in accordance with its quality
K12	Warranty guarantee against damage to goods
K13	The company is easy to contact
K14	Consistency of cooking oil quality
K15	Continuous supply of cooking oil
K16	Demand that is fulfilled

Based on research conducted by Hsu et al (2021) [19], Baig et al (2022) [6], Liu et al (2023) [5] and adjusted to the company's conditions from brainstroming conducted with production staff, PPIC, logistics, operations, quality control, purchase, so that 15 potential risk attributes were obtained.

Table 2. Potential Risks

Variable	Attributes
R1	Oil Price Instability
R2	Demand Fluctuation
R3	Natural Disasters
R4	Inappropriate product pricing, affecting downstream consumer markets
R5	Inappropriate upstream raw material procurement prices, affecting suppliers
R6	Damage to internal IT infrastructure or disruption to information systems
R7	Increase in supplier's total product cost (product cost, logistics)
R8	Disruption of raw material supply and production.
R9	Increased time and labor costs for reprocessing, returns and replacements.
R10	Inefficient use of labor (ineffective/poor allocation of tasks, resulting in reduced labor productivity)
R11	Personnel changes in senior management
R12	Increased freight/ higher transportation costs
R13	Lack of organizational integration in supply chain management
R14	Delivery delays
R15	Return of cooking oil products

Based on research conducted by Hsu et al (2021) [19], Baig et al (2022) [6], Liu et al (2023) [5] and adjusted to the company's conditions from brainstroming conducted with production staff, PPIC, logistics, operations, quality control, purchasing, so that 19 attributes of risk causes were obtained.

Table 3. Risk Causes

Variable	Attributes
PR1	Price changes from marketing and economic policies
PR2	Price changes and distributor warehouse availability
PR3	Climate change and natural factors
PR4	Poor overall product cost control
PR5	Poorly formulated company pricing strategy
PR6	Program abnormalities/operational negligence
PR7	Increased product, logistics and quality costs
PR8	Inadequate risk management mechanisms
PR9	Supplier prioritizes other buyers' orders
PR10	Poor supplier quality control
PR11	Not communicating properly before work
PR12	Management turnover/retirement
PR13	Increase in fuel prices and changes in regulations from the transporter
PR14	Information imbalance
PR15	Failure in transportation planning
PR16	Products do not meet specifications so that customers are less satisfied
PR17	Product damage (Cardboard dents, leaks, wet with water)
PR18	Damage during storage (especially loading and unloading process)
PR19	Damage due to falling from a height (when lifted by a forklift)

Based on research conducted by Kenanga & Ardi (2022) [18] and adapted to the company's conditions from brainstroming conducted with production, PPIC, logistics, operations, quality control, purchase staff, so that 20 resilience measure attributes are obtained.

Table 4. Resilience Measure

Variable	Indicator	Resilience Measure
RM1	Security	Cyber Security
RM2		Redundancy in IT systems
RM3	Knowledge Management	Training
RM4		Teamwork
RM5	Visibility	Knowledge of operating assets
RM6		Supply chain visibility
RM7	Risk Management	Monitoring
RM8	Collaboration	Risk sharing
RM9		Production planning
RM10		Supplier delivery efficiency
RM11	Agility	Marketing quick response
RM12		Stock availability level
RM13		Product quality
RM14		Safety and accuracy of delivery
RM15	Flexibility	On-time delivery of goods
RM16	Efficiency	Preventive maintenance and repair
RM17	Redundancy	Change of production plan
RM18	Financial strength	Insurance
RM19		Price margin
RM20	Market position	Customer relations

Data Processing

In the Quality Function Deployment (QFD) stage, a crucial first step is to determine the Voice of Customer (VOC) based on the criteria to be deployed to ensure alignment between customer wishes and process developmentIn this data processing, a scale is obtained for each customer requirement based on an interview with the head of the marketing department. Level of importance of customer needs with a linkert scale.

Table 5. Importance Score of Customer Needs

Variable	Attributes	Scale
K1	On-time delivery of products	5
K2	Timely procurement of documents	5
K3	No loss of products in transit/warehouse.	5
K4	Fast in service	5
K5	Loading and unloading process runs smoothly	5
K6	No errors on invoices and B/L	5
K7	Availability of facilities to obtain information and convey criticism / suggestions	3
K8	The company is responsive to questions/complaints	3
K9	Invoices and B/Ls are not delayed	4
K10	Ability to handle document discrepancies	4
K11	The price of the product is in accordance with its quality	4
K12	Warranty guarantee against damage to goods	5
K13	The company is easy to contact	5
K14	Consistency of cooking oil quality	5
K15	Continuous supply of cooking oil	5
K16	Demand that is fulfilled	5

HOQ 1 Calculation

The preparation of HOQ 1 begins with the initial stage, which is to detail the attributes of customer needs into Customer Needs (What's) and their weights.

Table 6. Weight of Customer Needs

Attributes	I_i	W_i
On-time delivery of products	5	0,068
Timely procurement of documents	5	0,068
No loss of products in transit/warehouse.	5	0,068
Fast in service	5	0,068
Loading and unloading process runs smoothly	5	0,068
No errors on invoices and B/L	5	0,068
Availability of facilities to obtain information and convey criticism / suggestions	3	0,041
The company is responsive to questions/complaints	3	0,041
Invoices and B/Ls are not delayed	4	0,055
Ability to handle document discrepancies	4	0,055
The price of the product is in accordance with its quality	4	0,055
Warranty guarantee against damage to goods	5	0,068
The company is easy to contact	5	0,068
Consistency of cooking oil quality	5	0,068
Continuous supply of cooking oil	5	0,068
Demand that is fulfilled	5	0,068

Based on the table above has an average customer importance value of value 5 as many as 11 attributes, value 4 as many as 3 attributes, and value 3 as many as 2 attributes and attribute K1 is on time in product delivery has a weight value of 0.068.

The next step in the preparation of HOQ 1 is to identify potential risks and assign likelihood values, which are obtained through interviews with the company.

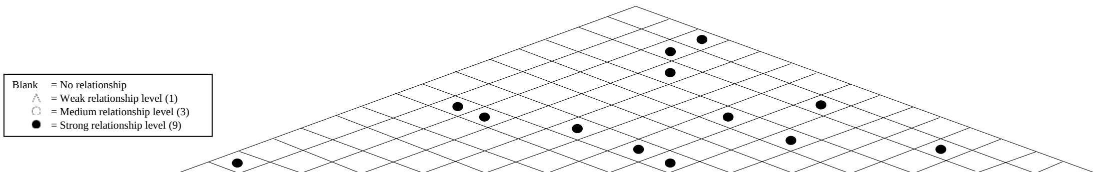
Table 7. Potential Risk and Likelihood Value

Variable	Attributes	Likelihood Scale
R1	Oil Price Instability	2,17
R2	Demand Fluctuation	2,17
R3	Natural Disasters	1,5
R4	Inappropriate product pricing, affecting downstream consumer markets	2
R5	Inappropriate upstream raw material procurement prices, affecting suppliers	2,33
R6	Damage to internal IT infrastructure or disruption to information systems	2,33
R7	Increase in supplier's total product cost (product cost, logistics)	2,33
R8	Disruption of raw material supply and production.	2,17
R9	Increased time and labor costs for reprocessing, returns and replacements.	1,83
R10	Inefficient use of labor (ineffective/poor allocation of tasks, resulting in reduced labor productivity)	2,33
R11	Personnel changes in senior management	2,17
R12	Increased freight/ higher transportation costs	1,83
R13	Lack of organizational integration in supply chain management	2,17
R14	Delivery delays	2,17
R15	Return of cooking oil products	2,17

Based on the results of data processing in HOQ 1, the potential risk that has the highest AIj and RIj values of 10.003 and 0.33 is the potential risk of Return of cooking oil products.

Table 8. RI_j Calculation Ranking Results on HOQ 1

Potential Risk	AI_j	RI_j	Ranking
Oil Price Instability	1,801	0,059	5
Demand Fluctuation	2,244	0,074	4
Natural Disasters	0,878	0,029	10
Inappropriate product pricing, affecting downstream consumer markets	0,464	0,015	14
Inappropriate upstream raw material procurement prices, affecting suppliers	0,603	0,02	12
Damage to internal IT infrastructure or disruption to information systems	1,3	0,043	6
Increase in supplier's total product cost (product cost, logistics)	0,603	0,02	13
Disruption of raw material supply and production.	0,857	0,028	11
Increased time and labor costs for reprocessing, returns and replacements.	1,177	0,039	7
Inefficient use of labor (ineffective/poor allocation of tasks, resulting in reduced labor productivity)	1,177	0,039	8
Personnel changes in senior management	1,096	0,036	9
Increased freight/ higher transportation costs	0,373	0,012	15
Lack of organizational integration in supply chain management	5,162	0,17	2
Delivery delays	2,571	0,085	3
Return of cooking oil products	10,003	0,33	1



W_i	I_i	Potential Risks / customer needs	Oil Price Instability	Demand Fluctuation	Natural Disasters	Inappropriate product pricing	Inappropriate procurement price	IT infrastructure damage	Increase in total product cost	Raw material supply disruption	Increased time and cost	Ineffective use of labor	Personnel changes	Increased carrier costs	Lack of organizational integration	Delivery delays	Return of oil products
0,068	5	On time delivery of products		3	3		1	3	1		1	1	1	3	1	9	
0,068	5	Timely document procurement		1				1			1	1	1		1	1	
0,068	5	No loss of products in transit/warehouse.		3	1				1								
0,068	5	Fast service		1				1	1				1		1		
0,068	5	Loading and unloading process runs smoothly		1	1						1				1		9
0,068	5	No errors on invoices and B/L		1						1					1		9
0,041	3	Availability of facilities to obtain information and convey criticism / suggestions	1	1				1								3	9
0,041	3	The company is responsive to questions/complaints	1	1	1	1		1			1					3	9
0,055	4	Invoices and B/Ls are not delayed													9		
0,055	4	Ability to handle document discrepancies									3	3	3		3		
0,055	4	The price of the product is in accordance with its quality				1	1		1	1	3				9	1	9
0,068	5	Warranty guarantee against damage to goods			1												9
0,068	5	The company is easy to contact	1					1			1	1	1		1		
0,068	5	Consistency of cooking oil quality	1			1	1			3		1			3		9
0,068	5	Continuous supply of cooking oil	9	3	1	1	1	1		1		1	1		9	3	9
0,068	5	Demand that is fulfilled		1	1												
		Likehood	2,17	2,17	1,5	2	2,33	2,33	2,33	2,17	1,83	2,33	2,17	1,83	2,17	2,17	2,33
		AI_j	1,801	2,244	0,878	0,464	0,603	1,3	0,603	0,857	1,177	1,177	1,096	0,373	5,162	2,571	10,003
		RI_j	0,059	0,074	0,029	0,015	0,02	0,043	0,02	0,028	0,039	0,039	0,036	0,012	0,17	0,085	0,33
		Ranking	5	4	10	14	12	6	13	11	7	8	9	15	2	3	1

Figure1. House of Quality (HOQ) 1

In HOQ 1, it is shown that customer needs and importance values can be identified. In addition, the results of HOQ 1 are that there are 5 highest ranks, namely cooking oil product returns, lack of organizational integration in supply chain management, delivery delays, demand fluctuations, oil price instability.

HOQ 2 Calculation

The preparation of HOQ 2 begins with the initial stage, namely detailing the potential risk attributes into Customer Needs (What's), as for the potential risks used in HOQ 2 as listed in HOQ 1. Cause of risk is the cause of the potential risk.

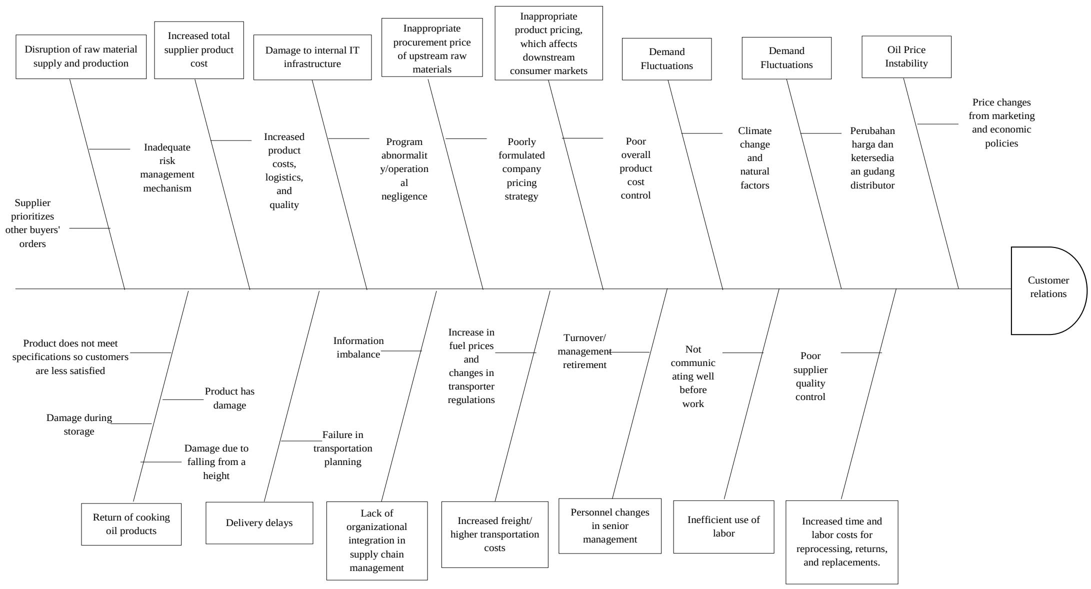


Figure 2. Fishbone Diagram

Cause of risk is the cause of the potential risk. The cause of the risk was obtained from interviews with PT. XYZ , which was then included in the explanation of the fishbone diagram. From the results of the fishbone diagram, 19 causes of risk were obtained.

Table 9. Risk Causes and Impact Value

Variable	Attributes	Impact Scale
PR1	Price changes from marketing and economic policies	4,17
PR2	Price changes and distributor warehouse availability	4,33
PR3	Climate change and natural factors	3,33
PR4	Poor overall product cost control	4
PR5	Poorly formulated company pricing strategy	4
PR6	Program abnormalities/operational negligence	4,17
PR7	Increased product, logistics and quality costs	4,33
PR8	Inadequate risk management mechanisms	4,17
PR9	Supplier prioritizes other buyers' orders	4,17
PR10	Poor supplier quality control	4,33
PR11	Not communicating properly before work	3,33
PR12	Management turnover/retirement	4,17
PR13	Increase in fuel prices and changes in regulations from the transporter	4,17
PR14	Information imbalance	4,17

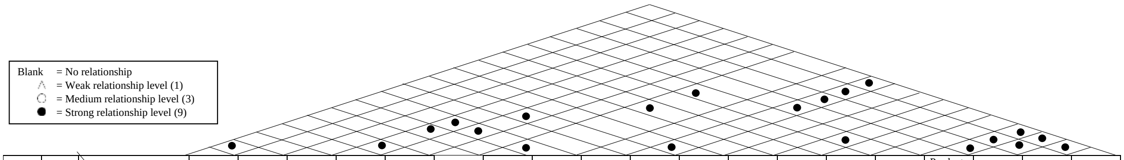
Variable	Attributes	Impact Scale
PR15	Failure in transportation planning	4
PR16	Products do not meet specifications so that customers are less satisfied	4,17
PR17	Product damage (Cardboard dents, leaks, wet with water)	4,33
PR18	Damage during storage (especially loading and unloading process)	4,17
PR19	Damage due to falling from a height (when lifted by a forklift)	4,17

Based on the table above, it can be seen that there are 4 potential risks that have an impact value of 4.33; 10 potential risks that have an impact value of 4.17; 3 potential risks that have an impact value of 4; 2 potential risks that have an impact value of 3.33.

Based on HOQ 2 processing, it can be seen that the cause of the risk that has the highest AIj and RIj values of 13.999 and 0.126 is the cause of product risk damage (dented, leaking, wet cardboard exposed to water).

Table 10. RI_j Calculation Ranking Results on HOQ 2

Risk Causes	AI_j	RI_j	Ranking
Price changes from marketing and economic policies	5,179	0,046	6
Price changes and distributor warehouse availability	3,468	0,031	10
Climate change and natural factors	3,696	0,033	9
Poor overall product cost control	2,956	0,027	13
Poorly formulated company pricing strategy	3,172	0,028	11
Program abnormalities/operational negligence	1,614	0,014	17
Increased product, logistics and quality costs	2,68	0,024	14
Inadequate risk management mechanisms	0,246	0,002	19
Supplier prioritizes other buyers' orders	2,198	0,02	16
Poor supplier quality control	13,367	0,12	5
Not communicating properly before work	3,167	0,028	12
Management turnover/retirement	3,966	0,036	8
Increase in fuel prices and changes in regulations from the transporter	1,485	0,013	18
Information imbalance	2,502	0,022	15
Failure in transportation planning	5,132	0,046	7
Products do not meet specifications so that customers are less satisfied	13,999	0,126	2
Product damage (Cardboard dents, leaks, wet with water)	14,661	0,132	1
Damage during storage (especially loading and unloading process)	13,999	0,126	3
Damage due to falling from a height (when lifted by a forklift)	13,999	0,126	4



RI_j	AI_j	Risk Causes / Potential risks	Price changes from marketing and economic policies	Price changes and distributor warehouse availability	Climate change and natural factors	Poor overall product cost control	Poorly formulated company pricing strategy	Program abnormalities/operational negligence	Increased product, logistics and quality costs	Inadequate risk management mechanisms	Supplier prioritizes other buyers' orders	Poor supplier quality control	Not communicating properly before work	Management turnover/retirement	Changes in regulations from the transporter	Information imbalance	Failure in transportation planning	Products do not meet specifications so that customers are less satisfied	Product damage	Damage during storage	Damage due to falling from a height
0,059	1,801	Oil Price Instability	9			9	9		3	1					1		1				
0,074	2,244	Demand Fluctuation	9	9			1		1												
0,029	0,878	Natural Disasters			9														1		
0,015	0,464	Inappropriate product pricing, affecting downstream consumer markets	3	9		1	1		1							1					
0,02	0,603	Inappropriate upstream raw material procurement prices, affecting suppliers				1	1		1		1										
0,043	1,3	Damage to internal IT infrastructure or disruption to information systems						9													
0,02	0,603	Increase in supplier's total product cost				1			9						9						
0,028	0,857	Disruption of raw material supply and production			3						9										
0,039	1,177	Increased time and labor costs for reprocessing, returns and replacements				3			3			3			3		9	9	9	9	9
0,039	1,177	Inefficient use of labor					3						3	3		1					
0,036	1,096	Personnel changes in senior management					1						9	9		1					
0,012	0,373	Increased higher freight/transportation costs				3			3								9	3	3	3	3
0,17	5,162	Increased higher freight/transportation costs									1		3	3		3					
0,085	2,571	Delivery delays			9						1						9				
0,33	10,003	Return of cooking oil products										9						9	9	9	9
		Likehood	4,17	4,33	3,33	4	4	4,17	4,33	4,17	4,17	4,33	3,33	4,17	4,17	4,17	4	4,17	4,33	4,17	4,17
		AI_j	5,179	3,468	3,696	2,956	3,172	1,614	2,68	0,246	2,198	13,367	3,167	3,966	1,485	2,502	5,132	13,999	14,661	13,999	13,999
		RI_j	0,046	0,031	0,033	0,027	0,028	0,014	0,024	0,002	0,02	0,12	0,028	0,036	0,013	0,022	0,046	0,126	0,132	0,126	0,126
		Ranking	6	10	9	13	11	17	14	19	16	5	12	8	18	15	7	2	1	3	4

Figure 3. House of Quality (HOQ) 2

In the HOQ 2 shown, it can be seen the cause of the risk and the likehood value. In addition, the results of HOQ 2 are that there are 5 highest ranking causes of risk, namely product damage (dented cardboard, leaking, wet with water), products do not meet specifications so that customers are less satisfied, damage during storage (especially the loading and unloading process), damage due to falling from a height (when lifted by a forklift), poor supplier quality control.

HOQ 3 Calculation

The preparation of HOQ 3 starts with the initial stage, which is to detail the attributes of the risk causes into Customer Needs (What's), as for the risk causes used in HOQ 3 as listed in HOQ 2. Resilience Measures are mitigation measures for the causes of risks that occur. Resilience Measures are obtained from interviews with PT. XYZ Nabati Indonesia, then an assessment is made based on the effectiveness value of each Resilience Measures.

Tabel 11. Resilience Measure and Effectiveness Value

Variable	Indicator	Resilience Measure	Effectiveness Scale
RM1	Security	Cyber Security	4
RM2		Redundancy in IT systems	3,67
RM3	Knowledge Management	Training	4,33
RM4		Teamwork	4,17
RM5	Visibility	Knowledge of operating assets	3,5
RM6		Supply chain visibility	3,5
RM7	Risk Management	Monitoring	4
RM8	Collaboration	Risk sharing	4,17

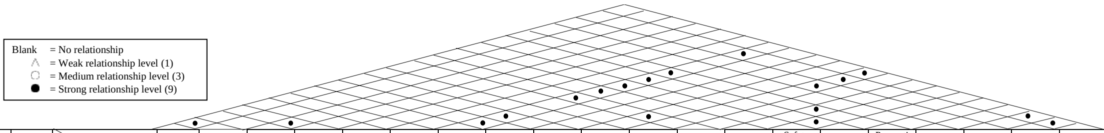
RM9		Production planning	4,33
RM10		Supplier delivery efficiency	4,17
RM11	Agility	Marketing quick response	4,17
RM12		Stock availability level	3,67
RM13		Product quality	4,33
RM14		Safety and accuracy of delivery	3,67
RM15	Flexibility	On-time delivery of goods	3,83
RM16	Efficiency	Preventive maintenance and repair	3,5
RM17	Redundancy	Change of production plan	4,17
RM18	Financial strength	Insurance	4,17
RM19		Price margin	3,5
RM20	Market position	Customer relations	4,17

Based on the table above, it can be seen that there are 3 resilience measures that have a likelihood value worth 4.33; 7 resilience measures that have an effectiveness value worth 4.17; 2 resilience measures that have an effectiveness value worth 4; 1 resilience measure that has an effectiveness value worth 3.83; 3 resilience measures that have an effectiveness value worth 3.67; 4 resilience measures that have an effectiveness value worth 3.5.

Based on HOQ 3 processing, it can be seen that the resilience measure that has the highest AIj and RIj values of 13.586 and 0.217 is the insurance-related resilience measure.

Tabel 12. RI_j Calculation Ranking Results on HOQ 3

Indicator	Resilience Measure	AI_j	RI_j	Ranking
Security	Cyber Security	1,008	0,016	13
	Redundancy in IT systems	0,925	0,015	14
Knowledge Management	Training	1,992	0,032	9
	Teamwork	1,918	0,031	10
Visibility	Knowledge of operating assets	0,455	0,007	18
	Supply chain visibility	0,826	0,013	15
Risk Management	Monitoring	2,392	0,038	6
Collaboration	Risk sharing	1,339	0,021	12
	Production planning	0,195	0,003	20
	Supplier delivery efficiency	0,702	0,011	16
Agility	Marketing quick response	12,46	0,199	2
	Stock availability level	0,29	0,005	19
	Product quality	10,678	0,171	3
	Safety and accuracy of delivery	2,29	0,037	7
Flexibility	On-time delivery of goods	2,114	0,034	8
Efficiency	Preventive maintenance and repair	2,975	0,048	5
Redundancy	Change of production plan	1,751	0,028	11
Financial strength	Insurance	13,586	0,217	1
	Price margin	0,011	0,011	17
Market position	Customer relations	3,845	0,061	4



RI_j	AI_j	Resilience Measure / Risk Causes	Cyber Security	Redundancy in IT systems	Training	Teamwork	Knowledge of operating assets	Supply chain visibility	Monitoring	Risk sharing	Production planning	Supplier delivery efficiency	Marketing quick response	Stock availability level	Product quality	Safety and accuracy of delivery	Delivery of goods on time	Preventive maintenance and repair	Change in production plan	Insurance	Price margin	Customer relations
0,046	5,179	Price changes from marketing and economic policies						1		1		1	9	1							3	3
0,031	3,468	Price changes and distributor warehouse availability						1			1					3	1				1	
0,033	3,696	Climate change and natural factors					1	1	1												1	
0,027	2,956	Poor overall product cost control					1		1					1								
0,028	3,172	Poorly formulated company pricing strategy	9	9					1									1				
0,014	1,614	Program abnormalities/operational negligence									1	3					3		3			
0,024	2,68	Increased product, logistics and quality costs			9	9	1			9												
0,002	0,246	Inadequate risk management mechanisms										1		3								
0,02	2,198	Supplier prioritizes other buyers' orders			3	3						1			9			3		9		
0,12	13,367	Poor supplier quality control			1	1																
0,028	3,167	Not communicating properly before work			1	1																
0,036	3,966	Management turnover/retirement			1	1																
0,013	1,485	Increase in fuel prices and changes in regulations from the transporter								1						9	9					
0,022	2,502	Information imbalance																				1
0,046	5,132	Failure in transportation planning					1			1		1				9	9					
0,126	13,999	Products do not meet specifications so that customers are less satisfied						1	1				9		9			3	3	9		3
0,132	14,661	Product damage							1				9		3			1		9		1
0,126	13,999	Damage during storage							1				1		3			1		3		1
0,126	13,999	Damage due to falling from a height							1				1		3			1		3		1
		Likehood	4	3,67	4,33	4,17	3,5	3,5	4	4,17	4,33	4,5	4,17	3,67	4,33	3,67	3,5	3,5	4,17	4,17	3,5	4,17
		AI_j	1,008	0,925	1,992	1,918	0,455	0,826	2,392	1,339	0,195	0,702	12,46	0,29	10,678	2,29	2,114	2,975	1,751	13,586	0,707	3,845
		RI_j	0,016	0,015	0,032	0,031	0,007	0,013	0,038	0,021	0,003	0,011	0,2	0,005	0,171	0,037	0,034	0,048	0,028	0,218	0,011	0,062
		Ranking	13	14	9	10	18	15	6	12	20	16	2	19	3	7	8	5	11	1	17	4

Figure 4. House of Quality (HOQ) 3

In HOQ 3 shown, the resilience measure and effectiveness value can be found. In addition, the results of HOQ 3 are the 5 highest ranking resilience measures that can be seen in table 4.9, namely insurance, marketing quick response, product quality, customer relations, preventive maintenance and repair.

Discussion

The following is an explanation of each resilience measure:

1. Resilience measure related to insurance
   Insurance provides consumers with a guarantee that if the product they buy is damaged or does not meet expectations. This provides protection for consumers against the risk of product returns.
2. Resilience measure related to marketing quick response
   A quick response from the marketing team can help respond quickly to changes in market demand, allowing the company to adjust marketing and production strategies to cope with demand fluctuations and reduce the risk of product returns.
3. Resilience measure related to product quality
   By maintaining high product quality, companies can build a strong reputation, having high product quality can reduce the risk of product returns and increase customer confidence, thereby increasing the company's resilience to demand fluctuations.
4. Resilience measure related to customer relationship
   Maintaining strong relationships with customers can help overcome product return issues by providing responsive customer service and satisfactory

solutions, allowing companies to understand changes in market demand and better adjust strategies.

5. Resilience measure related to preventive maintenance and repair
   Conducting regular preventive maintenance and repairs on production facilities and equipment can reduce the risk of product damage and production delays, thereby helping to overcome product return issues and demand fluctuations by maintaining smooth operations.

D. Conclusion

Based on the results of the research that has been carried out, HOQ 1 can be identified with the whats matrix is customer needs and the hows matrix is potential risk, resulting in the 5 highest potential risks, namely cooking oil product returns, lack of organizational integration in supply chain management, delivery delays, demand fluctuations, oil price instability. In HOQ 2 with the whats matrix is the potential risk and the hows matrix is the cause of the risk, the 5 highest risk causes are products that are damaged (dented cardboard, leaking, wet with water), products do not meet specifications so that customers are less satisfied, damage during storage (especially the loading and unloading process), damage due to falling from a height (when lifted by a forklift), poor supplier quality control. In HOQ 3, a resilience measure design is carried out which consists of 20 resilience measures as risk mitigation that can be carried out by the company with the top 5 ranks in the resilience measure, namely insurance, marketing rapid response, product quality, customer relations, preventive maintenance and repair. The results of this study allow each entity in the supply chain to plan improvements by prioritizing the resulting priorities. Nonetheless, flexibility is required in adjusting the sequence of actions in the event of a change in circumstances or certain conditions. Companies must be active in mitigating to overcome or minimize the impact of potential risks that may arise. A deeper understanding of customer needs is necessary for the company to maintain its competitiveness in a competitive market. It is recommended to continue the research by applying the Quality Function Deployment (QFD) method to achieve a more complex probabilistic language QFD level. In addition, research can expand its scope by integrating the concept of Sustainable Supply Chain Continuity Management. The research focus can also be moved to more macro supply chain shipping lines with the aim of developing an efficient and sustainable national logistics system.

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