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HOUSE OF RISK IMPLEMENTATION ON SUPPLY CHAIN OF MANUFACTURING SMES
(Studi Kasus: Yogyakarta, Indonesia)

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ABSTRACT

Uncertainty in supply chain activities poses various risks that can hinder the company's competitiveness. Thus, the flow of information from the process of procuring raw materials to products received by consumers must be ensured to run well. To achieve this, companies must be more sensitive to possible risks that arise from supply chain activities so that risk management is necessary. Therefore, this study aims to manage possible risks using the House of Risk (HOR) method. The research is divided into two main stages, namely the risk assessment stage and the risk management stage. At the risk assessment stage, the Aggregate Risk Potential (ARP) value will identify the severity level of the risk event and the occurrence rate of the risk agent. Then, at the risk management stage, it will identify preventive actions that are taken to reduce the severity and occurrence of risk agents. The results of the study indicate that there are 19 risk events and 16 risk agents that have the potential to occur in manufacturing SMEs as a case study of this research. Then, 8 risk agents were selected that needed to be followed up to reduce the level of risk. The result is that the 8 risk agents have reduced risk levels after being given preventive measures, which were initially at very high, high, and medium levels, dropping one level too high, medium, and low levels.

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1. Introduction

Every company has supply chain activities that play an important role in running the business. The supply chain is a series of processes from the parties directly involved in meeting customer demands, starting from material procurement activities, processing materials into products, product distribution, to receiving products to end customers (Geraldin, Pujawan and Dewi, 2007). Several parties involved include suppliers, manufacturers, distributors, and retailers. If one of the supply chains has a problem, it can have an impact on other processes because it looks like an interconnected chain. Various uncertainties are inherent in the supply chain such as uncertain demand, supply, and costs (Tang, 2006). This uncertainty has the potential to pose risks, both internally and externally to the company (Woods, 2007; Lalonde and Boiral, 2012). According to ISO 31000, the risk is the effect of uncertainty on the company's objectives. Actions to respond to possible uncertainties must focus on building a strong supply chain to increase competitiveness (Tse, Chung and Pawar, 2018).

The risks that arise in the supply chain must be minimized because they will have an impact on the overall business process (Asrol *et al.*, 2018). A higher level of risk will reduce efficiency in business processes. For this reason, the effort that needs to be done is to develop an appropriate risk mitigation strategy in the entire supply chain by considering all the stakeholders involved (Mishra *et al.*, 2016). All parties must have a role in the risk management process because coordination and collaboration among all these stakeholders will determine the success of implementing mitigation strategies to create a strong supply chain (Asrol *et al.*, 2018; Ferreira de Araújo Lima, Crema and Verbano, 2020). This can ensure that the flow of information from the process of availability of raw materials to products received by consumers goes well. Therefore, companies must be more sensitive to the risks that may arise from the supply chain, so risk management is needed to reduce the level of risk and the impact that may arise.

Various methods of risk management can be applied to cases experienced by various companies. House of Risk (HOR) is one of the tools that is often used. HOR is an analytical technique used to identify a source of risk and many supply chain risk events that have the potential to arise and hinder the supply chain management process (Kusmantini, Djoko and Rustamaji, 2015). With HOR, the probability of a risk agent and the severity of the risk event can be known (Pujawan and Geraldin, 2009). One risk agent can cause some risk events, then the HOR will generate a priority level for which the risk agent should be given preventive action (Pujawan and Geraldin, 2009). Next, determine the actions that are considered effective with the available resources to prevent the occurrence of the risk agents that have been prioritized.

A company classified as Small and Medium Enterprises (SMEs) in Yogyakarta is experiencing various obstacles in its supply chain activities. This UKM is engaged in manufacturing which produces make-to-order clothing. They provide a collection of product designs that change every certain period so that the raw material needs also change according to the available designs. Some designs with low demand will be removed from the list of designs that can be ordered, while others with high sales levels will remain available to consumers. This dynamic business process aims to adapt to market needs, which can provide convenience for the company as well as challenges. Challenges that occur include when the demand for certain products increases significantly, the company must ensure that the raw materials to meet the demand are available. Meanwhile, from the supplier side, the lead time for ordering materials sometimes cannot be fulfilled in a fast time because it adjusts to the existing stock. If the stock of the ordered material is still available, then the delivery process can arrive in a fast time, on the contrary, if the stock of the ordered material is not sufficient then you have to wait first. This causes the production process to be delayed and product delivery to consumers will be delayed from the promised time. The impact of this can affect the level of consumer satisfaction, loss in terms of time and cost, and the opportunity to gain consumer confidence is low. These various risks need to be analyzed further and actions must be taken as a solution to reduce the level of risk. Therefore, the HOR method will be used in this study to identify

possible risks that occur, calculate the level of risk and propose corrective actions to prevent the same problem from occurring so that it can reduce the level of risk.

2. Research Method

This research was conducted on manufacturing SMEs located in Yogyakarta. The HOR method will be used in this study to identify and measure the level of risk in the supply chain process at the company. The research steps were carried out following the methodology of the HOR method.

2.1. Data Analysis

2.1.1. Primary Data

The primary data used in the study were interviews and questionnaires. Interviews were conducted with the company management to find out the flow of supply chain activities, a list of risk events experienced, and a list of risk agents. Meanwhile, a questionnaire is used to obtain data about the severity level of the risk event and the occurrence level of the risk agent.

2.1.2. Secondary Data

Secondary data in this study were obtained through references from the writings that support the research. Various writings on risk management, the use of the HOR method and the steps are needed to support research.

2.2. Steps of the Research

The steps in this study following the methodology of the HOR method. Here are the steps:

1. Risk assessment stage
   a. Supply chain activity identification
      The first step in the research is to find out the supply chain activities in the company. To obtain this information, then conducted interviews to the company management.
   b. Risk event identification
      After the supply chain activities are identified, the next step is to identify risk events for each supply chain activity. This process is also carried out by conducting interviews with the company's management as those who understand the business activities as a whole. Each risk event then assessed how high the level of severity which leads to delays in business processes running well.
   c. Risk agent identification
      Every risk event that occurs needs to know the cause so that the risk agent identification process is then carried out. Each risk agent is also assessed how often it occurs and is experienced by the company.
   d. Identifying the relationship between risk events and risk agents
      Next, identify to determine the relationship between risk events and risk agents using the HOR matrix. At this stage, the ARP (Aggregate Risk Potential) value will be generated.
   e. Risk evaluation
      The last stage of the risk assessment is to evaluate the list of risk agents that need to be focused on first.
2. Risk treatment
   a. Plan mitigation strategy
      The list of risk agents to be mitigated is depicted on a map that shows how high the severity is and how often it occurs.
   b. Develop preventive action
      Next, create an action plan to address risk mitigation agent from happening again in the future.
   c. Determine the correlation between preventive action and risk agent
      Calculate the level of relationship between the mitigation action plan and the risk agent to produce a value that shows how effective the preventive action is when implemented.
   d. Provide a risk agent assessment that has identified preventive action
      The last step is to map the risk agents that have been given preventive action into the matrix to see if the severity and frequency of occurrence of a significant decreased risk agent.

3. Results and Discussion

Based on data obtained through interviews and questionnaires to the company management, the results will be presented and discussed in this section. The first stage of the supply chain activity at CV. X is presented in Table 1:

Table 1. Supply Chain Activity

Main Process	Sub-Process
Plan	Demand forecasting process
	Production planning process
	Material control (raw material)
Source	Procurement process
	Supplier selection and evaluation
Make	Production process and control
	Packing process
Deliver	Delivery of products to consumers
Return	Return of rejected goods to the supplier
	Receive returns from consumers

The next discussion is presented based on the implementation steps of the HOR method, namely:

1. Risk assessment
   a. The process of identifying risk events on the CV. X is based on the process described in Table 1. Each sub-process has one or more possible risk events that occur. The results depend on the results of interviews conducted with company management. This stage identifies risk events and assesses the severity of the risk (severity). In assessing the level of risk, a Likert scale is used, namely a scale of 1 – 5. A scale of 1 indicates that the risk event has no impact on the company's performance and profitability. A scale of 2 indicates a low influence, to a scale of 5 indicates a very high influence. The following are the results of the identification of risk events:

Table 2. Risk Event Identification

Main Process	Sub-Process	Risk Event	Severity
Plan	Demand forecasting process	Error in calculating material requirements planning (E1)	3
	Production planning process	Production equipment maintenance planning error (E2)	2
	Material control (raw material)	Material stock recording error (E3)	2
Source	Procurement process	Delivery is not timely (E4)	3
		Supplier can not fulfill the order (E5)	3
		Poor quality of materials from suppliers (E6)	4
		The quantity of materials from suppliers are not appropriate (E7)	3
		Constrained booking fee (E8)	3
	Supplier selection and evaluation	Prices of raw materials are not in accordance with the contract (E9)	2
Make	Production process and control	Occupational accidents (E10)	3
		Product Defect (E11)	3
		Production equipment failure (E12)	3
		Power outages (E13)	3
		Delayed assembly process (E14)	3
		Production lead time late (E15)	4
	Packing process	Packing process error (E16)	4

Main Process	Sub-Process	Risk Event	Severity
Deliver	Delivery of products to consumers	Late delivery process (E17)	3
Return	Returns reject goods to the supplier	Production process delayed (E18)	4
	Receive returns from consumers	Production process interrupted (E19)	4

b. Next, identify the risk agents and the possibility of each risk agent occurring. A scale of 1-5 is also used, where 1 means it rarely happens and 5 means it almost certainly will. Following are the results of risk agent identification:

Table 3. Risk Agent Identification

Risk Agent	Occurrence (Oj)
Lack of worker involvement in supporting company activities (A1)	3
Inaccuracy in determining material planning (A2)	2
Difficult to get raw materials (A3)	2
Dependence on one supplier (A4)	2
Late delivery service (A5)	2
The size of the raw material does not match what was ordered (A6)	3
Misinformation (A7)	2
Inappropriate raw materials (A8)	3
Raw material price reference does not match (A9)	4
Poor quality of raw materials (A10)	3
Maintenance of non-routine production equipment (A11)	2
Less careful when setting the initial machine (A12)	2
Work not according to procedure (A13)	3
Accounts payable (A14)	2
Sudden changes in orders from consumers (A15)	3
Increased consumer demand (A16)	3

c. After the list of risk agents and risk events is identified, the relationship between the two is assessed using a scale of 0, 1, 3, or 9 in each combination. A value of 0 indicates no correlation between risk and risk event agent; a value of 1 indicates a weak correlation, a value of 3 indicates a moderate correlation, and a value of 9 indicates a strong correlation. Identification is continued by calculating the ARP (Aggregate Risk Potential) value which shows the priority of the risk agent that needs to be addressed first. The ARP calculation formula is:

$$ARP_j = 0_j \sum_i S_i \, R_{ij}$$

Where;

O_j = The likelihood of risk occurrence agent (occurance level of risk)

S_i = The level of impact of a risk event (severity level of risk)

R_{ij} = Level of connection between risk agent (j) and risk (i)

The relationship between each risk agent and risk event HOR matrix shown in phase 1 in Table 4 below:

Table 4. HOR Matrix Level 1

Risk Event (Ej)	Risk Agent (Aj)																Severity (Si)
	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	
E1		9					3	9					1			9	3
E2							3				9						2
E3	1	3					3						3				2
E4			3	3			3										3
E5			9	3			3							3			3
E6		1	9	3			3	3	1	9							4
E7		3	3	3			3										3
E8				1										1			3
E9			3	1		1			9	3				1			2
E10								1			1	1	9				3
E11	3		1					9		9	9	9	9		3		3
E12											9	1	3			1	3
E13														3			3
E14				1		3		1		3	3	3	3		9		3
E15	1	1	1			3	3	3		3	3	3	3		9	3	4
E16							3						9				4
E17	1		1	1	9	1					3		3		9	3	3
E18		1	3	1		3	3	3		3	3	3	3	1	9	3	4
E19		1	3	1		3	3	3		3	3	3	3	1	9	3	4
Occurrence (Oj)	3	2	2	2	2	3	2	3	4	3	2	2	3	2	3	3	
ARP	54	116	242	116	54	150	216	324	88	342	258	156	486	62	513	225	
Rank	15	11	6	11	15	10	8	4	13	3	5	9	2	14	1	7	

d. The final step on the stage of risk assessment is to evaluate the risks of using the Pareto diagram. Making a Pareto diagram is based on the ARP value to find out which risk agent will be prioritized for further action. The Pareto principle with the 80/20 rule shows that 80% of risk events that arise come from 20% of risk agents. Thus, 20% of agents indicated the risk of the Pareto diagram is as follows:

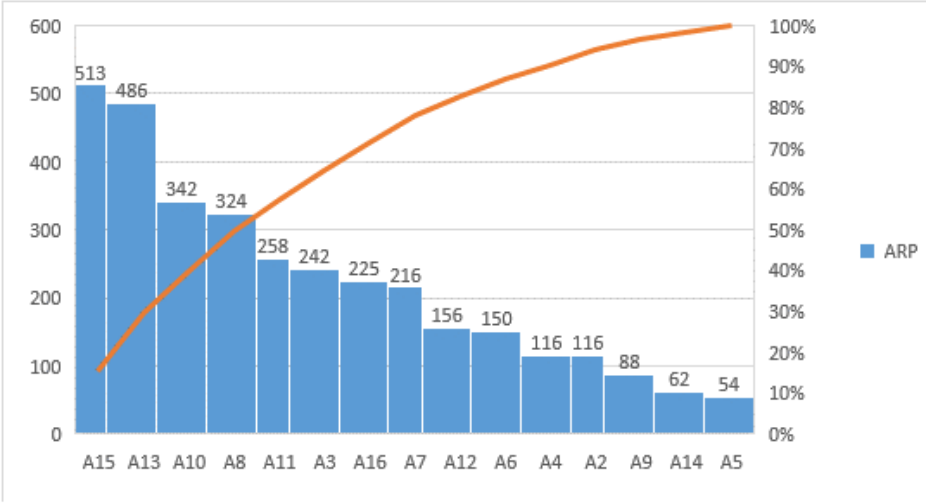

Figure 1. Pareto Diagram

Based on the Pareto diagram above, it can be seen that the selected risk agent included in 20% of the main causes of risk event that there are 8 A15, A13, A10, A8, A11, A3, A16, A7.

2. Risk Treatment
   a. Plan mitigation strategy

      From the results of the calculation of ARP in HOR phase 1, it is obtained several risks will be mitigated. The highest ARP value is a source of risk that must be immediately mitigated. In the Pareto diagram, it is known that the ranking of risk sources is a priority based on the ARP value. The sources of risk that are prioritized for mitigation can be seen in Table 5 below:

Table 5. Risk Agent Ranking Based on ARP Value

ARP Ranking	Code	Risk Agent	ARP Value	Oj	Si
1	A15	Sudden changes in orders from consumers	513	3	4
2	A13	Work not according to procedure	486	3	5
3	A10	Poor quality of raw materials	342	3	5
4	A8	Inappropriate raw materials	324	3	5
5	A11	Maintenance of non-routine production equipment	258	2	3
6	A3	Difficult to get raw materials	242	2	4
7	A16	Increased consumer demand	225	3	3
8	A7	Misinformation	216	2	4

Further mapping with models Probability Impact Matrix that aims to identify priority risk agents to be mitigated. Risk priority agent position can be seen in Figure 2 below:

		Severity				
		Very low (1)	Low (2)	Medium (3)	High (4)	Very high (5)
Occurrence	Very high (5)					
	High (4)					
	Medium (3)			A16	A15	A13, A10, A8
	Low (2)			A11	A3, A7	
	Very low (1)					

Figure 2. Risk Mapping Before Risk Treatment

Information:
Green : Low risk position
Kuning : Medium risk position
Merah : Critical risk position

It can be seen in the risk mapping that there are 6 risk agents in the red zone with a critical risk position and 2 risk agents in the yellow zone with a moderate risk position.

b. Develop preventive action

At this stage it will be measured the correlation between risk of preventive action with the selected agent. Degree of Difficulty (Dk) indicates the level of difficulty in implementing the proposed preventive action, where the value of 1 means preventive action is to be applied, the value of 2 means that preventive action rather easy to implement, and a value of 3 means that preventive action is difficult to implement. Table 6 below presents a risk management strategy:

Table 6. Risk Treatment Strategy

Risk Agent	Preventive Action	Code	Dk
Sudden changes in orders from consumers	Provide clear time limits for consumers regarding design changes	PA1	1
Work not according to procedure	Giving warning to employees who violate the procedures (up punishment for certain frequencies	PA2	2
Poor quality of raw materials	Creating quality standards of raw materials	PA3	1
Inappropriate raw materials	Doing a deal to suppliers of raw materials related to standards determined in advance	PA4	1
Maintenance of non-routine production equipment	Create a schedule and control maintenance routine production	PA5	2
Difficult to get raw materials	Looking for an alternative type of raw material to the consumer agreed beforehand	PA6	2
Increased consumer demand	Creating material and production scheduling in detail	PA7	3
Misinformation	Creating a track record of exchange of information tersistem	PA8	3

c. Determining the correlation between Preventive Action and Risk Agent

This section calculates the Total Effectiveness (TEk) value, which is how effective it is if the preventive action is implemented. Next, calculate the Effectiveness to Difficulty (ETDk) ratio by dividing the results from the Total Effectiveness (TEk) by the Degree of Difficulty (Dk). The next step, the

priority ranking of preventive action is known. The formula for calculating Total Effectiveness (TEk) is as follows:

$$TE_k = \sum_j ARP_j E_{jk}$$

Information:
TE_k = Total Effectiveness of any preventive action
ARP_j = Aggregate Risk Potential
E_{jk} = The relationship between preventive action and risk agent

Meanwhile, the calculation formula for Effectiveness to Difficulty (ETDk) is as follows:

$$ETD_k = \frac{TE_k}{D_k}$$

Information:
ETD_k = Effectiveness to Difficulty
TE_k = Total Effectiveness of any preventive action
D_k = Degree of Difficulty to take preventive action

The relationship between risk and preventive action agent identified using a value of 0, 1, 3, or 9. A value of 0 indicates no correlation between the risk agents and preventive action; value of 1 indicates a weak correlation, a value of 3 indicates moderate correlation, and the value 9 showed a strong correlation. The entire ETDk calculation can be seen in Table 7 below which is referred to as the phase 2 HOR Matrix.

Table 7. HOR Matrix Level 2

Risk Agent	Preventive Action								ARP
	PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	
A15	9					1	1	3	513
A13		9						3	486
A10			9	3		3	1	1	342
A8			3	9		3	1	1	324
A11					9			3	258
A3	1		1	1		9	3	3	242
A16	3				1		9	1	225
A7		1	1	3		1		9	216
TEk	5534	4590	4508	4832	2547	4905	3930	7332	
Dk	1	2	1	1	2	2	3	3	
ETD	5534	2295	4508	4832	1274	2453	1310	2444	
Rank	1	6	3	2	8	4	7	5	

d. Expert Assessment related to Risk Agents that have been Identified Preventive Action
Risk agents which have implemented a handling strategy are given a reassessment regarding the level of severity and occurrence. Furthermore, the results will be mapped into a risk mapping to determine the position of the risk agent after the handling strategy is given. The following is the risk agent value after the handling strategy:

Table 8. Risk Agent Assessment after Treatment

Code	Risk Agent	Oj	Si
A15	Sudden changes in orders from consumers	2	3
A13	Work not according to procedure	1	4
A10	Poor quality of raw materials	3	3
A8	Inappropriate raw materials	2	3
A11	Maintenance of non-routine production equipment	1	3
A3	Difficult to get raw materials	2	3
A16	Increased consumer demand	2	2
A7	Misinformation	1	4

The value of severity and occurrence in Table 8 is an assessment from the expert if the mitigation strategy is implemented in the company. The expectation from the company for treatment these risks is that the risks that occur in the company can be included in a lower category than the previous one. The following are the results of the risk mapping of the risk agents that have been given a treatment strategy:

		Severity				
		Very low (1)	Low (2)	Medium (3)	High (4)	Very high (5)
Occurrence	Very high (5)					
	High (4)					
	Medium (3)			A10		
	Low (2)		A16	A15, A8, A3		
	Very low (1)			A11	A13, A7	

Figure 3. Risk Mapping after Risk Treatment

As can be seen in the risk mapping above, the risk agent who was initially in a high-risk position has shifted to a medium-risk position. The risk agents that fall into the medium-risk category are A15, A13, A10, A8, A3, and A7, while other risk agents that shift to the low-risk category are A16 and A11.

4. Conclusion and Recommendation

4.1 Conclusion

Based on the results of processing and analysis carried out previously, it was concluded that there were 19 risk events with severity values for each, where a total of 16 risk agents were identified with their respective occurrence values related to supply chain activities that occurred in the company Z. From 19 risk events and 16 risk agents, obtained 8 risk agents that become priority handling based on the HOR matrix phase 1. Furthermore, mitigation actions are carried out by providing a handling strategy based on the identified risk agents presented in the HOR matrix phase 2. The result is that the risk agent has shifted. a lower risk position than before treatment.

4.2 Recommendation

For company management, it is expected to pay attention to and develop rules that need to be applied within the company, such as rules for cooperation with suppliers, production processes, rules related to the process of ordering products from consumers, shipping processes, and others. The goal is to make it easier for the company to carry out all business activities according to plan and reduce various errors and uncertainties from various parties. For further research, it is recommended to be

able to evaluate risks in more detail in each activity to produce targeted preventive actions.

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