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Mitigation of Supply Chain Risk Management in Supply of Production Raw Materials Using the House of Risk (HOR) Method

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Abstract

Several risks along the supply chain process will cause various kinds of problems, the flow of the raw material procurement process is determined by the roles of several stakeholders such as purchasing, supply chain, production, customer service, and logistics. This research is focused on determining the risks during the procurement of production raw materials and determining the best way to handle the existing risks. House of Risk (HOR) is a method used in this study, which consists of 2 stages with the first stage determining the risk events and risk agents and determining the priority of the risk agent, the second stage determining the priority of risk mitigation. The results of the first stage of HOR found 23 risk events and 24 risk agents with the highest ARP values were (A2) sudden request changes. In the second stage of HOR with the highest ETDK value (PA1) conducts inventory control.

Keywords: Supply Chain Risk Management, House of Risk (HOR), Supply Chain Operation Reference (SCOR)

1. Introduction

Along with the development of manufacturing industry enterprises, of course, there will always be consumer demand with changing conditions. To meet consumer demand, it is necessary to have procurement activities. During the procurement process, this section will deal with various forms of risk events and risk agent which of course have an impact on the smooth running of procurement activities, both from outside and from within the company.

According to (Handayani, 2016), the failure of suppliers to supply raw materials until consumer demand is not covered and experiences an imbalance between demand and suppliers is an event that is closely related to supply chain risk management. Then risk mitigation is a risk-handling activity by carrying out a preventive process to determine the right attitude to prevent risk events from occurring.

PT. XYZ is a company engaged in manufacturing by producing connectivity products and sensors for automotive original equipment manufacture (OEM*)* to global companies and is a major supplier of automotive component products to other global companies such as the US, China, Germany, and Italy.

Companies that produce automotive OEM, usually have a series of supply chain activities that are at risk of impacting the sustainability of the production process, especially during the process of raw material procurement activities which are the earliest processes in the supply chain. For the target to be achieved optimally, it is necessary to have a supply of raw materials.

PT. XYZ requires good supply chain risk management activities, this is done to avoid losses during its activities and always run smoothly. Even because the processed product is an automotive component, it must be assembled again into a product *(finish good)* which is used as the most vital part of every car. Without an engine, of course, the car cannot run, therefore an important component for the performance of the car engine.

We can determine the process of supply chain activities during the raw material procurement process which includes several departments, such as the supply chain department, warehousing department, production department, customer service department, and purchasing department. The focus of this research is to determine and assess the occurrence and causes of risk, evaluate risk management solutions, and assign risk management to each member involved in the supply chain activity process.

PT. XYZ may require even better risk management activities to determine and address risks that can occur at anytime, especially in supply chain functions. Therefore, this study aims to determine risks and determine risk mitigation actions that need to be practiced. One of the methods that determine risk and determines mitigation measures is the House Of Risk (HOR).

The process of finding the results of the assessment of the *House of Risk* (HOR) Method has 2 stages of the process, the first stage process is determining the indicators of risk events and also indicators of the risk agents and determining priority risk agent, the second stage process is determining risk mitigation based on the priority of risk agent that have been determined in the first stage of HOR. Pujawan and Geraldin (2009) revealed that this is an improvement of two methods, namely the Fuzzy Failure Models and Effect Analysis (FMEA) Method and the House of Quality (HOQ).

The first stage of the HOR method is to determine the risk events and risk agents that may occur during supply chain activities, in this stage, it is necessary to do what is called the Severity (S), Occurrence (O), and Correlation (R) value after that to determine the order of priority of the risk agent, then an Aggregate Risk Potential assessment is carried out (ARP) with the help of Pareto diagrams to determine risk mitigation measures to obtain improvements.

The first stage produces the priority level of the risk agent from the highest to the lowest, then we determine how many risk events indicators that we will use as a determination of tind will prevention for the second stage, determination of the relationship of

risk agent with risk mitigation becomes a reference for the calculation of the value of Total Effectiveness (Tek), then after that the Degree of Difficulty (Dk) which is determined by the value of each respondent as the value for the determination of the Effectiveness to Difficulty Ratio (ETDk) as the final result of the method to determine the priority of mitigation actions that need to be implemented (Kusnindah et al, 2014).

2. Theory Review

Raw Materials

Raw materials are materials that have not been processed at all and are used in production activities as long as the raw materials are of no changing nature or shape (Winardi 2003: 403).

According to Ristono (2005:5) Direct raw materials are materials used in the production process, but it is difficult to establish their cost. How much direct raw material is applied in a production process varies, depending on the size of the production volume or changes in output. Indirect raw materials are materials used in the production process, but it is difficult to determine the cost for each finished product. Factors affecting the cost of raw materials include the type of raw materials, the production process, and the production strategy of the enterprise.

According to Ahyari (2005:4). A factor influencing the selection of raw materials for future production is the intention to use several different quantities of materials to help the company achieve its future goals.

Prices for raw materials become a factor that determines how much a company spends on inventory. The company's spending policy will also affect all company policies, such as which policy gets the top priority, withholding the inventory of raw materials or directly using them. Furthermore, the actual use of raw materials must be considered to compile an estimate of the need for raw materials that are close to reality. Lead Time, which is the grace period that the company finds between the time the raw materials are ordered to the factory, also plays a role in determining inventory policy.

Supplies

Preparation is the process of monitoring and managing the flow of goods owned by a company to ensure that the goods are available for sale, used in the production process, or used as raw material inventory. (Rangkuti, 2004). According to Aulia Isaac (2010:159). Production activities are not currently underway because there are not enough supplies to support them. This is because the inventory is awaiting further processing, which may or may not happen soon.

Inventory is used to help speed up production and distribution processes and to help maintain price stability in the face of fluctuations in demand. Handoko (2000;335-336) states that the company stores inventory due to various functions, namely:

1) Decoupling function

This function allows companies to be able to meet consumer demand without relying on suppliers of goods. This allows the company to remain independent and flexible in dealing with suppliers, ensuring that it can meet the needs of its customers.

2) Economic LotSizing function

The purpose of the function is to collect inventory so that the company can produce and use all available resources in sufficient quantities to reduce the cost per unit of product.

3) Anticipation function

Companies often experience uncertainty in the timeframe of delivery of goods from other businesses, so they need to stockpile safety stock, or experience pre-predictable fluctuations in demand based on experience. This is especially the case during holidays when the demand for certain products tends to be higher than usual. Holding seasonal inventory can help reduce the amount of uncertainty a company experiences. (Asdjudiredja,1999).

Baroto (2002:54), Inventory control is designed to ensure that the company has the necessary inventory for finished products, goods in progress, components, and raw materials, in the right quantity, at the right time, to keep production running smoothly.

Supply Chain

Supply chain is a series of forms of cooperation between actors in a company to make and deliver products to the last user. A supply chain management supply chain method, tool, or approach is the way to manage this network. (Jarir et al, 2012). (Levi, et.al 2000) Defining supply chain is a method of integrating suppliers, manufacturers, distributors, retailers, and customers to achieve efficient production, to achieve the lowest cost, and provide the best customer service.

Supply chain covers all costs associated with the production of products, from the materials used to the finished goods produced. It also includes costs for auxiliary materials, components, parts, or equipment used to help support the company's overall operations. (Immawan & Princess, 2018). According to (Tjipto, 2014) supply chain covers all costs associated with the production of products, from materials used to finished goods produced. It also includes costs for auxiliary materials, components, parts, or equipment used to help support the company's overall operations.

Supply chain is the management of a network of suppliers, manufacturers, and distributor organizations. This network provides raw materials for organizations, converts such materials into products, and distributes these products to consumers. (Bateman & Snell, 2008). Supply chain management is a process that helps manage the flow of raw materials, information, and capital throughout the entire process set to maximize the satisfaction of the needs of each item in the supply chain. This helps ensure that the product is delivered on time, and also has the right quantity price (Timisela et al, 2014).

Activities that form an interconnected supply chain, therefore cannot be carried out exclusively. For example, acquiring materials necessary for production, converting those materials into finished products, and distributing and storing them if needed is part of the supply chain (Timisela et al, 2014).

Supply Chain Risk Management

Risk is the result of uncertainty in the company's objectives (ISO 31000). According to (Peck, 2003) supply chain risk management is an event caused by the disagreement between demand and supply. Risks that arise in the supply chain must be minimized because they will have an impact on the entire business process (Asrol et al, 2018). Meanwhile, according to (Walters, 2006), Risk is a form of threat that may occur and can interfere with normal activity that has been planned. The risk that is commonly experienced when the procurement process takes place is that the raw materials requested arrive are not as expected.

Then according to research that has been carried out by (Hendrick & Singhal, 2003) we can understand that the emergence of a disruption during the supply chain process in a company will have a bad impact for the foreseeable future and it is difficult to prevent it soon

Supply chain risk management is the process of managing the risks associated with a company's supply chain. It works closely with supply chain partners to implement risk management processes (Brindley in Handayani, 2016). Supply chain risk management is a process to ensure that products meet consumer demand, even if suppliers fail (Zsidisin et al in Handayani, 2016).).

Supply chain is not a simple vertical chain, but a multi-layered network of suppliers and customers. The supply chain process has a type of risk that consists of risks related to the production process, requests from customers, due dates, and finally cost management (Sarinah & Djatna, 2015). To manage the supply chain effectively, companies must work closely with their suppliers to meet the needs of their target markets. These partnerships can help ensure that products are delivered on time and meet customer expectations

Risk Mitigation

Risk mitigation involves changing suppliers, reducing linkages with risk suppliers, and taking time to impact the company (inventory, alternative suppliers, etc.). (Elkins et al. in Lufika, 2015). Risk mitigation is a way of preventing risk from occurring in the first place, so that good measures can be taken to address any potential risks.

Risks can arise in a variety of ways and can have a significant impact on supply chain operations. Mitigation strategies involve working together to improve coordination and collaboration among different parts of the supply chain, as well as using proactive supply strategies that focus on reducing the impact of potential risk factors (Tang in Lufika, 2015).

Various risk mitigation tools can be used, including FMEA, why analysis, and HOR. FMEA is a process that helps identify potential problems with a product or system, and why they could be the case. Analysis of why looks at the reasons why something might happen and tries to figure out how to avoid or fix the problem. HOR is a tool that helps organizations know how likely different risks are to occur, and what steps need to be taken to minimize their chances. Risk mitigation is a process used to reduce the likelihood of something bad happening. This process is based on the results of risk identification, that is, the process of determining which risks may occur and which may cause problems. Then, adjustments are made to the source of the risk, and the precautions that are raised, to reduce the possibility of the risk re-occurring. Risk mitigation strategies are then put in place to ensure that the risk events occurring again can be minimized. (Magfur & Nina, 2021).

Production

Production is a series of activities carried out by using various tools and equipment to produce output that can be sold to customers to make a profit. Production processes are linked together in a system, so equipment can be used to convert inputs into outputs. The production process carried out is in the form of (Assauri, 2008: 35). Group production is a production method in which processing is carried out for a group of products that are different from other groups of products produced, especially variations in terms of limited materials. This method is often used in large groups or factories.

The production process involves the manipulation of raw materials to create products in a particular design. It is often used in the process of producing raw materials into semi-finished ones intended for other industries.

The mass production is a production process in which products in large quantities are produced for the market. It is usually found in manufacturing and engineering (assembly) industries, but can also be found in processing or production processes such as factories. Multi-product mass production is a production process by which a series of different products are produced in a series of variations.

House of Risk Method

House of Risk (HOR) is one of the developments of FMEA and HOQ methods. this method is designed to help organizations identify and manage risks. The first stage, known as the risk identification stage, begins with the identification of the mode and effect of potential failure. The second stage, known as the risk management stage, focuses on implementing measures to prevent or mitigate the impact of such failure modes. HOR stage 1 is an initial stage that aims to identify risk events and potential risk agents. HOR's role in stage 1 is to rank risk agents based on Aggregate Risk Potential (ARP).

The use of metode House Of Risk (HOR) is used to determine preventive measures risk mitigation of supply chain. The role of HOR stage 2 is to prioritize preventive actions or actions that companies must take to maximize effectiveness in their efforts to deal with the risk agents selected in the first stages of HOR (Setiawan, 2018). The House of Risk (HOR) model is based on the idea of supply chain risk management

that focuses on preventive measures, reducing the probably of risk agent occurring.

Risk management begins with identifying the risks that need to be addressed. This process can be affected by the risk identified as the source of the risk. Once the risks are identified, their impact on the company's goals and objectives needs to be considered (Tampubolon et al, 2013).

The HOR model supply chain risk assessment is used to determine, analyze, measure, and mitigate risks that may arise during the manufacturing process. The application of HOR consists of two stages, namely (Pujawan & Geraldin, 2009):

1) HOR first stage

Used to determine risk events and potential risk agent, the output of the first stage of HOR is the risk agent priority based on the ARP value.

2) HOR second stage

Used to determine the mitigation measures implemented to address the priority of the risk agent. The results of the first stage of HOR will be used as input in the second stage of HOR.

The description in the first stage of HOR is in the HOR method, which is to determine the risk events and risk agents that are likely to occur during supply chain activities, in this stage it is necessary to do what is called the Severity (S), Occurrence (O) and Correlation (R) value after that to determine the order of priority of the risk agent, then an Aggregate Risk Potential assessment is carried out (ARP) with the help of Pareto diagrams to determine risk mitigation measures to obtain improvements.

The first stage produces the priority level of the risk agents from the highest to the lowest, then we determine how many risk agent indicators we will use as a preventive determination for the second stage, the determination of the relationship of the risk agent with risk mitigation becomes a reference for the calculation of the value of Total Effectiveness (Tek), then after that the Degree of Difficulty (Dk) which is determined by the value of each respondent as the value for the determination of the Effectiveness to Difficulty Ratio (ETDk) as the final result of the method to determine the priority of mitigation actions that need to be implemented. (Kusnindah et al, 2014).

Model Supply Chain Operation References (SCOR)

The Supply Chain Operations Reference (SCOR) model is enhanced by the flow of companies collaborating on the Supply Chain Counci. The Supply Chain Operations Reference (SCOR) model is a working design that projects the processes of business activity between supply chain flows from start to finish to meet supply chain demand and objectives (Natalia & Astuario, 2015).

Supply Chain Operation Reference (SCOR) is a reference model of supply chain operations. SCOR is able to map parts of the supply chain. Basically, SCOR is a process-based model. (Hanugrani et al, 2013) divide the SCOR process into 5, namely plan, source, make, delivery and return.

Severity, Occurrence, dan Correlation

Severity is a measure of the severity a result of which there will be potential failures that can affect the results of the assessment being tested or analyzed, Scale level 1 to 10 is the value of this Severity Level (Wahyunugraha et al, 2013).

Occurrence is an assessment that uses a certain level to determine the likelihood of equipment damage. This information can help determine the frequency of damage and help identify potential causes (Wahyunugraha et al, 2013). The scale used in determining the chances of the emergence of a source of risk uses a scale level of 1-10, meaning that a value of 1 (rarely occurs) to a value of 10 often occurs (Ulfah et al, 2016).

Correlation is used to measure the relationship between two indicators. If one indicator causes something else to happen, there is a correlation. The correlation value can be (0, 1, 3, 9), where 0 means no

correlation, 1 describes a small correlation, 3 describes a moderate correlation, and 9 describes a strong correlation. (Lutfi & Irawan, 2012).

Diagram Pareto

A calculation that can help to illustrate the problem of identifying the priority of such events is the Pareto diagram. It is known that an indicator can be compared with other indicators because it is composed of the highest to the lowest and the highest becomes the center for the process to the next stage, such as problem solving (Rahayu, 2014).

Pareto diagrams are used to determine or select the main factors for improving quality. Pareto diagrams are designed to search or find out which problems or agents are key in troubleshooting and an overall comparison can help identify repair priorities. Fixing the root agent will have a greater impact than resolving insignificant agents (Devani & Marwiji, 2014).

3. Research Method

Quantitative analysis using the HOR method. HOR is useful for determining the risks and causes of emerging risks and designing risk mitigation measures. The authors use primary data as well as secondary data as the instruments used. The population in this study was part of PT. XYZ meets the criteria of respondents. Purposive sampling techniques were used.

4. Results and Discussion

House of Risk Stages 1

1. Supply Chain Activity Mapping

Diagrams in the process of mapping supply chain activities at PT XYZ identified indicators with the Supply Chain Operations (SCOR) process approach, namely plan, source, make, deliver, and return. Mapping supply chain activities in this way aims to find out every activity in each member of the supply chain to be more classified. In detail, it can be seen in (Table 7.1).

TABLE 7.1 SUPPLY CHAIN ACTIVITIES

Member	Variable	Code	Activity
SCM	Plan	P1	Planning and materials inventory control
		P2	Production planning
	Source	S1	Planning and checking materials
		S2	Payment raw material products received
	Make	M1	Production Scedule
		M2	Production process product
		M3	Maintenance Production Facilities
	Delivery	D1	Delivery selection product
		D2	Storage product
		D3	Product delivery
	Return	R1	Product return to supplier

(Source: Primary Data, 2022)

2. Risk Event Identification

Based on the mapping of supply chain activities, a risk event determination is carried out for each member. All information related to each member's supply chain activities is obtained from interviews with several stakeholders such as supply chain, purchasing, production, customer service and logistics. As a result, there are 23 risk events that exist throughout the supply chain process at PT. XYZ.

Then an assessment was carried out from each respondent, that is 1 Supply Chain Manager, 1 Purchasing Assistant Manager, 1 Production Manager, 1 Customer Service, and 1 Logistics Manager.

3. Risk Agent Identification

Based on the mapping of supply chain activities, the determination of the risk agent for each member is carried out. All information related to each member's supply chain activities is obtained from interviews with several stakeholders such as supply chain, purchasing, production, customer service and

logistics. As a result, there are 27 risk agents that exist throughout the supply chain process at PT. XYZ. Then an assessment was carried out from each respondent, that is 1 Supply Chain Manager, 1 Purchasing Assistant Manager, 1 Production Manager, 1 Customer Service, and 1 Logistic Manager.

4. Questionnaire Validity Testing

Testing the validity of the questionnaire to be used is carried out with the help of 2 parties, that is the supervisor and 1 employee from PT. XYZ. This validation aims to simplify the display and content so that it is easy to understand and does not transmit misunderstandings to respondents. Then the validated questionnaire is corrected. Questionnaires that have gone through the improvement stage will be declared correct by the relevant parties after several adaptations have been made. After all the processes are certain, then the questionnaire is used to obtain related data.

5. Assesment of Risk Event and Risk Agent

Based on the risk events and risk agents, after which the risk events and risk agent are carried out. The assessment carried out is to fill out a risk event assessment questionnaire on a scale of 1-10. A value of 1 state that no visible effects are caused until a value of 10 states that the effect is the most dangerous. The results of the assessment and recapitulation of severity calculations can be seen in (Table 8.1).

TABLE 8.1 RESULTS OF ASSESSMENT AND RECAPITULATION OF SEVERITY CALCULATION

Risk Event (Ei)	Respond					*Si*
	1	2	3	4	5	
E1	8	2	7	8	10	7,00
E2	10	4	7	8	6	7,00
E3	7	9	6	8	10	8,00
E4	8	3	6	8	7	6,40
E5	5	6	10	8	8	7,40
E6	7	7	9	7	8	7,60
E7	2	6	6	6	10	6,00
E8	2	4	8	4	8	5,20
E9	8	7	6	7	8	7,20
E10	10	5	6	7	7	7,00
E11	8	4	10	10	8	8,00
E12	5	5	6	7	8	6,20
E13	3	5	9	7	8	6,40
E14	2	4	3	7	8	4,80
E15	3	7	8	8	7	6,60
E16	3	6	8	10	8	7,00
E17	5	8	8	8	8	7,40
E18	3	7	7	8	6	6,20
E19	5	6	8	6	8	6,60
E20	2	4	7	7	7	5,40
E21	2	6	7	8	4	5,40
E22	2	5	7	8	5	5,40
E23	3	5	6	8	8	6,00

(Source: Primary Data, 2022)

Assessment of the risk agent is carried out to determine the degree of occurrence of each risk agent. Risk assessment is carried out by filling out a risk assessment questionnaire on a scale of 1-10.

A value of 1 represents that the event rate is one-time in activity until a value of 10 represents that the incidence rate is more than once. The results of the assessment and recapitulation of occurance calculations can be seen in (Table 8.2).

TABLE 8.2 RESULTS OF ASSESSMENT AND RECAPITULATION OF OCCURANCE CALCULATIONS

Risk Agent (Ai)	Respond					*(Oi)*
	1	2	3	4	5	
A1	3	2	2	4	6	3,40
A2	10	7	9	9	6	8,20
A3	7	3	3	2	2	3,40
A4	7	6	2	2	2	3,80
A5	2	2	3	2	1	2,00
A6	8	6	1	2	4	4,20
A7	5	2	1	3	2	2,60
A8	2	2	2	2	1	1,80
A9	7	2	6	7	1	4,60
A10	9	5	3	5	5	5,40
A11	7	5	7	5	5	5,80
A12	6	2	4	4	2	3,60
A13	4	6	5	2	2	3,80
A14	3	3	2	2	2	2,40
A15	6	5	5	6	1	4,60
A16	3	6	1	4	1	3,00
A17	6	5	4	8	2	5,00
A18	4	2	5	5	2	3,60
A19	2	2	1	3	1	1,80
A20	4	3	6	7	1	4,20
A21	2	3	4	1	2	2,40

Risk Agent	Respond					(Oi)
A22	2	3	5	3	2	3,00
A23	2	4	1	1	1	1,80
A24	2	2	2	3	2	2,20
A25	1	2	4	2	3	2,40
A26	2	2	2	2	1	1,80
A27	2	4	3	3	1	2,60

(Source: Primary Data, 2022)

6. Assesment of The Correlations between Risk Event and Risk Agent

The assessment of the relationship between risk events and risk agent is carried out after getting answers from respondents regarding the severity of risk events and also the occurrence of risk agent. This correlation assessment is carried out by conducting a correlation questionnaire assessment between risk events and risk agent with scale values of 0,1,3, and 9. A value of 0 states that there is no relationship until a value of 9 expresses a very strong relationship between the risk event and the risk agent. The results of Assesment of The Correlations between Risk Event and Risk Agent can be seen in Table (8.4).

TABLE 8.4 RESULTS OF ASSESMENT OF THE CORRELATIONS BETWEEN RISK EVENT AND RISK AGENT

Code	Respond					*Correlation*
	1	2	3	4	5	*(Ri)*
E1-A1	1	3	9	9	1	4,6
E2-A2	9	9	9	9	9	9
E3-A3	9	9	9	9	3	7,8
E4-A4	3	3	1	1	1	1,8
E5-A5	3	3	1	1	3	2,2
E6-A6	1	9	9	9	1	5,8
E7-A7	0	9	9	1	9	5,6
E8-A8	1	3	0	1	3	1,6
E9-A9	3	9	3	3	3	4,2
E10-A10	9	9	3	2	9	6,4
E11-A11	3	3	9	9	3	5,4
E12-A12	1	3	9	9	1	4,6
E13-A13	0	3	3	1	3	2
E14-A14	1	0	3	3	1	1,6
E15-A15	1	3	9	9	9	6,2
E15-A16	0	0	1	1	1	0,6
E16-A17	1	1	9	1	1	2,6
E16-A18	1	1	9	1	0	2,4
E17-A19	1	0	1	1	0	0,6
E18-A20	3	3	9	3	0	3,6
E18-A21	1	1	3	1	0	1,2
E18-A22	0	0	1	1	1	0,6
E19-A23	0	0	1	0	1	0,4
E20-A24	0	1	3	1	1	1,2
E21-A25	1	0	0	1	1	0,6
E22-A26	3	0	3	1	1	1,6
E23-A27	3	1	3	1	1	1,8

(Source: Primary Data, 2022)

7. Calculations Aggregate Risk Potential (ARP)

ARP value is a value that indicates how much the risk agents needs to be addressed from its frequency impact. The risk agents that are the priority of the preventive measures to be taken are those with the highest ARP value. The results of Assessment and Calculation of Aggregate Risk Potential (ARP) Calculations can be seen in (Table 8.3).

TABLE 8.3 RESULTS OF ASSESSMENT AND CALCULATION OF AGGREGATE RISK POTENTIAL (ARP) CALCULATIONS

No	Risk Agent	ARP	No	Risk Agent	ARP	No	Risk Agent	ARP
1	A1	109,48	15	A15	188,23	15	A15	188,23
2	A2	516,6	16	A16	11,88	16	A16	11,88
3	A3	212,16	17	A17	91	17	A17	91
4	A4	43,78	18	A18	60,48	18	A18	60,48
5	A5	32,56	19	A19	7,99	19	A19	7,99
6	A6	185,14	20	A20	93,74	20	A20	93,74
7	A7	87,36	21	A21	17,86	21	A21	17,86
8	A8	14,98	22	A22	11,16	22	A22	11,16
9	A9	139,1	23	A23	4,75	23	A23	4,75
10	A10	241,92	24	A24	14,26	24	A24	14,26
11	A11	250,56	25	A25	7,78	25	A25	7,78
12	A12	102,67	26	A26	15,55	26	A26	15,55
13	A13	48,64	27	A27	28,08	27	A27	28,08
14	A14	18,43						

(Source: Primary Data, 2022)

8. Risk Evaluation

Based on the Aggregate Risk Potential (ARP) value, after that, the risk evaluation stage is carried out. At this stage, it aims to determine the priority of the risk agent and it is necessary to carry out mitigation measures. Determining the priority level of the risk

agent needs to be addressed by analyzing based on Aggregate Risk Potential (ARP) ratings with the help of a Pareto diagram which can be seen in (Table 8.5).

TABLE 8.5 PARETO DIAGRAM CUMULATIVE NUMBER PROCESSING RESULTS

Risk Agents	ARP	ARP Cumulative	Percentage Cumulative (%)
A2	516,60	517	20,2%
A10	250,56	767	29,9%
A11	249,48	1017	39,7%
A3	212,16	1229	47,9%
A15	188,23	1417	55,3%
A6	185,14	1602	62,5%
A9	139,10	1741	67,9%
A1	109,48	1851	72,2%
A12	102,67	1953	76,2%
A20	93,74	2047	79,9%
A17	91,00	2138	83,4%
A7	87,36	2226	86,8%
A18	60,48	2286	89,2%
A13	48,64	2335	91,1%
A4	43,78	2378	92,8%
A5	32,56	2411	94,0%
A27	28,08	2439	95,1%
A14	18,43	2457	95,9%
A21	17,86	2475	96,6%
A26	15,55	2491	97,2%
A8	14,98	2506	97,7%
A24	14,26	2520	98,3%
A16	11,88	2532	98,8%
A22	11,16	2543	99,2%
A19	7,99	2551	99,5%
A25	7,78	2559	99,8%
A23	4,75	2564	100,0%

(Source: Primary Data, 2022)

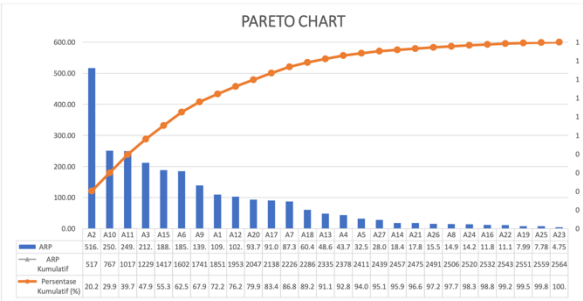

Figure 10. Pareto Chart
(Source: Primary Data, 2022)

A cumulative ARP value percentage of 80% covers several risk agents. The risk agent is included in the priorities that need to be designed as mitigation measures. The priority risk agent are a sudden change in demand (A2), Workers not present (A10), Lack of maintenance (A11), Communication and information errors between PPIC and production managers (A3), and inadequate storage facilities (A15).

House of Risk Stages 2

1. Designing Mitigation Measure

Based on the results of the priority level of the cause of risk, then proceed to the process of designing mitigation measures intended for each risk agent. There are 6 mitigation measures that can be applied in the hope of reducing the impact of the risk event and the emergence of risk agent.

2. Correlation Assessment between Risk Mitigation and Risk agent

This stage is carried out to determine the relationship value of the priority of the risk agent with the risk mitigation indicators that have been previously determined. This stage is carried out by issuing an assessment questionnaire on a scale of 0,1, 3 to 9, the smallest value stating a very strong relationship between the priority of the risk agent and mitigation measures. The results of the assessment and recapitulation of the correlation between the risk agent and risk mitigation measures can be seen in (Table 8.6).

TABLE 8.6 RESULT OF ASSESMENT AND RECAPITULATION OF CORRELATION CALCULATIONS BETWEEN THE RISK AGENT AND RISK MITIGATION

Code	Respond					
	1	2	3	4	5	Ri
A2-PA1	9	9	9	9	9	9,00
A2-PA4	1	0	0	9	0	2,00
A10-PA2	9	9	3	1	3	5,00
A10-PA6	3	9	3	0	0	3,00
A11-PA2	3	0	0	0	0	0,60
A11-PA3	9	9	9	3	1	6,20
A3-PA4	9	9	3	9	1	6,20

A15-PA4	0	0	3	0	9	2,40
A15-PA5	9	9	1	3	1	4,60
A15-PA6	0	0	3	0	9	2,40

(Source: Primary Data, 2022)

3. Calculations Total Effectiveness (Tek)

The stage after assessing the relationship between the risk agent and risk mitigation is to determine the Total Effectiveness. The calculation of the Total Effectiveness value serves to find out the level that is useful for knowing the level of use of each mitigation action that has been set in the face of the priority of the risk agent. The Total Effectiveness value is obtained from the calculation of the formula (Tek). (Table 8.7) shows the Total Effectiveness calculation and recapitulation of the assessment calculation of each mitigation action

TABLE 8.7 PROCESSING RESULT AND RCAPITULATION OF TOTAL EFFECTIVENESS

No	Mitigation	*Total Effectiveness*
1	PA1	4649,40
2	PA2	1402,49
3	PA3	1546,78
4	PA4	2800,35
5	PA5	865,87
6	PA6	1203,44

(Source: Primary Data, 2022)

It can be seen that the PA1 mitigation measures (Conducting inventory control) have the highest Total Effectiveness value of 4649.40. This is because this mitigation step correlates with the cause of large risks. As for mitigation measures, PA5 (Warehouse capacity increase) has the smallest Total Effectiveness value of 865.87. This is because these mitigation measures have only a small relationship and are only related to one cause of risk.

4. Calculations Degree of Difficulty (DK)

After calculating the Total Effectiveness (Tek) of the risk mitigation measures, the next step is measuring the Degree of Difficulty (DK). This stage aims to determine the level of difficulty of the mitigation measures to be applied. The implementation is by filling out a questionnaire assessing the degree of difficulty of mitigation measures on a scale of 1 to 5. A value of 1 states that mitigation measures are very easy to implement, up to a value of 5 states that mitigation measures are very difficult to implement..

Then an assessment was carried out from each respondent, that is 1 Supply Chain Manager, 1 Purchasing Assistant Manager, 1 Production Manager, 1 Customer Service, and 1 Logistics Manager. The results of the assessment and recapitulation of Deggree of Difficulty respectively mitigation measures are shown in (Table 8.8)

TABLE 8.8 PROCESSING RESULT AND RECAPITULATIONS DEGREE OF DIFFICULTY OF MITIGATIOS ACTIONS

Code	Respond					DK
	1	**2**	**3**	**4**	**5**	
PA1	2	1	1	3	1	1,60
PA2	3	3	3	2	3	2,80
PA3	2	2	3	2	3	2,40
PA4	1	2	1	1	1	1,20
PA5	4	4	5	4	4	4,20
PA6	2	3	3	2	3	2,60

(Source: Primary Data, 2022)

5. Calculations Rasio Degree of Difficulty (ETDk)

This assessment aims to determine the priority ranking of the mitigation actions evaluated. The value is obtained from the calculation of the ETDK equation formula. The results of processing and recapitulation of the rasio Total Effectiveness to Difficulty values can be seen in (Table 8.9):

TABLE 8.9 RESULT OF PROCESSING AND RECAPITULATION OF RASIO TOTAL EFFECTIVENESS TO DIFFICULTY VALUES

No	Code	*Single*	*Min*	*ETDk*
1	PA1	4649,40	1,60	2905,88
2	PA2	1402,49	2,80	500,89
3	PA3	1546,78	2,40	644,49
4	PA4	2800,35	1,20	2333,62
5	PA5	865,87	4,20	206,16
6	PA6	1203,44	2,60	462,86

(Source: Primary Data, 2022)

Assessment results of the correlation between mitigation actions and risk agent, the value of Total Effectiveness (Tek), assessment of the Degree of Difficulty (DK), and calculation of the Rasio Total Effectiveness to Difficulty (ETDk) in the input into the second stage of the house of risk table, the

function of this table are to summarize the results of assessments and calculations for easy understanding. The table of the second stages of risk can be seen in (Table 8.10).

TABLE 8.10 TABLE HOUSE OF RISK STAGES 2

Risk Agent	Mitigations						*ARP*
	PA1	PA2	PA3	PA4	PA5	PA6	
A2	9			2			516,60
A10		5				3	250,56
A11		0,6	6,2				249,48
A3				6,2			212,16
A15				2,4	4,6	2,4	188,23
TEK	4649,40	1402,49	1546,78	2800,35	865,87	1203,44	
DK	1,60	2,80	2,40	1,20	4,20	2,60	
ETDK	2905,88	500,89	644,49	2333,62	206,16	462,86	
Rank	1	4	3	2	6	5	

(Source: Primary Data, 2022)

6. Manajerial Implications

Based on the results of the overall assessment in the second stages of the House of Risk (HOR) table, the ranking of mitigation measures can be applied to employees at PT. XYZ can be seen from the highest Rasio Total Effectiveness to Difficulty (ETDK) value. We can see that 3 mitigation measures are best applied to PT. XYZ empoloyees to overcome the risks faced are as follows:

a. PA1 (Inventory control) Mitigation measures by controlling inventory are carried out to prevent problems of errors in forecasting, ups, and downs in raw material prices, and delays in receiving raw materials. This mitigation action is based on maintaining the inventory of raw materials so that there is no shortage or excess inventory. Inventory control is very well done by not paying attention to the uncertainty of raw material demand that occurs.

b. PA4 (Improve coordination between divisions)

The next mitigation action is to improve coordination between divisions. This mitigation measure serves in overcoming the problem of delays in receiving raw materials. Coordination is like communication with external parties. Coordination and cooperation relationships with external parties must run very well and smoothly so that common goals can be achieved without any or very small obstacles encountered, improve communication and cooperation reduce operational planning errors, and lack of raw material inventory.

c. PA3 (Schedule maintenance of production machines periodically)

The next mitigation action is to schedule the maintenance of production machines at regular intervals. This mitigation action is carried out to overcome the problem of damage or engine congestion when the production process is running, and it is hoped that this action can make the machine run properly. Doing maintenance regularly will be more optimal than repairing tools/machines when they are damaged. Damage to the machine can certainly make losses to the company because it can affect the production process.

5. Conclusion

Based on the results of the study, supply chain activities there were 23 risk events with 27 risk agents. From a total of 27 risk agent, 5 risk agent were selected for which mitigation measures need to be determined. The chosen risk agent with the highest ARP value was A2 (sudden change in demand) which was 516.60, while the lowest was A15 (inadequate storage facilities) which was 188.23.

The design of preventive measures carried out on selected risk agent obtained 6 mitigation measures, from the results of the evaluation of mitigation measures, it is known that the most effective mitigation action to be carried out is PA1 (Conducting inventory control) with an ETDk value of 2905.88. As for mitigation measures, the smallest PA5 (Increasing warehouse capacity) with an ETDk value of 206.16.

6. Suggestion

1. For researchers who conduct this research, it is better to take companies that have a larger capacity and then take more speakers and respondents, so that they can provide more indicators and also more maximum conclusions.
2. Furthermore, researchers should be able to identify and carry out more indicators of risk

events, causes of risks, and risk mitigation actions to get a more detailed picture.

3. For companies, the output of this research should be used for evaluation to find out the supply chain risk mitigation measures that need to be implemented by PT. XYZ to reduce the risks that arise and identify using SCOR completely so that the indicators obtained are also complete and so that they can measure with a maximum scale and better in the future to pay more attention to a more structured scheduling system, especially in raw material inventory planning activities, production, and delivery. It is hoped that it will be more able to build cooperation and build intensive communication with internal and external parties.

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