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Supply Chain Risk Analysis and Mitigation Using House of Risk in Furniture SMEs

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Abstract:- In each supply chain, both large and small companies have different levels of risk, which can have an impact on the continuity of the production process. Problems such as engine damage, late delivery, defective products, and others always occur and need to be addressed immediately. This study aims to identify the risks that have occurred or are likely to occur in the supply chain of Simaluy SMEs and determine which risks should be prioritized for mitigation using the HOR method. From the results of interviews and observations, the researchers found 18 risk events and 21 risk agents. Obtained 8 risk agents consisting of obstacles in the delivery of materials (A20), difficulty obtaining raw materials (A15), decreased employee productivity (A2), Human Error (A4), no maintenance schedule on the machine (A3), no cooperation with suppliers (A17), operators who do not work for certain reasons (A21) and machine damage (A6) identified in HOR 1 as a priority to be resolved first after the aggregate risk potential (ARP) value is calculated. Furthermore, HOR 2 proposed 8 preventive actions and determine the company's mitigation priorities based on the ratio of effectiveness to difficulty in implementing preventive measures.

Keywords:- *Aggregate Risk potential, HOR, preventive actions, Risk agent, Risk event, Supply Chain.*

I. INTRODUCTION

The existence of business competition that is so tight in the industrial world, requires companies to be able to compete to be superior. In practice, companies must maintain long-term relationships such as relationships with suppliers, customers, and distributors [1]. One strategy that can be carried out by businesses is to increase productivity and product quality, including identifying risks in a supply chain so that the sources of risk are identified [2].

What is meant by the supply chain itself is the network of business companies that work together to make and deliver products to end customers [3]. However, controlling supply chain activities is a challenge because there are many risks that can harm the company's business. Therefore companies need to know the main factors that can affect the smooth supply chain and what risk mitigation can be applied to overcome the risks that occur [4]. In order to minimize risk, Companies must develop risk management procedures that enable them to identify and manage potential risks at every stage of the supply chain.

In recent years, supply chain risk management (SCRM) has become increasingly important as a means of reducing supply chain uncertainty [5]. Supply Chain Risk Management (SCRM) is defined as the risk that occurs as a result of the process of moving materials from suppliers to final consumers [6]. Supply chain risk management (SCRM) includes a variety of strategies to manage supply chains effectively, companies must efficiently manage three types of flows: raw materials, money, and information [7]. SCRM significantly affects partner collaboration and the effectiveness of the entire production chain [8]. This involves a variety of strategies, including identifying, evaluating, mitigating, and tracking unanticipated events or conditions that may have negative impacts at any stage of the supply chain [9] [10]. Thus, supply chain risk management has become critical to successful supply chain operations. Risk management involves making decisions to accept, avoid, transfer, or share known risks, or implementing actions to reduce the consequences or likelihood of an adverse event. In summary, effective SCRM practices are essential for companies to manage risks and maintain the stability of their supply chain operations. In carrying out supply chain activities, the House of Risk (HOR) method can be used to identify and evaluate possible risks that may impact business and the environment [11].

IKM Simaluy is a furniture industry that produces various kinds of processed teak wood which is located in the Soumolewa environment, South Buton Regency. In producing their products, IKM uses a make-to-order system. The products produced are chairs, cabinets, beds, sills, window doors, fluting, and various other products. The results of the Simaluy IKM products are sold to the Surabaya market. Simaluy IKM supply chain activities often experience obstacles in the production process flow activities. Based on observations and interviews with owners of IKM Simaluy, there are several risk events that hinder, including material planning errors in both raw materials and supporting materials, supplier's failure to fulfill substandard material orders, machine damage, and other risks that break the supply chain of Simaluy IKM.

Several studies have been carried out on risk management in overcoming risk mitigation, including the Risk Mitigation of the Donut Product Supply Chain Using the House of Risk Method at Nicesy MSMEs [12]. Risk analysis and mitigation at PT. XYZ which is engaged in manufacturing and services [13]. FMEA is used for risk identification and mitigation at PT. X in the offshore facilities section that manages oil and gas [14]. The combination of HOR and fuzzy logic for supply chain risk mitigation at PT. X [15]. As well as the House of Risk

implementation on the SMES supply chain of manufacturing [16].

As for this research, the Supply Chain Operation Reference (SCOR) and House of Risk (HOR) will be used. however, it is different from previous research because this research focuses on the furniture industry whose main material is teak wood which has unique characteristics because the main raw material comes from nature, is rare, expensive, and can be standardized on the characteristics of the final product so that it can cause a risk of uncertainty in meet customer needs. It is hoped that this research can provide a good contribution to overcoming risks and mitigating sources of risk that can arise along the supply chain flow in Simaluy IKMs so that IKMs can produce smoothly.

II. RESEARCH METHOD

The first step in research is to identify problems that arise to assess the state or condition of the company, and then analyze problems that occur in the present and in the past through observation and interviews. The SCOR (Supply Chain Operation Reference) approach is used to measure supply chain performance, which has five main processes: plan, source, make, deliver, and return. The purpose of activity mapping is to make it easier to identify supply chain hazards [2].

The next step is using the House of Risk (HOR) method, where FMEA (Failure Modes and Effects Analysis) and House of Quality (HOQ) are combined in the HOR (House of Risk) to prioritize risk sources and select the first source whose action must be carried out in a way that most efficient. There are two steps taken in HOR, which are as follows: HOR1 is used to identify risks that must be prioritized first, you can use the 80:20 Pareto chart to identify the sequence of risks that need to be addressed, where 80% of the risks will be selected as the basis for implementing countermeasures. Then, HOR 2 is used to decide what should be implemented as a priority response. Its success depends on how well the business can implement these precautions. [17] that is :

- Identification of risk events (Ei) that occur at the source, make, delivery, and return stages of the planning process.
- *risk events*/Ei in the form of an event that causes a potential loss. The risk event is then assessed as “Severity/ *Si*namely assessing the severity of a risk event.
- *Risk Agent/Aj*or risk agent ie cause of the risk event occurs, then an assessment is carried out "Occurrence/Oj" is the level of opportunity occurrence of risk agents with scale
- Determine the correlation relationship (Rij) between the risk event and the risk agent. Use a scale of 0,1,3 and 9 namely: a scale of 0 with no correlation, 1 is low, 3 is moderate, and 9 high.
- Calculate the value of ARPj = Oj. ∑I Si. Ri
- Sort ARP Value (Aggregate Risk *Potential*) from largest to smallest, to simplify Aij's priority selection with the help of Pareto charts. The HOR 1 model can be seen in Figure 2 below.

The steps in the HOR 2 stage are:

- Identification of preventive actions (PA) to reduce the impact of risk agents.
- Determine the correlation value between risk agents and preventive actions (Ejk)
- Calculating total effectiveness (TEk) with the formula: Tech =ΣARPj x Ejk
- Calculate and assess the level of difficulty (Dk) using a scale of 3 (easily implemented), 4 (quite difficult to implement), and 5 (very difficult to apply).
- Calculate the total effectiveness ratio for each of the proposed actions. Calculate the value of ETDk = Tech/Dk
- Sort the proposed actions from the ETDk value from largest to smallest.

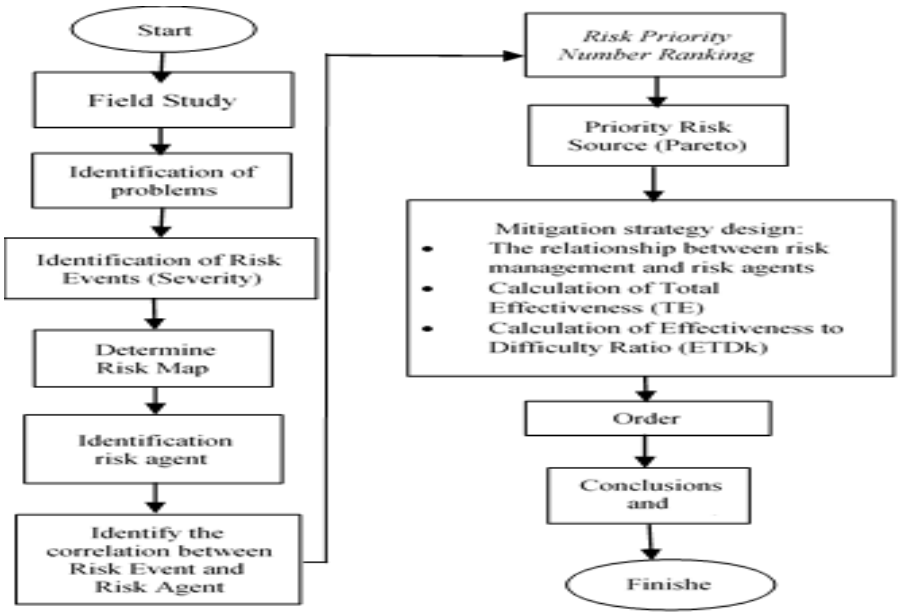

Fig. 1: Research Flowchart

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III. RESULTS AND DISCUSSION

A. HOR Stage 1

Risk is identified by looking at how all business operations are carried out, from the acquisition of raw materials to the delivery of finished goods. Interviews were conducted with business owners with an interest in supply chain activities to confirm these findings. The identification results will then be assessed using the scale used in the severity assessment. Determining the results of identifying the severity of each risk event based on interviews obtained with 21 hazard events (risk events). The identification of these risks can be seen in Table 1. A risk event is the occurrence of an event that causes potential harm to the company or the environment [18].

Table 1: Identification of Risk Events

Business Process	*Sub Process*	*Risk Events*	*code*	*Severity*
plan	Production Planning	Error planning raw materials and support	E1	5
	Purchase of materials	The order cannot be fulfilled by the supplier	E2	9
		Lack of budget	E3	9
		Fluctuating material prices	E4	6
Source	Receipt of materials	Delay in arrival	E5	8
		Discrepancies in the number of items dating with the order	E6	8
	Raw material inspection	Quality is not up to standard	E7	8
	Storage of materials	Lack of raw materials and support	E8	9
make	Implementation of the production process	Product measurement errors made	E9	7
		The process of splitting wood is not straight	E10	4
		Profiling isn't perfect	E11	5
		Failed cutting process	E12	3
		The paint-drying process takes a long time	E13	4
		engine failure	E14	9
		Materials are damaged	E15	9
	Production control	There is a defective product	E16	8
		Product completion time that does not meet the target	E17	8
deliver	Delivery of products to consumers	There was a delay in delivery	E18	6
		Lack of transportation	E19	6
return	Product returns	Product returns from customers	E20	8
	Product handling	There are additional expenses	E21	3

The next stage involves identifying risk agents. The results of the identification of possible sources of risk indicate that these sources often occur. This risk opportunity generates one or more risks that can disrupt the operations involved in the supply chain flow with a certain level of impact and 21 risk agents are obtained as shown in Table 2.

Table 2: Occurrence assessment (risk agent)

Risk Agent	*code*	*Occurrence*
Sudden requests	A1	2
Materials are difficult to obtain	A2	6
human error	A3	5
Decrease in employee productivity	A4	5
There is no cooperation with the supplier	A5	3
engine failure	A6	6
Worn profile blades	A7	5
The quality of raw materials is below standard	A8	4
There is a weather factor	A9	2
The level of product defects varies	A10	2
Limited means of transportation	A11	3
Lack of employee skills	A12	5
There are orders for materials from outside the area	A13	3
Lack of manpower	A14	2
Barriers to the delivery of materials	A15	8
There was a power outage	A16	5
There is no machine maintenance schedule	A17	8

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The customer gave the wrong size	A18	2
Less handling of rejected products	A19	3
Purchase of fewer materials	A20	8
The operator is not working for some reason	A21	6

The next stage in HOR 1 is to evaluate the magnitude of the relationship between the previously identified risk events and the risk agent. The correlation assessment between risk events and risk agents follows the criteria of 0 for no correlation, 1 for weak correlation, 3 for enough correlation, and 9 for strong correlation. And to produce the ARP value, it is done by multiplying the value of Occurrence with the sigma of the multiplication of the Severity value, and the number of correlations between the Risk event and the Risk agent. This formula is used to determine which risk agent needs to be completed first based on priority order. This is shown in Table 3 below.

Table 3: Stage 1 HOR Matrix

RE	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**	**A11**	**A12**	**A13**	**A14**	**A15**	**A16**	**A17**	**A18**	**A19**	**A20**	**A21**	**Si**
E1	3		9	3											1							5
E2	9				3										1							9
E3	3																		9			7
E4		9			1										3					9		6
E5		9			3				1		3		3		9							8
E6			1		3																	8
E7	1	3	3		9																	8
E8	3	9	1		9				3		1		9		9					9		9
E9			9	9														9				7
E10			9	3		1						1					3					4
E11			9	9			9					1					3					5
E12			9	3		9						1					3					3
E13									9													4
E14			1									9					9					9
E15		3			3			1					3									9
E16			1	9													1					8
E17		3	1	9		9			3					9	9	9	1			9	9	8
E18									3		9			3		1	1			1	9	6
E19																						6
E20								9		9												8
E21																			9			3
Oj	2	6	5	5	3	6	5	4	2	3	3	5	3	2	8	5	8	2	3	8	6	
ARPj	304	1692	1410	1440	783	618	225	324	226	216	261	465	396	180	2056	390	1112	126	81	2208	756	
Rank	14	3	5	4	7	9	17	13	16	18	15	10	11	19	2	12	6	20	21	1	8	

Table 4. Arp calculation results

Code	ARPj	%ARPj	% Cum
A20	2208	14,46%	14,46%
A15	2056	13,47%	27,93%
A2	1692	11,08%	39,01%
A4	1440	9,43%	48,44%
A3	1410	9,23%	57,67%
A17	1112	7,28%	64,96%
A5	783	5,13%	70,08%
A21	756	4,95%	75,03%
A6	618	4,05%	79,08%
A12	465	3,05%	82,13%
A13	396	2,59%	84,72%
A16	390	2,55%	87,27%

A8	324	2,12%	89,40%
A1	304	1,99%	91,39%
A11	261	1,71%	93,10%
A9	226	1,48%	94,58%

The risk factor rating is determined using the ARP value based on Table 3. The ranking starts with the highest ARP risk agent to the smallest. To make it easier to find the dominating risk agent value, the ARP rankings are then arranged in a Pareto chart.

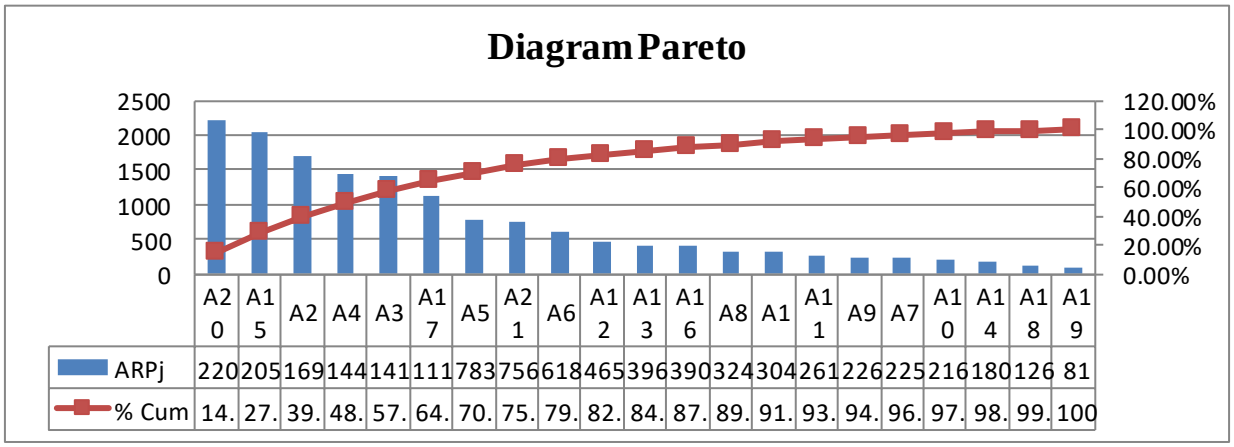

Fig. 2: Stage 1 HOR Pareto Chart

The ARP value in Figure 2 of the Pareto diagram shows the 9 highest risk causes namely A20, A15, A2, A4, A3, A17, A5, A21, and A6 contributing as much as 79% of the total ARP value. The risk agent is a priority source of risk in the CV Simaluy supply chain process.

Table 5: Dominant risk agent

code	ARPj	S	O
A20	2056	8	8
A15	1704	9	8
A2	1530	9	6
A4	1440	6	5
A3	1370	9	5
A17	1112	8	8
A5	756	8	3
A21	630	3	6
A6	618	8	6

Before handling the selected risk sources, a risk level assessment can be carried out based on the occurrence value and severity. The position of the risk source (risk agent) chosen before the risk handling is carried out is shown in Fig. 3 below:

Fig 3. Risk map before treatment

On the risk map above, you can determine the location of the risk source. The areas in red have 6 potential risk factors. This shows that source risk is in a precarious position if it is not handled efficiently and effectively. In the yellow area, there are also 2 other sources of risk. This indicates that the source of risk is in a moderate position, requiring routine resource management and effective control. Then there is one source of danger which is located in the green area. This means that the source of risk is in a light position, but the source of risk in the green areas must still be controlled and managed properly so as not to cause losses.

B. HOR Stage 2

Risk mitigation occurs during HOR phase 2 in the form of managing risk sources. Risk reduction is the process of reducing or eliminating potential risks and is expected to pay attention to the risk mitigation that has been carried out in order to minimize each identified risk. Sources of risk (risk agents) will be identified and mitigated based on the findings of the risk evaluation.

Table 6: *Risk agent* priority

Code	Risk Agent	ARPj
A20	Purchase of fewer materials	2056
A15	Barriers to the delivery of materials	1704
A2	Difficulty obtaining raw materials	1530
A4	Decreased employee productivity	1440
A3	Human error	1370
A17	There is no maintenance schedule for the machine	1112
A5	There is no cooperation with suppliers	756
A21	Operators that do not work for some reason	630
A6	engine failure	618

Based on the 80-20 Pareto diagram rule, which states that problems with a percentage below 80% are priority problems that must be resolved first. This Pareto chart will show which risk factors have the greatest impact based on the total existing ARP so that it can help companies to identify problems that most affect their business and take quick action to solve them. So based on the Pareto diagram in Figure 2, the cumulative ARP percentage line shows that Risk Agent A21, namely purchasing fewer materials, is the biggest risk faced by CV Simaluy. This happens because the IKM is located in an archipelago where some of the materials for making products come from the island of Java and often experience delays in arrival.

Mitigation action planning, which is often referred to as preventive action, is carried out to deal with Risk Agents according to the priorities identified in the Pareto diagram. The following are suggested mitigation proposals for Simaluy IKMs:

Table 7: Mitigation proposals

Code	Risk Agent
P1	Perform cooperation contracts with suppliers
P2	Perform routine checks on the machine
P3	Provide training to workers
P4	Cooperation agreement with punishment and reward
P5	Conduct regular assessments and evaluations of workers
P6	planning the purchase of materials properly
P7	Collaborate with delivery services
P8	Provide more safety stock of raw materials than usual in certain seasons

Table 8: HOR Stage 2

Code	PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	RAPj
A20						9		1	2056
A15	3			3			9		1704
A2	9			1		3		9	1530
A4			9	3	3				1440
A3			9		9				1370
A17		9							1112
A5	9								756
A21				9	9				630
A6		9							618
Tech	25686	15570	25290	16632	22320	23094	15336	15826	
Dk	5	3	5	4	3	3	4	3	
ETDk	5137,2	5190	5058	4158	7440	7698	3834	5275.33	
Rk	5	4	6	7	2	1	8	3	

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Table 9: ETDk calculation results

Code	ETDk	%ETDk	% Cum
PA6	7698	17.58%	17.58%
PA5	7440	16.99%	34.57%
PA8	5275,3	12.05%	46.62%
PA2	5190	11.85%	58.47%
PA1	5137,2	11.73%	70.20%
PA3	5058	11.55%	81.75%
PA4	4158	9.50%	91.24%
PA7	3834	8.76%	100.00%

Based on the ETDk calculation results table, it is found that planning the purchase of materials properly (PA6) has the highest value of 7698 which completes 2risk agent(purchasing fewer materials (A20), and Difficulty obtaining raw materials (A2) and the smallest is making cooperation with shipping services (PA7) with a value of 3834 which makes 1risk agent, namely the obstacles in the delivery of materials (A15).

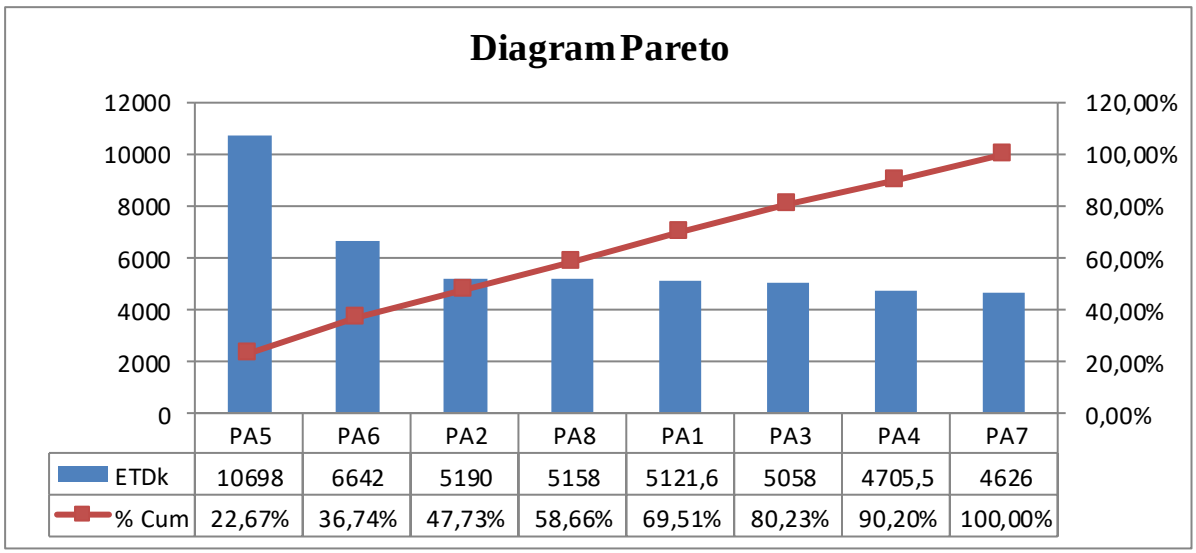

Fig. 4: Stage 2 HOR Pareto Chart

IV. CONCLUSION

Conclusions that can be drawn through research and data processing using HOR:

Based on the risk event findings in the Simaluy IKM business process, 21 risk events were obtained consisting of the Plan, Source, Make, Deliver, and Return processes. Based on the results of risk agent assistance (risk causes) obtained 21 risk agents, which were then narrowed down to 9 risk agents based on the results of 80% of the Pareto diagram which became the company's priority, namely: obstacles in material delivery (A20), Difficulty obtaining raw materials (A15), Decreased employee productivity (A2), Human Error (A4), no maintenance schedule for the machine (A3), no cooperation with suppliers (A17), operators who do not work for certain reasons (A21) and Machine damage (A6).

There are 8 Preventive Actions (preventive actions) suggested as a handling technique using the HOR stage 2 approach, namely conducting cooperation contracts with suppliers, carrying out routine checks on machines, providing training to workers, cooperation agreements with punishment and reward, conducting assessments and evaluations periodically with workers, planning the purchase of materials properly and making cooperation with the delivery service.

In order to overcome risks in the supply chain flow and minimize potential losses for the company, it is hoped that the Simaluy IKM can be considered for treatment based on this research. Financial variable components can be added to further research to find out the advantages and disadvantages experienced by the company.

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