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ANALYSIS OF SUPPLY CHAIN RISKS USING SUPPLY CHAIN OPERATION REFERENCE (SCOR) HOUSE OF RISK (HOR) AND FUZZY ANALYTICAL NETWORK PROCESS (FANP) METHOD

Abstract: *This paper the risk of supply chain systems using the method of Supply Chain Operation Reference (SCOR), House of Risk (HOR) and Fuzzy Analytical Network Process (FANP). The SCOR method is used to identify risks that will appear in the supply chain flow by dividing into five processes, namely plan, source, make, deliver, and return. Furthermore, the HOR method is used to identify risk sources so as to obtain the aggregate risk potential (ARP). As for designing risk handling, the FANP method is used so that it produces a sequence of weights from risk handling. A case in a paralon pipe company was used for the application of research. From this study, 25 risk events and 25 risk sources were identified to get 25 Aggregate Risk Potential (ARP). The Pareto chart is used to get 10 Risk agents. The HOR method is used to obtain 23 alternative risk controls. Furthermore, the FANP method is used to determine the priority of 23 risk controls. And with a table, we get the priority order of risk control.*

Keywords: *Supply Chain; Risk; House of Risk; Fuzzy Analytical Network Process.*

1. Introduction

A supply chain is a network of companies that work together to create and deliver a product to the end user. The supply chain involves an ongoing relationship regarding information, goods and money. Information flows both from upstream to downstream and from downstream to upstream, while goods generally flow from upstream to downstream.

Viewed horizontally, there are five main components or actors in the supply chain, namely suppliers, manufacturers, wholesalers (distributors), retailers, and customers.

Vertically, there are several main components of the supply chain, namely buyers, transporter, warehouse, seller, and so on.

Supply chain risk management is collaboration with partners in the supply chain to implement a risk management process to deal with emerging risks and uncertainties caused by logistical activities or resources in the supply chain.

Risks that occur in supply chain management can be classified into three, namely: Internal risk that arises from within the company organization, supply chain risk that arises from outside the organization but is still in the supply chain, and external risk that comes from external to the supply chain and arises. from interactions with the environment

Internal risk is a risk that arises from within the company organization, including: risks inherent in operational processes such as accidents, reliability of equipment and risks

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that arise directly from management decisions, such as batch size selection, safety stock levels, company financial problems and delivery schedule.

Supply chain risk is a risk that arises from outside the organization but is still in the supply chain. This occurs from interactions between members of the supply chain. Especially in terms of: risks originating from suppliers, among others, reliability, material availability, lead times, problems with shipping, industrial actions, etc. and risks originating from consumers; variable demand, payments, problems in the demand process, and customized requirements.

External risk is the risk that comes from the external supply chain and that arises from interactions with the environment.

This supply chain risk occurs in all companies that are members of the supply chain network, which consists of: suppliers, manufacturers, and distributors.

Gunung Cahaya Utama Incorporation (GCU) is a paralon pipe manufacturing company that is part of the supply chain network for paralon pipe products. As a manufacturing company, GCU gets material supplies from five suppliers and sells its products to one distributor (buyer).

GCU produces based on make to stock and make to order. The company serves general consumers with a make to stock system and serves regular customers with a make to order system. To support production activities, the company is supported by several suppliers.

Business activities in companies often experience uncertainty. Internal uncertainty is a major factor in this company which has an influence on the problems that occur. Some obstacles arise related to raw materials, product quality, available quantity, lack of expertise and qualifications of human resources and machine failure or downtime.

In addition to internal uncertainties there are also external uncertainties, including: uncertainty in demand and uncertainty in supplier supply. This uncertainty is a potential risk that can disrupt the company's supply chain activities. Meanwhile, the company has not carried out risk management.

Several studies on supply chain risk management have been carried out by researchers. (Moeinzadeh & Hajfathaliha, 2009) conduct research on supply chain risk management in companies engaged in the development and implementation of electricity, oil, gas and rail transportation. In his research, The fuzzy ANP and Visekriterijumsko Kompromisno Rangiranje (VIKOR) methods were used. Fuzzy ANP method is used to divide priority risk categories in the supply chain, while the VIKOR method is used to determine the most prioritized risk sequences. In other study, (Pujawan & Geraldin, 2009) conduct supply chain risk management research in the petrochemical industry using SCOR models such as plan, source, make, delivery, and return combined by the HOR. HOR 1 is used to determine priority risk and design risk handling while HOR 2 is used to determine the weight of risk management that will be prioritized. Meanwhile, (Berenji & Anantharaman, 2011) conducting supply chain risk research in the manufacturing industry using Fuzzy ANP and Fuzzy TOPSIS methods. Fuzzy ANP is used to determine the weight of supply chain risk. In this study supply chain risk is divided into risk suppliers, operation risk, demand risk, competitive / economic risk, control plan risk and social / political risk. After identifying the high risk weighting, risk strategy planning is done with the Fuzzy TOPSIS method.

Astutik et al. (2015) conducted a research on Risk Management Strategies in Organic Fertilizer Supply Chains Using Fuzzy Analytical Hierarchy Process (FAHP) Method ". In his research, risk analysis is done by using SCOR models such as plan, source, make, delivery, and return combined by HOR 1. HOR 1 is used to determine priority risk and design risk management strategies, while Fuzzy AHP method is used to determine the weight of the risk management strategy will be prioritized in the hope that it can handle supply chain risks to company.

Klumpp and Abidi (2013) conduct supply chain risk simulation research. In his research the risk factors considered were natural disasters, then divided into several risk categories including Geophysical, Meteorological, Hydrological, Climatological. Weighting is done by using the ANP method to determine the risks that will be handled first.

Dhurandher et al. (2013) conduct supply chain risk management research. In this research, the supply chain risk has become inaccuracies in forecasting, damage during the production process, economic and political changes, and natural disasters. Fuzzy AHP method in this study has a role to determine the weight of supply chain risk so that the highest risk weight will be known and a risk management strategy will be carried out based on the highest risk weighting.

Ulfah et al. (2016) conducted a Design and Build Research on Refined Sugar Supply Chain Management Model. Supply chain performance measurements were assessed based on the desire of refined sugar consumers using the Kano model. Then do supply chain risk analysis using SCOR models such as plan, source, make, delivery, and return into the HOR. HOR 1 is used to determine priority risk and design risk handling while HOR 2 is used to determine the weight of risk management that will be prioritized.

Ariyanti and Andika (2016) conduct supply chain risk management research using the FMEA method. In researching the FMEA method is able to provide an assessment of the impact, probability and detection of the risks that arise in the supply chain.

Mangla et al. (2015) conduct supply chain risk management research in the automotive industry. Parsamehr and Fatemeh in their research divided supply chain risk into external risk, final customer risk, supplier risk, manufacturing risk, and distributor risk. Fuzzy ANP method is used to determine the weight of the supply chain risk.

Based on these literatures, it can be synthesized that the House of Risk (HOR) Method is able to analyze risks and design risk management in supply chain activities. The weakness of the House of Risk (HOR) method is that there is no correlation between sources of risk in determining the weight of risk management. So, some of these researchers combined the House of Risk (HOR) and fuzzy AHP methods to determine the weight of risk management. In its development, the AHP fuzzy method was developed into the ANP fuzzy method because it was able to improve the weakness of the AHP in the form of the ability to accommodate the interrelationships between criteria or or sub-criteria. There are 2 types of linkages in the ANP method, namely the linkages in a set of elements (inner dependence) and the relationships between different elements (outer dependence). The existence of these linkages causes the ANP method better than the AHP method.

Based on this synthesis, this research aims to analyze supply chain analysis using the House of Risk (HOR) and Fuzzy Analytical Network Process (FANP) methods in the PVC pipe industry.

2. Theoritical Framework

2.1 The House of Risk (HOR) method

The House of Risk (HOR) method is the development of the FMEA method (Failure Mode and Effect Analysis) and House of Quality (HOQ) tools on the Qualtiy Function Deployment (QFD). Adopting the procedure above, HOR I was developed through the following steps (Pujawan & Geraldin, 2009):

1. Identifying risk events that can occur in every business process. This can be done through the supply chain mapping process (plan, source, make, deliver, and return)

and then identify "what can be wrong" in each of these processes.

2. Assessing the impact (severity) of the risk event (if it occurs) with a scale of 1-5 where 5 represents very severe. The severity of each risk event is entered into the right column of, indicated as Si.
3. Identifying risk agents and assess the likelihood of occurrence of each risk agent. Here, a scale of 1-5 is also applied where 1 means almost never happens and the value of 5 means almost certainly occurs. The risk agents (Aj) are placed in the top row of the table and the corresponding occurrence is in the bottom row, denoted as Oj.
4. Developing a relationship matrix, namely the relationship between each risk agent and each risk event, Rij (Agrawal et al., 2016) where 0 represents no correlation and 1, 3, and 9 represent, respectively, low , medium, and high correlation.
5. Calculating the aggregate potential risk of agent j (ARPj) which is determined as the product of the probability of occurrence of the risk agent and the aggregate impact generated by the risk event caused by the risk agent j. The calculation of the ARP value uses the following calculation:

   $$ARP\ j = Oj\ \Sigma\ Si\ Rij$$

6. Rank of risk agents according to potential aggregate risk in descending order (from big to low value).
7. Determination of the priority risk potential category and non priority based on the Pareto diagram using the Pareto legal principle, known as the 80: 20 law. It means that 80% of the company's losses are caused by 20% risks and 80% of crucial risks the company's risk impact can be overcome. Then the risk management of priority risk agents is carried out.

2.2 Fuzzy Analytical Network Process

Fuzzy methods accommodate the vague nature of decision making to provide judgment which can overcome uncertainty in qualitative criteria. While Analytic Network Process (ANP) method is a multi-criteria valuation method for decision structuring and analysis that has the ability to measure consistency of valuation and flexibility in choice at the subcriteria level. The steps in working on the Fuzzy Analytical Network Process (FANP) according to (Kusumadewi et al., 2006) is as follows:

1. Build a problem model in a structured manner
2. Make a paired comparison questionnaire
3. Change the linguistic variables into fuzzy numbers from the paired comparison questionnaire
4. Calculate geometric averages .
5. Defuzzifikasi
   Defuzzification is calculated using the center of gravity method (COG). The formulas of defuzzification are as follows.
6. Making supermatrix
   The supermatrix to be arranged is super matrix and super matrix limit.

3. Research Method

This research is a descriptive study, which aims to describe or describe accurately the facts and properties of an object. This descriptive research is commonly referred to as survey research because the data used are collected by interviewing techniques and supported by interview guides and questionnaire schedules.

The object of this research is a paralon pipe manufacturing company, with the scope of the planning, logistics, purchasing, production, distribution and sales departments.

Data were collected by means of observation, interviews, and questionnaires. Questionnaires were designed, distributed, filled out, collected, repaitulated, and analyzed.

The questionnaires are: risk event questionnaire, risk source questionnaire, risk event and risk source relationship questionnaire, relationship assessment questionnaire between risk events and risk sources, risk management questionnaire, and pairwise comparison questionnaire.

The risk event questionnaire is a questionnaire filled out by respondents to provide an event risk assessment. This questionnaire is filled in by the Supervisor Planning, Supervisor Purchasing and Production Supervisors. There are five options that the respondent can fill in, namely: Very Impactless, Impactful, Sufficiently Affected, Impacted, or Highly Impacted

A risk source questionnaire is a questionnaire filled out by respondents to provide an assessment of the frequency with which a risk source occurs. There are five choices that respondents can choose, namely: Very Infrequent, Infrequent, Quite Frequent, Frequent, and Very Often. This questionnaire is also filled out by the Planning Supervisor, Purchasing Supervisor and Production Supervisor.

The relationship assessment questionnaire between risk events and risk sources is a questionnaire to ask respondents for responses to assess the relationship between risk events and risk sources. Respondents who filled out this questionnaire were: Planning Supervisor, Purchasing Supervisor and Production Supervisor.

In this questionnaire, the value for describing the relationship between the risk event and the risk source is an integer that lies between the values 1 to 9.

The risk management questionnaire is a questionnaire filled out by respondents to provide alternative risk treatment strategies. Respondents who filled out this questionnaire were: Planning Supervisor, Purchasing Supervisor and Production Supervisor.

The pairwise comparison questionnaire is a questionnaire filled out by respondents to assess the comparison between criteria and between sub-criteria. The criterion in this case is the priority risk agent. The sub-criteria in this case is risk control.

The respondents on the questionnaire were Supervisor Planning, Supervisor Purchasing and Production Supervisor.
There are nine pairs of comparison scale values, starting in sequence from number one to number nine. The paired comparison value options are: Just Equal, which means that the two elements are equally influential, Weakly More Important, which means that one element is more influential than the other, Strongly More Important, which means that one element is very influential compared to the other, Very Strongly More Important , which means that one element is clearly more influential than other elements, and Absolutely More Important, which means that one element is absolutely more influential than other elements.

4. Results

4.1 Agregate Risk Potential (ARP) and Handling Priority

A questionnaire is used to obtain risk event data in a pvc pipe industry. Based on the results of the questionnaire, obtained 25 risk events that have occurred in the past.
The second questionnaire was given to the management of the industry to determine the aggregate risk potential (ARP). Based on the results of the second questionnaire, obtained 17 potential aggregate risk potential (ARP). Table 1 shows The ARP sequence.

Table 1. Sequence of ARP

Code	Risk Agent	Sequence	ARP
A17	There is no maintenance management	1	345
A5	Lack of communication between departments	2	344
A18	Quality inspection is not thorough	3	270
A11	Inspection of the receipt of raw materials is not accurate	4	261
A14	There is no occupational health and safety management	5	225
A21	Sudden purchase request	6	225
A25	marketing management is not good	7	204
A19	Lack of expertise and qualifications of human resources	8	177
A12	Depends on one supplier	9	171
A7	limited transportation facilities	10	132
A1	Significant increase in demand	11	67
A2	Seasonal factor	12	66
A6	Limited of HRD	13	62
A15	Inefficient production	14	62
A16	Lack of preparation when the production process will be carried out	15	60
A22	The list of purchases does not cover clear specifications	16	60
A10	Electricity supply is disrupted	17	56

Of all 17 risk agents, it is necessary to determine which of the 17 ARPs is prioritized for further handling. The tool used is the Pareto diagram. Figure 1 shows the pareto diagram.

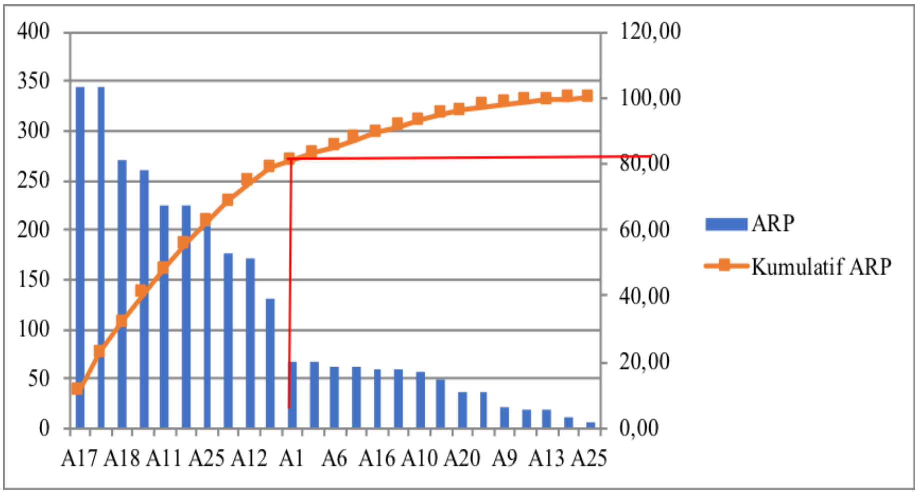

Figure 1. Pareto Diagram of Aggregate Risk Potential (ARP)

4.2 Risk Control Alternative

Based on the Pareto diagram in Figure 1, 10 risk agents were included in 80% of all 17 risk agents that were considered to be prioritized for further handling. Table 2. Shows the alternative handling of the 10 risk agents.

Table 2. Control of Supply Chain Risk

No	Code		Priority risk agent	Risk control	code
1	A_{17}		There is no maintenance management	Maintenance training	P1
				doing maintenance regularly	P2
2	A_{5}		Lack of communication between departments	Good communication	P3
				Making integrated information system	P4
				Making procedure operational standard	P5
3	A_{18}		Quality inspection is not thorough	Checking product quality	P6
				quality control training	P7
4	A_{11}		Inspection of the receipt of raw materials is not accurate	Checking raw material	P8
				Making inspection form	P9
5	A_{14}		There is no occupational health and safety management	Creating conduciv to work	P10
				use personal protective equipment	P11
6	A_{21}		Sudden purchase request	Flexible supply base	P12
				Making safety stock	P13
7	A_{25}		Marketing management is not good	Doing promotion	P14
				Discounting	P15
				doing marketing intelligence	P16
8	A_{19}		Lack of expertise and qualifications of human resources	Working motivation training	P17
				Recruiting workers	P18
				Doing daily evaluation	P19
9	A_{12}		Depends on one supplier	Cooperate with trusted suppliers	P20
				Give sanctions to suppliers	P21
10	A_{7}		limited transportation facilities	Additional means of transportation	P22
				Use of transportation services	P23

4.3 ANP Structure for Handling Risks

The next step is determining the ANP hierarchy. To make a hierarchy, it is needed to make initial provisions. The provision is, risk agents are considered as criteria. While alternative treatments are considered as sub criteria. Figure 2 shows the ANP hierarchy matrix that was created.

Next, a number of steps are taken to determine the weight of each criterion. The tool used is a paired comparison questionnaire. After getting the criteria weight, fuzzy ANP (FANP) analysis is carried out.

4.4 FANP Analysis

In fuzzy analysis, linguistic numbers are converted into fuzzy numbers. FANP analysis consists of fuzzyfication , defazzyfication and normalization.

The defuzzyfication table aims to find out how influential the criteria are one against the other criteria. for the A17 criterion against A5 is 0.675 which means that the criterion A17 is 0.675 times more influential than the A5 criterion, so the A5 criterion is 1.908 times more influential than the criteria A.

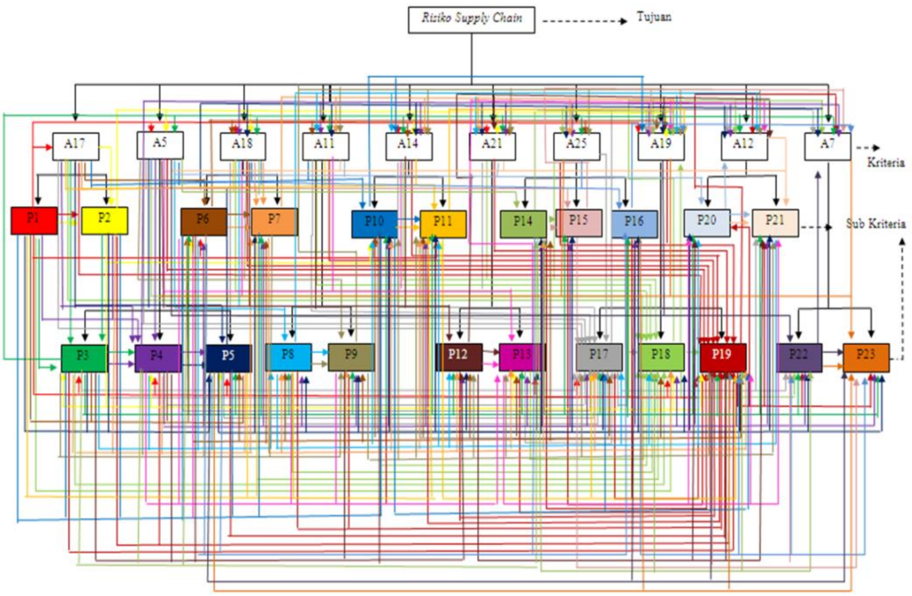

Figure 2. ANP network structure handling risk

Table 3. Defuzzyfication of Clusters Absence of Machine Maintenance Management (A17)

	A17	A5	A18	A14	A21	A19
A17	1,000	0,675	0,511	0,457	0,675	0,675
A5	1,908	1,000	0,675	0,457	1,000	0,511
A18	3,000	1,908	1,000	0,675	0,457	1,000
A14	1,422	1,422	1,908	1,000	1,000	0,675
A21	1,908	1,000	1,422	1,000	1,000	1,000
A19	1,908	3,000	1,000	1,908	1,000	1,000

4.5 Logical Consisteny Validation

Tujuan dari perhitungan konsistensi logis adalah untuk mengetahui konsistensi dari jawaban kuesioner yang telah diisi oleh responden, akan berpengaruh terhadap kestabilan hasil. Berikut merupakan langkah-langkah perhitungan konsistensi logis pada kluster tidak adanya manajemen perawatan mesin (A17) :

1. Calculating Consistency Ratio

The consistency ratio (CR) is the product of the weighted average calculation matrix with the priority vector (PV) of each row.

Table 4. Consistency Ratio

Weighted average calculation matrix x PV = CR

	A17	A5	A18	A14	A21	A19		Vp		
A17	1,000	0,675	0,511	0,457	0,675	0,675		0,101		0,6395
A5	1,908	1,000	0,675	0,457	1,000	0,511		0,128		0,8224
A18	3,000	1,908	1,000	0,675	0,457	1,000	×	0,172	=	1,1576
A14	1,422	1,422	1,908	1,000	1,000	0,675		0,183		1,1765
A21	1,908	1,000	1,422	1,000	1,000	1,000		0,184		1,1637
A19	1,908	3,000	1,000	1,908	1,000	1,000		0,233		1,5131

2. Vector Consistency

Vector Consistency is the division between the Consistency Ratio (CR) and the partial weight of each line. Vector Consistency can be seen in Table 5.

Table 5. Consistency Vector (CV)

CR	partial weight of each line	CV
0.639	0.101	6.355
0.822	0.128	6.437
1.158	0.172	6.745
1.176	0.183	6.426
1.164	0.184	6.312
1.513	0.233	6.508

3. The average entry (λmaks)

The average entry can be calculated using a formula:

$$\lambda_{maks} = \frac{\sum_{i=1}^{n} vector\ consistency}{n}$$

$$\lambda_{maks} = \frac{6{,}355+6{,}437+6{,}745+6{,}426+6{,}312+6{,}508}{6}$$

$$\lambda_{maks} = 6{,}464$$

4. Consistency Index (CI)

Consistency Index can be calculated using the formula:

$$CI = \frac{\lambda maks - n}{n-1}$$

$$CI = \frac{6{,}464-6}{6-1}$$

$$CI = 0{,}093$$

5. Consistency Ratio (CR)

Consistency Ratio can be calculated using the formula:

$$CR = \frac{\text{CI}}{Random\ consistency\ index}$$

$$CR = \frac{0{,}093}{1{,}24}$$

$$CR = 0{,}075$$

The calculation result shows that the value of the consistency ratio (CR) = 0.075. Which means that the value of CR <0.1. So based on this, it can be concluded that the respondents' answers are consistent. Meaning that the results of the questionnaire are valid.

After getting the criterion vector value and doing consistency validation, the weighted supermatrix can be calculated by multiplying the supermatrix not weighted by the criterion vector.

Table 6. Weighting criteria for Clusters Absence of Machine Maintenance Management

	A17	A5	A18	A14	A21	A19	m	Vp
A17	1,000	0,675	0,511	0,457	0,675	0,675	0,645	0,101
A5	1,908	1,000	0,675	0,457	1,000	0,511	0,819	0,128
A18	3,000	1,908	1,000	0,675	0,457	1,000	1,099	0,172
A14	1,422	1,422	1,908	1,000	1,000	0,675	1,173	0,183
A21	1,908	1,000	1,422	1,000	1,000	1,000	1,181	0,184
A19	1,908	3,000	1,000	1,908	1,000	1,000	1,490	0,233
Total							6,406	1,000

Against the weighted Supermatrix value, it is then iterated until it reaches steady state conditions. In the weighted supermatrix condition reaching steady state, the supermatrix Limit value is obtained, which is the final result of the FANP method. The supermatrix limit value is shown in table 7.

From table 7, besides showing the supermatrix limit value (weight), it also shows the order of alternative priority actions.

4.6 Risk Management Measures

With the risk control, the company can reduce the risks that occur. The following is the risk management carried out (table 8).

Table 7. Limit Supermatrix

Subcriteria	weight	Alternative priority
P1	0,0276	20
P2	0,0301	18
P3	0,0343	16
P4	0,0476	9
P5	0,0562	3
P6	0,0684	2
P7	0,0463	10
P8	0,0500	8
P9	0,0518	6
P10	0,0509	7
P11	0,0550	4
P12	0,0346	15
P13	0,0543	5
P14	0,0260	21
P15	0,0216	22
P16	0,0413	12
P17	0,0337	17
P18	0,0279	19
P19	0,1063	1
P20	0,0203	23
P21	0,0454	11
P22	0,0389	14
P23	0,0410	13
Total	1,00	

Table 8. Benefit of risk control

Priority risk agent	Risk control	Benefit
There is no maintenance management	Doing regularly maintenance	✓ Production runs well and is under control ✓ damage to the machine can be detected
Lack of communication between departments	Making integrated information system	✓ management can control the company.
Quality inspection is not thorough	Training quality control	✓ productivity increases ✓ human error is reduced
Inspection of the receipt of raw materials is not accurate	making inspection form	✓ good quality ✓ easy to do inspection.
There is no occupational health and safety management	use personal protective equipment	✓ comfortable to work ✓ Can eliminate work accidents
Sudden purchase request	Making safety stock	✓ Anticipate sudden request ✓ reduce product obsolescence
marketing management is not good	doing marketing intelligence	✓ choosing potential customers
Lack of expertise and qualifications of human resources	Working motivation training	✓ increasing productivity ✓ reducing human error ✓ there is work competence standard
Depends on one supplier	Cooperate with trusted suppliers	✓ The company has a trusted partner ✓ Suppliers work well
limited transportation facilities	Use of transportation services	✓ Products can be sent on time ✓ Consumers feel satisfied

5. Discussion

Risk control and risk control priorities will be discussed further. Risk Control can be seen in Figure 3. Figure 3 shows the number of 23 Risk Controls, where each of the Risk control values are: P1 of 2.76%, P2 of 3.01%, P3 of 3.43%, P4 of 4.76%, P5 of 5.62%, P6 of 6.84%, P7 4.63%, P8 at 5.00%, P9 at 5.18%, P10 at 5.09%, P11 at 5.50%, P12 at 3.46%, P13 at 5.43%, P14 at 2.60%, P15 at 2.16%, P16 at 4.13%, P17 of 3.37%, P18 of 2.79%, P19 of 10.63%, P20 of 2.03% P21 of 4.54%, P22 of 3.89%, and P23 of 4.10%.

Furthermore, the risk control value can be sorted in the Priority Risk Control in Table 9.

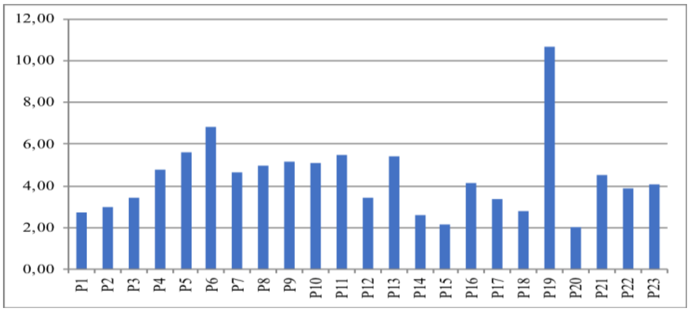

Figure 3. Risk control Number

Table 9. Risk Priority

Risk Priority Number (%)	Risk Priority	Code	Risk Control
10.63	1	P19	Regularly evaluating daily with a sheet sheet
6.84	2	P6	Ensuring product quality in each process
5.62	3	P5	Making a standard operational procedures for the department's internal communication system
5.50	4	P11	The use of PPE for each worker
5.43	5	P13	Making a safety stock product
5.18	6	P9	Making inspection forms to tighten inspection process
5.09	7	P10	Creating a conducive working environment
5.00	8	P8	Checking the quality of raw materials
4.76	9	P4	Making an integrated information system
4.63	10	P7	Training on quality control
4.54	11	P21	Determining penalty for supplier
4.13	12	P16	Conducting marketing intelligence
4.10	13	P23	Using transportation services
3.89	14	P22	Addition transportation facilities
3.46	15	P12	Flexible supply base
3.43	16	P3	Establishing good communication with various parties
3.37	17	P17	Training and motivation for workers
3.01	18	P2	Planning and carrying out routine maintenance
2.79	19	P18	Employee recruitment
2.76	20	P1	Maintenance training
2.60	21	P14	Conducting promotions
2.16	22	P15	Applying discount
2.03	23	P20	Cooperating with a reliable supplier

From the Table 9, it can be seen that the highest to lowest risk handling weight is regularly evaluating daily with a sheet sheet (P19) weighing 10.63%, ensuring product quality in each process (P6) with a weight of 6.84%, making a standard operational procedures for the department's internal communication system (P5) with a weight of 5.62%, the use of PPE for each worker (P11) weighing 5.50%, making a safety stock product (P13) weighing 5.43%, making inspection forms to tighten inspection process (P9) with a weight of 5.18%, creating a conducive working environment (P10) with a weight of 5.09%, checking the quality of raw materials (P8) with a weight of 5.00%, making an integrated information system (P4) with weighing 4.76%, training on quality control (P7) weighing 4.63%, determining penalty for supplier (P21) with a weight of 4.54%, conducting marketing intelligence (P16) with a weight of 4.13%, using transportation services (P23) with a weight of 4.10%, addition transportation facilities (P22) weighing 3.89%, flexible supply base (P12) weighing 3.46%, establishing good communication with various parties (P3) weighing 3.43%, training and motivation for workers (P17) with weighing 3.37%, planning and carrying out routine maintenance (P2) with a weight of 3.01%, employee recruitment (P18) weighing 2.79%, training on maintenance (P1) weighing 2.76%, conducting promotions (P14) weighing 2.60%, applying discount (P15) weighing 2.16%, and cooperating with a reliable supplier (P20) weighing 2.03%.

6. Conclusion

17 risks of supply chain to company be identified. Of 17 supply chain risks, 10 risk sources are categorized as the biggest risk source with a percentage of more than 80% of all risk risks. Therefore, 10 sources of risk get priority handling. Of the 10 risk sources, 23 alternative treatment measures were successfully established. Based on the results of FANP analysis, the order of priority for handling the source of risk is generated, as follows: P19 = 10.63%, P6 = 6.84%, P5 = 5.62%, P11 = 5.50%, P13 = 5.43% , P9 = 5.18%, P10 = 5.09%, P8 = 5.00%, P4 = 4.76%, P7 = 4.63%, P21 = 4.54%, P16 = 4.13%, P23 = 4.10%, P22 = 3.89%, P12 = 3.46%, P3 = 3.43%, P17 = 3.37%, P2 = 3.01%, P18 = 2.79%, P1 = 2.76%, P14 = 2.60%, P15 2.16%, P20 = 2.03%.

This research has also provided 10 suggestions for risk control and has been verified by the management of the company, which shows that risk control can provide benefits to the company if the company implements it.

The limitation of this research is that this research was conducted only in the pvc pipe industry. The results of this study can help identify potential risk events in the supply chain network and determine the control of each risk so that it contributes to increased work comfort, increased productivity, increased product quality, and decreased reject product.

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