Available online at: http://jurnal.untirta.ac.id/index.php/jiss

JOURNAL INDUSTRIAL SERVICESS

Industrial Engineering Advance Research & Application

eISSN 2461-0631

Building a resilient supply chain: Mitigating risks in label-holder production

Maria Ulfah*, Achmad Bahauddin, Ratna Ekawati, Atia Sonda, Yusraini Muharni, Aditya Rahadian Fachrur

Department of Industrial Engineering, Universitas Sultan Ageng Tirtayasa, Jl. Jend. Sudirman KM 3, Cilegon 42435, Banten, Indonesia

ARTICLE INFO

Article history:
Received 4 March 2024
Received in revised form 14 June 2024
Accepted 15 June 2024
Published online 16 June 2024

Keywords:
House of Risk
Label-holder
Mitigation actions
Risk

Editor:
Bobby Kurniawan

Publisher's note:
The publisher remains neutral concerning jurisdictional claims in published maps and institutional affiliations.

ABSTRACT

This study investigates risk mitigation strategies within the label holder supply chain at a company specializing in convection-produced label holders. The House of Risk approach will be used to identify and prioritize potential risks and their sources throughout the supply chain activities, as defined by the Supply Chain Operation Reference (SCOR) method. Common supply chain risks include torn mica, detached stitches, and improper strap lengths. The risk identification process within the label holder supply chain activities resulted in 30 risk events, 27 risk agents, and 13 prioritized risk mitigation actions. These actions include regular routine machine maintenance, employee briefings, identifying backup suppliers, consistent performance monitoring, station coordination before production, machinery and tool upgrades for quality assurance, yearly shutdowns/maintenance, establishing customer contracts, user feedback coordination, training for raw material receiving personnel, implementing periodic product testing, enacting efficient inventory management practices, and improving finished goods quality management.

1. Introduction

Supply chain risk management involves systematically identifying, assessing, and mitigating potential disruptions within the logistics network to minimize their negative impacts on performance [1]. Companies face various risks along their label holder supply chain, such as torn mica, detached stitches, and improper strap lengths. These issues highlight the need to mitigate risks using a structured approach like the House of Risk.

These uncertainties about future events can disrupt normal activities or even halt planned operations [2]. Risks can emerge at any point within the supply chain, affecting suppliers, factories, distributors, and ultimately, consumers [3, 4, 5]. While complete risk avoidance is impossible, proper risk management can significantly reduce or even eliminate their impact [6, 7]. A single risk event can often trigger a cascade of other issues [6, 7]. Supply chain risk management is essential for minimizing the frequency and impact of disruptions, which are a constant challenge in today's business environment [8].

The research identfiies the risk faced by a label-holder manufacturer. This research employs the House of Risk (HOR) approach, which consists of two phases: HOR 1 focuses on identifying, analyzing, and evaluating potential risks, while HOR 2 addresses risk handling or mitigation strategies [9].

Previous research on supply-chain risk management has explored various strategies, including approaches such as the House of Risk for assessing risk management strategies [10], mitigating risks in businesses such as the Mangosteen industry [11], mitigating risks in the production process of packaged fruit juice drinks [12], assessing risks in maritime supply chains [13], and conceptualizing community in disaster risk management [14]. Studies include "Risk Management Analysis and Risk Handling Strategies at PT Agility International Using the House of Risk (HOR) Method" [15], "Risk Analysis of Product Failure Affecting Service Quality Using the House of Risk and Supply Chain Operations Reference" [16], "Identification of Supply Chain Risks with the House of Risk (HOR) Method" [17], and "Risk Mitigation Analysis in a Supply Chain of Coffee Using the House of Risk Method" [18].

2. Material and method

The research method used in this study involves conducting a literature review and a field study of the

*Corresponding author:
Email: maria67_ulfah@yahoo.com

http://dx.doi.org/10.62870/jiss.v10i1.24497

Label Holder supply chain flow. This is followed by mapping supply chain activities using the Supply Chain Operations Reference (SCOR) model, which consists of five dimensions: plan, source, make, deliver, and return. Subsequently, supply chain risk management is implemented using the House of Risk method. This risk management process includes risk identification, risk assessment, risk evaluation, and risk mitigation [19].

This research includes the stages of risk identification, risk analysis, risk evaluation, and risk mitigation. From the identification stage to the evaluation stage, the House of Risk 1 (HOR 1) model is used, and for the mitigation stage, the HOR 2 model is employed. At the risk identification stage, the determination of supply chain processes or activities is guided by the SCOR (Supply Chain Operations Reference) model, which consists of five process stages: plan, source, make, deliver, and return.

The stages of supply chain risk management are as follows:

1. **Risk Identification.** This stage involves identifying risks that may occur and have the potential to occur in supply chain activities. An important aspect of this stage is to list as many potential risks as possible through field surveys and interviews. This stage uses the FMEA (Failure Modes and Effect Analysis) method.
2. **Risk Analysis.** After identifying the risks, the next step is risk measurement by assessing the potential occurrence, severity (disruption), and probability of occurrence of the risks. Risk measurement is conducted by evaluating the severity of the risk event if it occurs and the likelihood of risk sources causing the risk. The methods used for analyzing risk are the Supply Chain Operations Reference (SCOR) model and the House of Risk (HOR) model.
3. **Risk Evaluation.** This stage involves evaluating the results from the risk analysis stage using a Pareto diagram. The House of Risk (HOR-1) model is employed here. In manual calculations, the ARP percentage is obtained and categorized into two types: priority and non-priority. The assignment of these categories is based on the Pareto principle, which states that 80% of the problems are caused by 20% of the root causes. Therefore, the ARP percentages with priority categories are taken from the ARP percentages that reach 80%, so that risk sources with priority categories will be followed up for mitigation.
4. **Risk Mitigation.** This stage uses the HOR-2 model to mitigate risks, reduce the consequences of risks, and prioritize risk control actions with the highest total effectiveness and efficient costs. Risk mitigation aims to reduce or eliminate the possibility of certain risks occurring or the consequences they cause. Risk mitigation using the House of Risk phase 2 model takes the input from the results of the House of Risk phase 1 model.

3. Results and discussions

3.1. Risk identification

The initial stage of the House of Risk (HOR) method in this research is risk identification. At this stage, interviews, discussions, and questionnaires are conducted with the company owner, along with field observations, to identify risk events from the Label-Holder supply chain activity flow. Risk identification is considered a fundamental stage in the risk management process.

The identification of the supply chain activity process is based on the SCOR model, which is divided into the sub-processes of plan, source, make, deliver, and return. The supply chain activity process is also illustrated in the Label-Holder supply chain mapping. The division of the supply chain activity process aims to identify where the risks occur. The SCOR model, developed by the Supply Chain Council (SCC), is used to measure and improve the total performance of a company's supply chain. Table 1 presents the results of the supply chain activity mapping based on the SCOR model.

3.2. Risk analysis

Risk analysis begins with determining the severity value (S) of the risk events. Next, the risk agents are identified, and their occurrence values are determined. After that, the correlation value between the risk event and risk agent is assessed to obtain the Aggregate Risk Potential (ARP) value for each risk source.

The results of the SCOR analysis are presented in Table 2 for the severity value of the risk event and Table 3 for the occurrence value of the risk agent. After determining the severity value of the risk event, the occurrence value of the risk agent, and the correlation value between the risk event and the risk agent, the next step is to determine the Aggregate Risk Potential (ARP) value.

HOR 1 is used to determine the ARP value of the risk agent. After obtaining the ARP values, the risk agents are prioritized or ranked to calculate the cumulative percentage of ARP using a Pareto diagram. This helps identify the risk agents that should be prioritized for mitigation in HOR 2.

In HOR 1, the identification of Risk Agents and Risk Events is carried out through a questionnaire, which is then assessed. The risk sources/risk agents with the highest scores will receive the top priority for mitigation. The value used to determine the top priority of risk agents is called Aggregate Risk Priority (ARP).

3.3. Risk evaluation

After the identification of risk events and risk analysis, the next stage is supply chain risk evaluation. At the risk evaluation stage, the cumulative ARP values can be prioritized based on the risk agent ranking. Sorting the ARP values from the largest to the smallest helps analyze them using a Pareto chart.

Table 1.
SCOR analysis

Criteria (level 1)	Atributte (level 2)	Sub-criteria (level 3)
Plan	Reliability	Conformity in production scheduling
		Owner's meeting with supplier
	Responsiveness	Time required during the production planning process
		Raw material requirements planning
		New product cost calculation period
	Agility	Unexpected alternatives (e.g. Raw material of mica is broken, machine is broken
	Cost	Operational financial planning (production and delivery costs)
	Assets	Cash cost planning for operational needs of mica raw
Source	Reliability	Shortage of material mica
		Conformity of raw materials to product specifications and quantity
		Conformity of delivery time and quantity
		Arrival of raw material orders without defects
	Responsiveness	Looking for alternative suppliers
		Schedule changes that affect delivery
		Raw material storage time too long
		Raw material payment time
	Agility	Supplier backup availability
	Cost	Difficulty finding other suppliers with affordable raw material prices
Make	Reliability	Defective finished goods
	Agility	Flexibility in product manufacturing
	Cost	Production cost when repairing defective items on the production line
		Machine maintenance repair costs (sewing machines, punching machines)
Deliver	Reliability	Product delivery to customers not on time
		Product damage during delivery to customers
		Loss and theft of finished products during delivery to customers
	Cost	Cost of late delivery of products to customers
Return	Reliability	Complaints on defective products
	Responsiveness	Speed and accuracy in defective product return claims
	Cost	Raw material cost for return to repair defective products
		Return shipping cost of products that conform to product standards

Table 2.
Severity of risk event

Process	Sub Process	Code	Risk Event	Severity (S_i)
Plan	Reliability	E1	Conformity in production scheduling	2
		E2	Owner's meeting with supplier	1
	Responsiveness	E3	Time required during the production planning process	2
		E4	Raw material requirements planning	4
		E5	New product cost calculation period	2
	Agility	E6	Unexpected alternatives (e.g. Raw material of mica is broken, machine is broken	3
	Cost	E7	Operational financial planning (production and delivery costs)	3
	Assets	E8	Cash cost planning for operational needs of mica raw	1
Source	Reliability	E9	Shortage of material mica	5
		E10	Conformity of raw materials to product specifications and quantity	7
		E11	Conformity of delivery time and quantity	7
		E12	Arrival of raw material orders without defects	7
	Responsiveness	E13	Looking for alternative suppliers	5
		E14	Schedule changes that affect delivery	4
		E15	Raw material storage time too long	4
		E16	Raw material payment time	3
	Agility	E17	Supplier backup availability	1
	Cost	E18	Difficulty finding other suppliers with affordable raw material prices	3
Make	Reliability	E19	Defective finished goods	9
	Agility	E20	Flexibility in product manufacturing	2
	Cost	E21	Production cost when repairing defective items on the production line	5
		E22	Machine maintenance repair costs	5
Deliver	Reliability	E23	Product delivery to customers not on time	6
		E24	Product damage during delivery to customers	9
		E25	Loss and theft of finished products during delivery to customers	8
	Cost	E26	Cost of late delivery of products to customers	6
Return	Reliability	E27	Complaints on defective products	7
	Responsiveness	E28	Speed and accuracy in defective product return claims	6
	Cost	E29	Raw material cost for return to repair defective products	7
		E30	Return shipping cost of products that conform to product standards	4

Table 3.
Occurrence of risk agent data

Code	Risk Agent	Occurrence
Demand		
A1	Sudden demand by consumers	9
A2	Sudden change in delivery demand	8
A3	Products that are not in accordance with consumer demand	3
A4	Products that do not meet customer specifications	2
A5	Sudden changes in demand volume	7
Man		
A6	Workers arrive late	6
A7	Work violates CV (Company) regulations	3
A8	Less conscientious human resources	3
A9	Human Error	2
A10	Workers are Indifferent	3
Manchine & Equipment		
A11	Broken Machine	4
A12	Engine is old	3
A13	Machine productivity varies	3
A14	Machine limitations (when product overload)	5
Method		
A15	Lack of worker monitoring	4
A16	Lack of communication and information between workers	6
A17	SOPs that are not relevant	5
A18	Lack of worker rolling	4
Materials		
A19	Raw material scarcity	5
A20	Increase in raw material prices	7
A21	Poor quality of raw materials	6
A22	Changing quality of materials	4
A23	Supplier Limitations	3
Environment		
A24	Power outage	3
A25	Natural disaster factors	1
A26	Weather and climate factors	6
A27	Space limitations	8

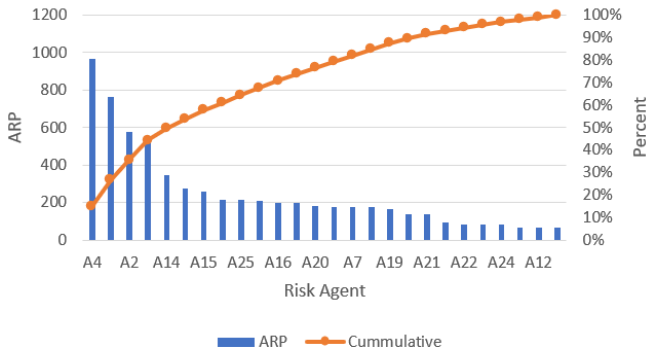

Figure 1. Pareto diagram of label-holder risk agent

Table 4.
Risk agent handling data

Code	Source of risk to be addressed
A4	Products that do not meet customer specifications
A1	Sudden demand by consumers
A2	Sudden change in delivery demand
A3	Products that do not match consumer demand
A14	Machine limitation (when product overload)
A5	Sudden changes in demand volume
A15	Lack of worker monitoring
A6	Workers arrive late
A25	Natural disaster factors
A9	Human Error
A16	Lack of communication and information between workers
A18	Lack of worker rolling
A20	Increase in raw material prices

Table 5.
Mitigation action

Code	Source of risk to be addressed
PA1	Carry out routine machine maintenance on a regular basis
PA2	Regular employee briefing
PA3	Looking for a backup supplier
PA4	Always monitor employee performance
PA5	Coordination between stations before production
PA6	Update machines or tools with adequate quality
PA7	Shutdown/Maintenance every year
PA8	Contract with customer (1 year term)
PA9	Coordination with users for feedback
PA10	Training of raw material receiving personnel
PA11	Test products regularly
PA12	Efficient inventory management
PA13	Improve quality management of finished goods

After obtaining the entire ARP values, the priority risk agents are ranked to determine the cumulative percentage of ARP using a Pareto diagram. Risk agents with the largest ARP values, identified using a Pareto diagram, will be input into HOR 2, prioritizing them for mitigation. The risk agents to be mitigated based on the ARP values using the Pareto diagram are shown in Fig. 1. From the evaluation results based on HOR 1 and the Pareto diagram, it can be determined which risk agents are prioritized for mitigation.

3.4 Risk mitigation

The calculation of the total effectiveness (TE) of each proposed mitigation strategy aims to assess the effectiveness of the mitigation strategies. The calculation of the total effectiveness ratio (ETDk) is used to rank or prioritize the mitigation actions to be taken. Next, the degree of difficulty (Dk) is measured, which indicates the level of difficulty in implementing the mitigation action steps. The degree of difficulty is classified into three categories: easy to implement with a score of 3, moderate to implement with a score of 4, and difficult to implement with a score of 5 [21]. Based on the prioritized risk agents, mitigation actions are carried out as shown in Table 4.

In the second phase of the House of Risk, actions to deal with priority risk agents were determined based on the results of the HOR 1 analysis, considering the effectiveness of preventive measures, the difficulty of implementing preventive measures, and the effectiveness ratio of preventive measures. The analysis of mitigation actions in supply chain risk management identified actions to reduce the impact of occurring risks. Through this analysis, the company can consider various options such as supplier diversification, development of a business continuity plan, increased transparency and communication with suppliers, or implementation of technology that enables better visibility and monitoring in the supply chain. For mitigation actions, based on HOR 2 calculations, 13 mitigation actions can be recommended to mitigate risk agents along the supply chain in producing Label-Holder, as shown in Table 5. Prioritizing the implementation of a mitigation strategy involves determining alternative risk mitigation assessments that can be implemented while considering the limitations of cost, human resources, and other aspects of the company [22].

4. Conclusions

From the identification results along the Label Holder supply chain activities, 30 risk events and 27 risk agents were identified. Additionally, 13 supply chain risk mitigation actions were identified: carrying out regular routine machine maintenance, conducting routine employee briefings, seeking backup suppliers, continually monitoring employee performance, coordinating between stations before production, updating machines or tools with adequate quality, scheduling shutdowns or maintenance every year, establishing contracts with customers, coordinating with users for feedback, providing personal training in the raw material reception section, conducting periodic product testing, implementing efficient inventory management, and improving the quality management of finished goods.

Declaration statement

Maria Ulfah: **Conceptualization, Methodology, Supervision, Project administration**. Achmad Bahauddin: **Software**. Ratna Ekawati: **Resources, Formal analysis**. Atia Sonda: **Visualization, Investigation**. Aditya Rahadian Fachrur : **Data curation, Validation**.,**Writing, Original Draft**. Yusraini Muharni: **Resources, Validation**., **Review & Editing**.

Acknowledgement

We would also like to thank PT X for giving us the opportunity to conduct research on the company. We hope that this research will benefit the company in managing their supply chain risks.

Disclosure statement

The authors report there are no competing interests to declare.

Funding statement

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article or its supplementary materials.

References

[1] J. Paul, Transformasi rantai suplai dengan model SCOR. Jakarta: PPM Manajemen, 2014.

[2] A. H. K. Nadhira, T. Oktiarso, and T. D. Harsoyo, "Manajemen risiko rantai pasok produk sayuran menggunakan metode supply chain operation reference dan model house of risk," *Kurawal - Jurnal Teknologi, Informasi dan Industri*, vol. 2, no. 2, pp. 101–117, Oct. 2019, doi: 10.33479/kurawal.2019.2.2.101-117.

[3] M. Ulfah, "Mitigasi risiko rantai pasok industri furniture dengan menggunakan metode house of risk di IKM Sinar Muda", *Journal Industrial Servicess,* vol. 7, no. 1, Oktober 2021, doi: 10.36055/jiss.v7i1.12745.

[4] Y. K. Tse, S. H. Chung, and K. S. Pawar, "Risk perception and decision making in the supply chain: theory and practice," *Ind. Manag. Data Syst.*, vol. 118, no. 7, pp. 1322–1326, Sep. 2018, doi: 10.1108/IMDS-08-2018-605/FULL/PDF.

[5] D. Anggrahini, P. D. Karningsih, and M. Sulistiyono, "Managing Quality Risk in a Frozen Shrimp Supply

Chain: A Case Study, " *Procedia Manuf.*, vol. 4, pp. 252–260, Jan. 2015, doi: 10.1016/J.PROMFG.2015.11.039.

[6] I. Tubagus, "Improving anticipative learning through entrepreneurial orientation in small to medium size enterprises," *Eur. Res. Stud. J.*, vol. 20, no. 3 (A), pp. 758–767, 2017, doi: 10.35808/ersj/742.

[7] W. Ho, T. Zheng, H. Yildiz, and S. Talluri, "Supply chain risk management: a literature review," *International Journal of Production Research*, vol. 53, no. 16, pp.5031–5069, Aug. 2015, doi: 10.1080/00207543.2015.1030467.

[8] H. Ge, J. Nolan, R. Gray, S. Goetz, and Y. Han, "Supply chain complexity and risk mitigation – A hybrid optimization–simulation model," *International Journal of Production Economics*, vol. 179, pp. 228–238, Sep. 2016, doi: 10.1016/j.ijpe.2016.06.014.

[9] M Ulfah, "Aksi mitigasi risiko rantai pasok gula rafinasi dengan menggunakan cartesian diagram," *Jurnal Industrial Services*, vol. 2, no. 2, pp.169-175, Maret 2017, doi: 10.36055/jiss.v7i1.12745.

[10] N. Ntabe, L. LeBel, A. D. Munson, and L. A. SantaEulalia, "A systematic literature review of the supply chain operations reference (SCOR) model application with special attention to environmental issues," *Int. J. Prod. Econ.*, vol. 169, pp. 310–332, Nov. 2015, doi: 10.1016/J.IJPE.2015.08.008.

[11] T. Immawan and D. K. Putri, "House of risk approach for assessing supply chain risk management strategies: a case study in crumb rubber company Ltd.," *MATEC WebConf*, vol. 154, pp. 1–4, 2018, doi: 10.1051/matecconf/201815401097.

[12] R. Astuti, R. L. R. Silalahi, and R. A. Rosyadi, "Risk mitigation strategy for mangosteen business using House of Risk (HOR) methods: (A case study in "Wijaya Buah", Blitar District, Indonesia)," *KnE Life Sciences*, vol. 4, no. 2, pp. 17–27, 2017, doi: 10.18502/kls.v4i2.1653.

[13] R. D. Lufika, P. D. Sentia, I. Ilyas, F. Erwan, A.Andriansyah, and A. Muthmainnah, "Risk mitigation design in the production process of packaged fruit juice drinks using a Fuzzy Based House of Risk (HOR) Approach," *Jurnal Sistem Teknik Industri*, vol. 24, no. 2, pp 245-253, 2022, doi: 10.32734/jsti.v24i2.8498.

[14] C. Wan, X. Yan, D. Zhang, Z. Qu, and Z. Yang, "An advanced fuzzy Bayesian-based FMEA approach for assessing maritime supply chain risks," Transportation Research Part E: *Logistics and Transportation Review*, vol. 125, pp. 222-240, 2019, doi: 10.1016/j.tre.2019.03.011.

[15] A. Andriyanto and N. K. Mustamin, "Analisis manajemen risiko dan strategi penanganan risiko pada PT Agility International menggunakan metode House Of Risk (HOR)," *Jurnal Logistik Bisnis*, vol. 10, no. 02, pp. 4–11, Nov. 2020, doi: 10.46369/logistik.v10i02.949.

[16] I. N. Putri, "Analisis risiko kegagalan produk mempengaruhi kualitas pelayanan menggunakan house of risk dan supply chain operations reference," *Jurnal Optimasi Teknik Industri (JOTI)*, vol. 2, no. 1, pp. 19–23, Mar. 2020, doi: 10.30998/joti.v2i1.4049.

[17] J. A. Hadi, M. A. Febrianti, G. A. Yudhistira, and Q. Qurtubi, "Identifikasi risiko rantai pasok dengan metode House of Risk (HOR)," *Performa: Media Ilmiah Teknik Industri*, vol. 19, no. 2, Oct. 2020, doi: 10.20961/performa.19.2.46388.

[18] B. H. Purnomo, B. Suryadharma, and R. G. Al-hakim, "Risk mitigation analysis in a supply chain of coffee using House of Risk method," Industria: *Jurnal Teknologi dan Manajemen Agroindustri*, vol. 10, no. 2, pp. 111–124, Aug. 2021, doi: 10.21776/ub.industria.2021.010.02.3.

[19] M. Ulfah, M. S. Maarif, and S. R. Sukardi. "Analisis dan perbaikan manajemen risiko rantai pasok gula rafinasi dengan pendekatan House of Risk," *Jurnal Teknologi Industri Pertanian IPB*, vol. 26, No. 1, pp.87-103, 2016.

[20] S. A. Nugraheni, R. Yuniarti, and R. A. Sari, "The Analysis of Supply Chain Risk on Ready to Drink (RTD) product using House of Risk method," *Journal of Engineering and Management Industrial System*, vol. 5, no. 1, pp.46-57, 2017.

[21] I. N. Pujawan and L. H. Geraldin. "House of Risk: A Model for Proactive," *Supply Chain Risk Management Business Process Management Journal*, pp. 1-15, 2014 doi: 10.1108/14637150911003801.

[22] E. Elvandra, A. R. Maarif, M. S. Sukardi, "Management of Supply Chain Risk in Cattle Slice Fattening at PT Catur Mitra Taruma," *Business Process Management Journal*, vol. 4, no. 1, pp. 97, 2018, doi: 10.1108/14637150911003801.