Supply chain risk assessment of cotton shirt production uses the house of risk method

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Abstract. The purpose of this study is to mitigate risks in supply chain activities in the production of cotton shirts. The method used in this research is the House of Risk (HOR) approach based on the Supply Chain Operation Reference (SCOR) model. The House of Risk (HOR) offers a framework for effectively controlling risks in managing risks from risk agents. Aggregate Potential Risk (ARP) is used to determine the priority of risk sources that need to do in the design of mitigation strategies. The research results identify as many as 26 Risk Events and 21 Risk Agents. Three Risk Agents based on ARP values are Procedures for Delivery of Less Organized Raw Materials, limited and Sudden Product Demand from consumers Mitigation actions used to prevent the causes of risk from occurring are creating standard operating procedures for raw material delivery activities. Also, a contract system establishes between suppliers of raw materials and freight forwarding services. Migration in human resources is evaluating employee performance. Empowerment of the community around the company, subcontracting to other similar companies, reviewing raw material stock is an act of meditation in sudden product demand.

1. Introduction

In carrying out business processes, a company has a problem of uncertainty or unplanned events that disrupt the flow of production processes. This uncertainty has an impact on increasing the needs of data sources in anticipating it [1,2]. The determining factors and disorders cause the occurrence of risk [3]. Operational considerations are related to uncertainty in demand, the supply of raw materials and costs. While disruption factors such as natural disasters or economic crises [4].

House of risk (HOR) is one of the uncertainty measurement analysis methods in the supply chain developed by Pujawan, and Geraldin [5]. This model is a development of the quality function deployment (QFD) method, which uses the house of quality (HOQ) to prepare mitigation actions in the face of potential risks in the supply chain. House of risk aims to identify hazards in the supply chain and design prevention strategies to minimize the likelihood of agent risk [6,7]. The House of risk (HOR) divides strategy design into two stages, namely the risk identification and risk treatment phases.

Uncertainty in a make to order industry is very likely to occur. Some of these uncertainties include highly fluctuating demand [8,9], short product life cycle [10–12], outsourcing system when demand is high [13]and the quality of human resources. This research focuses on a cotton t-shirt convection business in Lampung, whose production system is still dependent on consumer demand. Some of the obstacles faced by business owners in running their enterprises include sudden desire and the quality of
human resources. This study aims to identify and design a strategy of possible risks that might occur in the supply chain of the production of Katon shirts. The results of the risk mitigation undertaken are expected to be management input in the face of possible risks that occur in the future.

2. Method
This research was conducted based on the results of interviews with business owners regarding the constraints that occur while running their business. This research does not discuss related to quantitative data, which is a personal data analysis of company data. The research step guide by the concept of the house of risk[5], which consists of the risk identification phase and the risk treatment phase.

In the concept of the house of risk, risk assessment uses Failure Mode and Effect Analysis (FMEA). The occurrence assessment is carried out to determine the probability level of the risk agent and severity associated with the risk event, which is to assess the severity of the risk event. The steps of the risk identification phase are as follows:
1. Identify risk events that can occur in every business process. This risk can finish through mapping the supply chain of cotton t-shirt production based on the SCOR model (plan, source, make, deliver, and return).
2. Estimating the impact of severity risk events (1-10).
3. Identify sources of risk and assess the likelihood of each risk source occurrence (1-10).
4. Develop matrix relationships. The relationship between each source of risk and each risk event, Rij (0, 1, 3, 9) where 0 indicates no correlation and 1, 3, 9 show a successively low, medium and high relationship.
5. Calculate the aggregate risk potential (agent = j = ARPj) determined as a result of the likelihood of events occurring at the source of risk j and the aggregate of causal effects of each risk event caused by the source of risk j.
   \[
   ARP_j = O_j \sum S_i.R_{ij}
   \]  
6. Ranking risk sources based on a collection of potential risks in descending order (from large to lowest value).

The steps in the risk treatment phase are:
1. Select some risk sources with high priority ranking that might use the Pareto analysis of the ARPj.
2. Identify the consideration of actions relevant to the prevention of sources of risk.
3. Determine the relationship between each precautionary measure and each source of risk, Ejk. Values (0, 1, 3, 9) which indicate that there are no correlations, low, medium, and the long relationship between actions k and source j, respectively.
4. Calculate the total effectiveness of each action.
   \[
   TE_k = \sum ARP_j x E_{jk}
   \]
5. Estimating the degree of difficulty in performing each action. The value scale used is weight 3 for mitigation actions that are easy to implement. Weight 4 for mitigation actions that are somewhat difficult to implement and weight 5 for mitigation actions that are difficult to implement.
6. Put those values in a row in the bottom row of the valid total.
   \[
   ETD_k = \frac{TE_k}{D_k}
   \]
7. Determine the priority ranking of each action (Rk), where ranking 1 gives the meaning of the work with the highest ETDk.

3. Result
The mapping of the company's business activities in the production of cotton shirts does by a discussion with the owner of the company. Identification of company supply chain activities based on the SCOR model that occurs in the process of plan, source, make, delivery, and return. Risk event identification is used to determine the risks that may arise in the process of the supply chain of cotton t-shirts with a total of 26 risk events identified (Table 1). Identification of risk agents in every possible risk event that arises made by observation and direct interviews with business owners with the results of 21 risk agents (table 2).
The determination of severity level (Table 1) and assessment of occurrence level assessment (Table 2) uses a scale of 1-10 based on the results of the business owner. They use the results as a basis for calculating the development of the matrix relationship and the Aggregate Risk Potential of an agent (ARP). It determines as a consequence of the likelihood of events occurring from the source of risk and the collection of impacts due to risk events caused by sources of uncertainty. The results of the identified risk agents that have the most considerable ARP value determined by the Pareto diagram will be input to HOR2. The priority risk agent to mitigate (Fig. 1) with the priority of mitigation based on the ARP value of A7 (Procedure for sending raw materials less organized) ARP 3344, A10 (Limited Human Resources) ARP 3258, and A4 (Sudden requests from consumers) ARP 3024.

**Table 1. Risk event and severity**

| Process | Sub Process | Risk Event | (Ei) | Severity |
|---------|-------------|------------|------|----------|
| Plan    | Product demand | Sudden changes in production plans | E1 | 6 |
| Control of raw material inventory | Inadequate inventory parameters | E2 | 3 |
| Source  | Procurement process | Delay in raw materials from suppliers | E3 | 6 |
|          |              | Disruption of raw material supply | E4 | 6 |
|          |              | Raw materials sent are not inspected by the recipient of the goods | E5 | 3 |
|          |              | Changes in the quality of raw materials | E6 | 8 |
|          |              | Error choosing supplier | E7 | 3 |
|          |              | Error item posted by the supplier | E8 | 3 |
|          |              | Lack of communication with suppliers | E9 | 2 |
|          |              | Lack of expertise and qualifications for human resources | E10 | 6 |
| Make    | Execution | Defect products | E11 | 9 |
|         |            | Inventory cannot use | E12 | 1 |
|         | Production scheduling | Delay in production | E13 | 6 |
|         |            | Inefficient process | E14 | 3 |
|         | Packing process | Engine failure (downtime) | E15 | 9 |
|         |            | Lack of engine maintenance | E16 | 9 |
|         | Conduct product inspection | The packaging is damaged or torn | E17 | 6 |
|         |             | Delay in completion of production | E18 | 6 |
|         | Delivery process | Do not carry out production activities | E19 | 9 |
|         | Warehousing | Lack of employee ability | E20 | 3 |
|         |              | Lack of quality checking products | E21 | 8 |
| Return  | Return of the defected product | The product sent to the wrong destination | E22 | 9 |
|         |              | Stacking of finished products | E23 | 3 |
|         |              | Damage to raw materials during storage | E24 | 3 |
|         |              | Late delivery of products to consumers | E25 | 9 |
|         |              | Delay in the return process from the management industry to consumers | E26 | 9 |

**Table 2. Identify causes of occurrence risks and value**
Unorganized shipping procedures due to only one supplier in the business. A single supplier is very influential on the stability of the raw material flow. The selection of suppliers of raw materials should consider supplier reliability [14] so that it does not interfere with the production process. In the supply chain principle, flexible supplier sources are more profitable for the company in minimizing inventory constraints or risks related to raw material delays [15].

![ARP risk agent pareto diagram](image)

**Figure 1.** ARP risk agent pareto diagram

**Table 3.** Matrix of mitigation strategy (HORII)
The results of the identification of mitigation actions from three Priority Risk Agents produce six mitigation actions with notation PA1 (making operational standard procedures for the delivery of raw materials), PA2 (creating a contract system between suppliers of raw materials and freight forwarding services), PA3 (evaluating employee performance), PA4 (community empowerment around the company), PA5 (subcontracting with other similar companies), and PA6 (review of raw material stock).

After identifying mitigation actions, a correlation value (Ejk) is measured between the mitigation actions with priority risk agents and Total Effectiveness (TEk) by adding up the results of multiplying the correlation values (Ejk) with the ARP of each priority risk agent (AJ). The next step is to measure the degree of difficulty until the stage 2 HOR model is obtained (Table 3).

In the supply chain system, collaboration with other companies is the key to success in running a business. Subcontracting with other companies is one way to increase operating efficiency [16–18] with established quality standards. Trust maintenance and excellent communication minimize the issue of outsourcing. Outsourcing system produces product quality and time faster than adding human resources whose condition has not tested. Production capacity constrains the selection of this system when sudden or high order.

Evaluate employee performance by making precise employee administration data, then target data for making the right products that can be achieved by employees. Compensation [19] and skill improvement are ways to improve employee performance and retain skilled employees. They are making standard operational procedures for the delivery of raw materials in supporting the production process so that the product arrives at consumers on time.

4. Conclusions

Based on the analysis of data that has finished, obtained six mitigation actions in handling three Priority Risk Agents. Three priority action mitigations are procedures for sending raw materials that are less organized, limited human resources, and sudden product demand from consumers. Six mitigation actions are prioritized to be realized by carrying out sub-contracts or cooperation with similar companies, evaluating employee performance, making standard operating procedures for raw material delivery activities, empowering communities around the company, reviewing raw materials, and establishing supplier contract systems with shipping services. Cooperation with similar companies in...
certain conditions has a significant influence in maintaining the sustainability of the company. This research can be forwarded to a lean supply chain to get a more effective and efficient supply chain system.

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