

MANAGING RISK IN PALM SUGAR REVERSE SUPPLY CHAIN USING INTEGRATION HOUSE OF RISK AND INTERPRETIVE STRUCTURAL MODELING

NURUL UMMI^{1*}, MARIMIN², ERLIZA NOOR³ and MUHAMMAD ROMLI⁴

¹Graduate Program of Agro-industrial Engineering, Faculty of Agricultural Engineering and Technology, IPB University (Bogor Agricultural University) Bogor, Indonesia.

^{2, 3, 4}Department of Agro-industrial Technology, Faculty of Agricultural Engineering and Technology, IPB University (Bogor Agricultural University), Bogor, Indonesia.

Email: ^{*}(Corresponding Author) ¹nurul.ummi@untirta.ac.id, ²marimin@ipb.ac.id, ³erlizanoor@yahoo.com, ⁴mromli@hotmail.com

Abstract

Palm sugar is an agro-industrial product that is very susceptible to damage. From the results in the field, it is known that 10%-20% of palm sugar is damaged during distribution. Providing value back to damaged palm sugar products can be done by implementing the Reverse Supply Chain (RSC). The food industry must face some risks in implementing RSC. Therefore, we should immediately address these risks to ensure the RSC activities run well. This study identifies risks and determines risk mitigation strategies based on risk priorities. Risk management in RSC activities is carried out by mapping RSC activities in the Reverse Supply Chain Operation Reference (RSCOR) model. This study provides a House of Risk (HOR) and Interpretive Structural Modeling (ISM) based RSC risk management model to determine risk priorities and mitigation based on risk priorities and to understand the relationship between other mitigating action variables. Based on the Pareto principle, it is found that twenty-four risk sources are the primary concern because they contribute to 80% of the occurrence of the risk. Through the HOR 2 method, decision makers can prioritize risk mitigation actions based on the largest Effectiveness to Difficulty Ratio of Action (ETDk) value that indicates the possibility of mitigation actions to be realized by looking at the effectiveness of mitigation actions and the availability of available resources. However, this action model has not considered how mitigation actions are related to other mitigation actions. Therefore, the HOR2 method is combined with the ISM method to complete the model. Through the ISM method, decision makers can prioritize risk mitigation actions in cluster IV (Independent).

Keywords: House of Risk, Interpretive Structural Modeling, Palm sugar, Reverse Supply Chain Risk, Risk Management

1. INTRODUCTION

The food industry must face some risks in implementing Reverse Supply Chain (RSC) (Banasik et al., 2017; Noor, et al. 2016). The security of food products and the shelf life of agricultural products require fast and efficient logistics operations, which is a significant challenge in reverse logistic (RL) activities in the food industry (Vlachos, 2014).

Every year millions of tons of organic waste are buried or burned, creating problems for the environment, and incurring additional costs for transportation. One effort to reduce these problems, according to Cheraghalipour et al., 2018 can be made by converting organic waste into fertilizer. As in the case of Closed Loop Supply Chain (CLSC) citrus fruit. Damaged fruit will become organic waste and immediately sent back to the fertilizer manufacturing center to be further processed into organic fertilizer (Roghianian & Cheraghalipour, 2019).

Palm sugar is one of the foods that are very susceptible to damage. From the results in the field, it is known that 10%-20% of palm sugar is damaged during distribution. The damage will increase if palm sugar is not immediately consumed or processed further. Damage to food products can occur due to environmental conditions, changes in temperature and humidity, and long transportation routes. In addition, product damage is also caused by poor packaging and long product turnover. These conditions can decrease product quality (Fancello et al., 2017; Noor et al., 2016; Zhang, Qiu, & Zhang, 2017). RSC can be done to give added value to damaged palm sugar products, namely by sending back the damaged products to producers or third parties for reprocessing. This study tries to conduct RSC to add added value to palm sugar in other derivative products such as palm sugar and ginger sugar.

In implementing RSC activities, producers or third parties often face risks (Nazari, et al., 2018; Senthil, et al., 2018). There are several complex risks in the RSC agro-industry, such as marketing risk (Huang & Wang, 2018), supply and demand uncertainty (Asim et al. 2019), (Polo et al., 2019), operational risk (Y Zhang et al., 2021), Technological risk (Govindan & Bouzon, 2018), etc. We should immediately address these risks to ensure the RSC activities run well. This study aims to identify and categorize risks in palm sugar RSC activities and help decision-makers choose risk mitigation measures based on priority.

2. METHOD

Various risks in the RSC must be compiled and sorted by priority. The magnitude of loss and the likelihood of the risk occurring are taken into consideration while choosing the risks. (Vlachos, 2014). The first step in figuring out the sequence of supply chain hazards is a verification and risk mapping using the Supply Chain Operation Reference (SCOR) and HOR methodologies (Umami, et al., 2018). The HOR method is a modification of the FMEA and the quality house model (HOQ) to sort the sources of risk. The selected risk becomes a top priority for immediate action to reduce the potential threat from risk sources (Pujawan and Geraldin 2009).

In contrast to Umami et al. (2018), Nguyen et al. (2018) claim that the order of risk is established by combining the HOR technique with interpretive structural modeling (ISM). Based on the Aggregate Risk Potential of Risk Agent j (ARP $_j$) value, HOR can help with risk prioritization. At the same time, ISM can map the relationship between risks and generate the main risks that trigger the most other risks. By incorporating this strategy, decision-makers can choose which risks need to be handled right away and which can wait until they have adjusted their budget and resources.

Generally, the stages in RSC risk management in palm sugar use the HOR, and ISM approaches. Risk identification begins with mapping the RSC activities based on the development of the Reverse Supply Chain Operation Reference (RSCOR) model, then identifying and determining the order of risk priorities is carried out with HOR phase 1. Meanwhile, risk mitigation is carried out using HOR phase 2 and ISM to map the relationship between preventive actions in risk mitigation. Risk identification and risk mitigation are carried

out based on the opinion of experts and academics. The steps in using HOR 1 and 2 and ISM are as follows:

2.1 House of Risk phase 1 and 2

The following are the stages in the HOR 1:

1. RSCOR model-based identification of RSC business processes for the palm sugar sector. This process division aims to find out where these risks can arise.
2. Identify risk events in RSC activities. A risk event is an event that may arise and cause a disturbance.
3. Determine the magnitude of the impact of a risk event's disturbance (severity). The severity value (S_i) based on the FMEA method ranges from 1 -10 (lowest to highest).
4. Identification of the risk agent, or any elements that may contribute to the occurrence of the risk event, or cause of risk. Based on the occurrence value (O_j), each risk factor is evaluated. The weighting scale for occurrence values refers to the FMEA method using a scale of 1-10 (lowest to highest)
5. Establish the relationship between the risk agent and a risk event. The formula used in the R_{ij} component of the relationship between the risk event i and the risk agent j is as follows: $R_{ij} \{0, 1\}$.
6. Calculate the value of Aggregate Risk Potentials (ARP). The calculation of the ARP value according to Pujawan and Geraldine 2009 are:

$$ARP_j = O_j \times \sum S_i \times R_{ij}$$

Where

ARP_j = A collection of potential risks from the source/cause of risk (risk agent)

O_j = Risk occurrence level from the source of risk

S_i = the degree of a risk's impact (severity level of risk)

R_{ij} = Relationship between risk and head of the risk

7. Based on the ARP value, determine the priority of the risks.
8. The stages in HOR 2 refer to Pujawan and Geraldine 2009.

2.2 Interpretive Structural Modeling

The ISM steps are as follows:

1. Identify system elements.
2. Establish a contextual connection between the components.
3. Create a structural self-interaction matrix (SSIM)

Expert judgments based on a variety of management strategies, including brainstorming, nominal techniques, etc., are used in the ISM methodology. Furthermore, develop the contextual relationship between variables. The correlation among the two elements (i and j) is directly related to the question. There are four symbols used, namely:

V: the correlation among the elements E_i and E_j , not the reverse

A: the link among the elements E_j and E_i , not the reverse

X: the bond among E_i and E_j (can be vice versa)

O: this proves that E_i and E_j are unconnected.

4. The Reachability matrix (RM)

The RM transforms SSIM into the form of a binary matrix. This matrix substitutes V, A, X, and O with 0 and 1 for each case

The substitution rules are as follows:

1. The relationship between E_i and E_j in SSIM is V if the elements $E_{ij} = 1$ and $E_{ji} = 0$ in RM.
2. The relationship between the components E_i to E_j in SSIM is A if the elements $E_{ij} = 0$ and $E_{ji} = 1$ in RM.
3. The relationship between the elements E_i and E_j in the SSIM is X, then in the RM, E_{ij} and E_{ji} are both equal to 1.
4. If the relationship between the elements E_i and E_j in SSIM is O, then in RM, the elements E_{ij} and E_{ji} are both equal to 0.

5. Specify components at various ISM structure levels.

Analysis of the driver power and dependent power variables is the goal (Saxena dan Seth 2012). Variables are classified into four classes. The division of clusters is as follows:

1. Cluster 1: Weak dependent variables and a weak driver (AUTONOMOUS) Although there may be a tiny relationship, and this sector variable is often unconnected to the system.
2. Cluster 2: Strongly dependent variables with a weak driver (DEPENDENT) This sector includes variables that are heavily dependent on other components and are not independent of the system.
3. Cluster 3: Strongly dependent variables with a strong driver (LINKAGE) Since the link between the variables in this field is unstable, it is important to thoroughly study the variables. Each change in one of these variables will have an influence on the others, and feedback on the effect can make the impact stronger.

4. Cluster 4: weak dependent variables with a strong driver (INDEPENDENT). The variables in this area are referred to as independent variables and are included in the remainder of the system.
6. Develop a Canonical matrix.
7. Build a Directional Graph (Digraph) that is interconnected and in the form of a hierarchical level

3. RESULT AND DISCUSSION

3.1 Supply Chain Activity Mapping

A group of businesses affiliated with the Supply Chain Council (SCC) created the Supply Chain Operation Reference (SCOR) model as a tool and benchmark to assist businesses in developing and improving their supply chain processes. The SCOR model offers a well-organized framework for process-based supply chain management. This model was introduced by the SCC to help organizations improve the effectiveness of their supply chains (Council 2008). The SCOR model offers a framework that unifies the partners engaged, performance indicators, processes, best practices, and framework. Mapping of supply chain activities can be done using a five-process management approach to the SCOR model (Pujawan and Geraldin 2009). Plan, Source, Make, Deliver, and Return are the five essential parts of this SCOR paradigm (Rangel et al. 2015). A closed-loop logistics chain reference cycle (CLCOR) model technique is used when mapping activities in CLSC activities. This technique develops the SCOR model as a forward and backward supply chain. Eight primary components make up CLCOR: four are involved in forward logistics activities, namely Plan (P), Source (S), Make (M), and Deliver (D), and four more are involved in backward logistics activities, namely Source Return (SR), Make Return (MR), Deliver Return (DR), and Logistic Information (LI) (Xiao et al. 2012).

Because the remanufacturing process entails numerous actions, SCOR terminology is crucial from the perspective of the RSC process. The first step in the remanufacturing process is gathering discarded or rejected goods or products that are not included in the industrial suitability or products that are close to shelf life and are not consumed immediately. The product is returned to the center for manufacturing, dismantling, cleaning, and production planning, manufacturing the finished product, and shipping the remanufactured product to market. The remanufacturing activities are consistent with the terminology of the SCOR model (Ansari et al. 2020). The SCOR model approach can also measure the company's business performance in developing a RL monitoring system (Kuswandi et al. 2018). Based on the SCOR and CLCOR models, the process-based RSC activity mapping in this study is the development of SCOR and CLCOR for the reverse flow, namely the Reverse Supply Chain Operation Reference (RSCOR). RSCOR is broken down into six main components, namely Return (R), Plan (P), Source (S), Make (M) and Deliver (DR), and also Logistic Information (LI), see Table 1.

Table 1: The RSCOR Components

Main Components of RSCOR	Sub-Process
Return (R)	Legal Contract
	Environment
	Product return
Plan (P)	Demand forecast
	Production planning
	Material inventory control
	Financial planning
Source (S)	Scheduling
	Delivery of raw materials from raw material sources
	Receipt of raw materials
Make (M)	Product quality
	Production process
	Packaging and labeling
	Human Resources (HR)
	Storage Space
	Machinery and Technology
Deliver (D)	Product delivery schedule
	Transportation
Logistic Information (LI)	Logistics information
	Price information

3.2 Reverse Supply Chain Risk

Based on a review of the existing literature, several risks occur in RSC activities, it can be seen in Table 2.

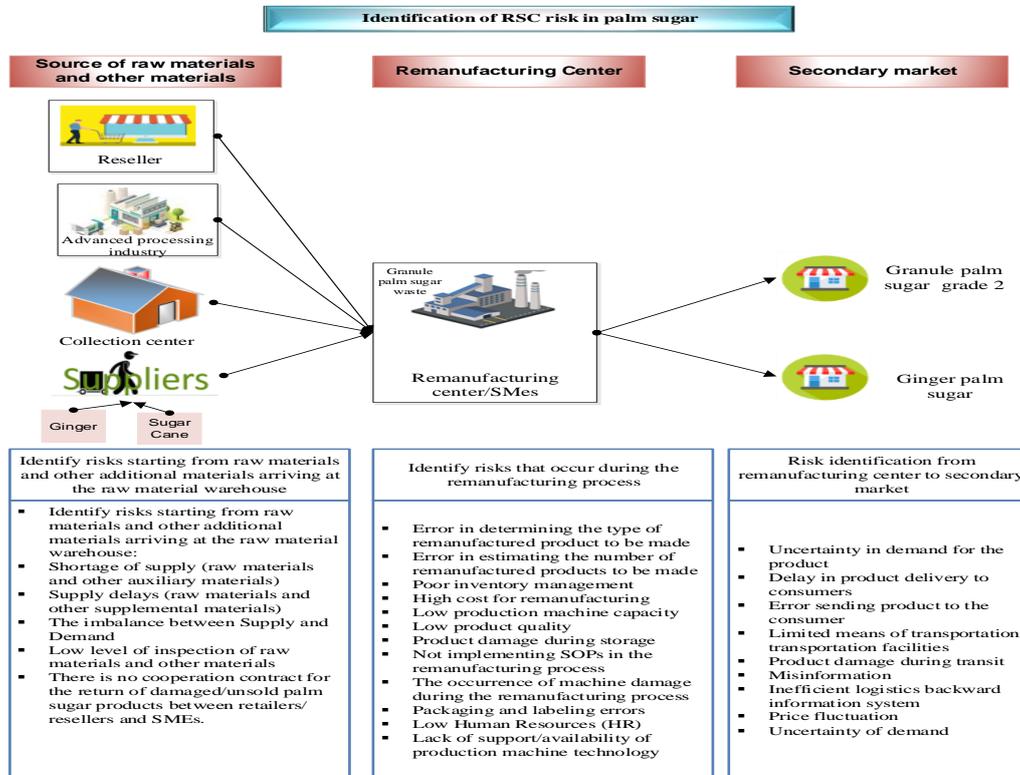
Table 2: Type of RSC Risk

Types of risk	Author
Uncertainty about the quantity of the product returned	(Biçe dan Batun 2021) (Zhou et al. 2017) (Zeballos et al. 2018), (Paydar et al. 2017), (Jindal dan Sangwan 2014), (Han et al. 2016), (Heydari dan Ghasemi 2018), (Sun et al. 2019), (Hatefi dan Jolai 2014), (Ma et al. 2019).
Uncertainty of demand	(Polo et al. 2019), (Cardoso et al. 2016), (Amin dan Zhang 2013), (Nazari et al. 2018), (Yu dan Solvang 2016), (Ma et al. 2019), (Entezaminia et al. 2017), (Bakhshi dan Heydari 2021).
Uncertainty about the quality of returned products	(Almaraj dan Trafalis 2019), (Zeballos et al. 2018), (Maiti dan Giri 2015), (Nazari et al. 2018), (Jindal dan Sangwan 2014), (Papen dan Amin 2019)
Financial (Cost)	(Polo et al. 2019), (Govindan dan Bouzon 2018), (Chileshe et al. 2015)
Supply uncertainty	(Zhang et al. 2021), (Amin dan Zhang 2013), (Jabbarzadeh et al. 2018), (Han et al. 2016), (Xiao et al. 2012), (Rezaei et al. 2020).

Environment	(Shekarian et al. 2021), (Mohajeri dan Fallah 2016), (Ma et al. 2019), (Alumur et al. 2012), (Jabbarzadeh et al. 2018), (Entezaminia et al. 2017), (Xiao et al. 2012), (Papen dan Amin 2019).
Transportation includes transportation costs	(Asim et al. 2019), (Yu dan Solvang 2016), (Jabbarzadeh et al. 2018)
Delivery time risk	(Asim et al. 2019), (Zhou et al. 2017)
Capacity uncertainty	(Mohajeri dan Fallah 2016), (Alumur et al. 2012), (Heydari dan Ghasemi 2018), (Fazli-Khalaf dan Hamidieh 2017), (Bakhshi dan Heydari 2021)
Operational	(Zhang et al. 2021), (Chileshe et al. 2015), (Jabbarzadeh et al. 2018)
Production	(Asim et al. 2019), (Huang dan Wang 2018), (Entezaminia et al. 2017)
Inventory	(Zhou et al. 2017), (Vahdani dan Ahmadzadeh 2019)
Price	(Shekarian et al. 2021), (Vahdani dan Ahmadzadeh 2019), (Soleimani dan Govindan 2014)
Technology	(Govindan dan Bouzon 2018), (Xiao et al. 2012)
Human Resources	(Paydar et al. 2017), (Xiao et al. 2012)
Marketing	(Huang dan Wang 2018), (Govindan dan Bouzon 2018)
Deteriorated products	(Moubed et al. 2021), (Sun et al. 2019)
Data processing	(Xiao et al. 2012)

In the palm sugar supply chain's RSC activity, several risks occur, starting from the source of raw materials from resellers, other processing industries, collection centers, and the small medium enterprise (SMEs) itself to the remanufacturing process to the secondary market. Throughout the supply chain backflow, the risks that occur are identified. The results of risk identification in each section are as follows in Figure 1:

Figure 1: Identification of RSC Risk in Palm Sugar



3.3 House of Risk phase 1

3.3.1 Risk Event

Experts then validate the findings of the risk identification process for the palm sugar RSC activities. Risk events in supply chain backward activities refer to the RSCOR method, which consists of 6 main components. The six central components are then identified as sub-processes. Risk events are determined by detailing the risks/disruptions that occur from each sub-process. Based on the results of Face Validation, there are 31 risk events in the RSC of Palm sugar. See appendix Table 7.

3.3.2 Risk Agent

Based on the value of occurrence (Oj) or frequency of occurrence, each risk agent is assessed. The chance that a risk agent may cause the appearance of one or more risks that can interrupt business activities is expressed by the term "occurrence" (Oj). There are 39 sources of risks with the level of frequency of events that occur, as shown in appendix Table 8.

3.3.3 Correlation matrix between risk events and risk agents

An expert makes the determination of the relationship between a risk event and the risk agent. The expert assesses the strength of the correlation between the risk event and the risk agent,

where $R_{ij} \in \{0, 1\}$. If a source of risk (risk agent) causes a risk event, it is said that there is a correlation $R_{ij} = 1$. And if risk agent j and risk event i do not correlate, then $R_{ij} = 0$. The weighting of the correlation value between each risk agent and each risk event refers to the FMEA approach. The scale used is $R_{ij} \in \{0, 1, 3, 9\}$. A correlation between risk event and risk agents is shown by a value of 0 if there is none correlation, a value of 1 implies a low correlation, a value of 3 denotes a moderate correlation, and a value of 9 denotes a strong correlation. To ascertain the relationship between each risk event and the risk agent, expert judgment is utilized.

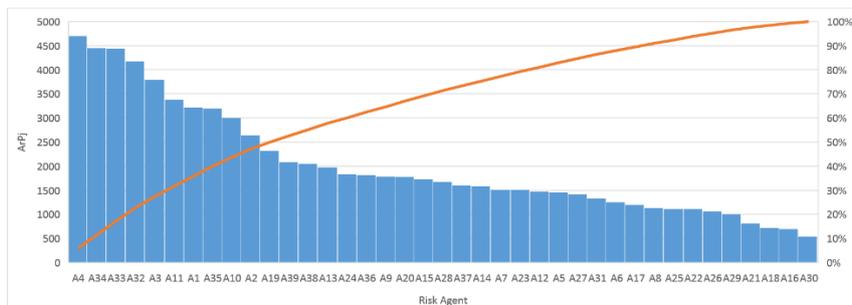
3.3.4 Aggregate Risk Potentials (ARP) and Risk Priority Index

ARP describes a set of potential risks. This ARP value will be used to determine the priority of the risk agent that needs to be handled by risk mitigation. Table 3 shows that the highest ARP value is 4.704, namely Planning, which does not consider uncertainty (A4). And the lowest ARP is 546, namely means of transportation that cannot protect products from changes in weather and the environment (A30). Following the determination of the ARP value, the risk priority and overall risk classification are carried out. Risk management is carried out based on risk priority. Determination of risk management is carried out using the Pareto 80:20 principles. Three categories make up the risk classification: category A (high-risk agents, which account for 50% of all risk agents), category B (moderate risk agents, 30% of all risk agents), and category C (low-risk agents, which account for 20% of all risk agents) (Ulfah 2016). Figure 2, prioritizing the order of risks priority, shows that 11 risk agents contribute to 50% of risk events. The 11 agents are A4, A34, A33, A32, A3, A11, A1, A35, A10, A2, A19. And 13 risk agents contributed to the other 30% risk events, namely A39, A38, A13, A24, A36, A9, A20, A15, A28, A37, A14 and A23.

Table 3: Aggregate Risk Potentials (ARP) Value and Classification

Code	ARPj	% Cum	Class	Code	ARPj	% Cum	Class	Code	ARPj	% Cum	Class
A4	4704	6%	A	A39	2079	53%	B	A12	1470	81%	C
A34	4452	12%		A38	2052	55%		A5	1458	83%	
A33	4446	17%		A13	1980	58%		A27	1422	85%	
A32	4176	23%		A24	1830	60%		A31	1335	86%	
A3	3798	27%		A36	1818	62%		A6	1260	88%	
A11	3384	32%		A9	1788	65%		A17	1197	90%	
A1	3222	36%		A20	1782	67%		A8	1134	91%	
A35	3192	40%		A15	1740	69%		A25	1113	92%	
A10	3003	44%		A28	1680	71%		A22	1110	94%	
A2	2646	47%		A37	1602	73%		A26	1071	95%	
A19	2322	50%		A14	1584	75%		A29	1008	96%	
			A7	1512	77%	A21		816	97%		
			A23	1512	79%	A18		720	98%		
						A16	702	99%			
						A30	546	100%			

Figure 2: Pareto Chart Source of Risk



3.5 House of Risk 2

HOR 2 is used to identify and prioritize risk mitigation measures that must be carried out by the business effectively while taking into account the availability of corporate resources and funds. From table 4, it can be seen that there are 20 mitigation actions with the level of difficulty to be faced, namely very complicated (5), complex (4), quite difficult (3), easy (2), and straightforward (1) categories. The difficulty level (Dk) dramatically affects the Effectiveness to Difficulty Ratio of Action (ETD) value because even though the effectiveness value (TEk) is considerable, if the difficulty level is high, the ETDk value will be small. Therefore, the greater the ETD value, the more influential the mitigation action is realized.

Table 4: Preventive Action

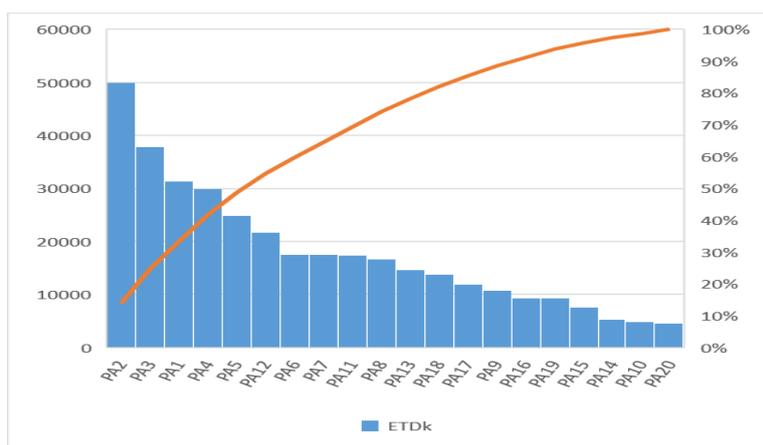
Preventive Action (PAk)	Code	TEk	Dk	ETDk	Rank
Build a RL information system in the form of a QR Code that is integrated with the database system in SMEs	PA2	199,908	4	49,977	1
Increased Cooperation between SMEs, Suppliers, Resellers, and further processing industries through cooperation contracts related to the acceptance of return products at agreed prices	PA3	151,362	4	37,841	2
Optimization of remanufacturing production by taking into account the uncertainty of supply and demand	PA1	125,604	4	31,401	3
Increased cooperation with resellers in the secondary market	PA4	119,601	4	29,900	4
Improve customer service responsiveness through offline & Online Marketing	PA5	99,522	4	24,881	5
Product tracking information services to consumers	PA12	43,398	2	21,699	6
IT operation training to improve HR skills	PA6	52,758	3	17,586	7
There is a penalty in the article of the cooperation contract agreement if one of the producers or resellers violates the contract agreement.	PA7	52,659	3	17,553	8
Cooperation with the expedition service for product delivery	PA11	34,668	2	17,334	9
The existence of SOP in controlling product quality from incoming materials, and processes to products sent to consumers	PA8	33,480	2	16,740	10

Preventive and predictive maintenance of production machines regularly.	PA13	44,064	3	14,688	11
Production and packaging technology operation training	PA18	41,472	3	13,824	12
Maintenance training to improve HR skills.	PA17	35,586	3	11,862	13
There are Strict Rules for implementing SOP.	PA9	21,600	2	10,800	14
The separation between the production warehouse and raw material warehouse	PA16	18,792	2	9,396	15
Coordination with Transporters	PA19	18,792	2	9,396	16
Provision of temperature and humidity measuring instruments and manufacture of glass windows as ventilation for production warehouses and raw material warehouses to facilitate humidity and lighting regulation	PA15	15,120	2	7,560	17
Carry out routine vehicle maintenance	PA14	16,092	3	5,364	18
Procurement of transportation facilities with lower capacity and high mobility	PA10	24,408	5	4,882	19
Selection of quality packaging materials to minimize contamination	PA20	13,608	3	4,536	20

The Pareto diagram of the ETDk value is the relationship between the mitigation action and the effectiveness value if the mitigation action is carried out. The higher the ratio, the more cost-effective the proposed action is, as shown in Figure 3.

Table 4 shows that the mitigation action (PA2) has an ETDk value of 49,977. This mitigation action becomes the priority because it has the most considerable ETD value, which shows practical mitigation actions to be realized. The second rank is (PA3) with an ETD value of 37,841. And the third rank is (PA1) with an ETD value of 31.401. The sequence of other mitigation actions can be seen in Table 4.

Figure 3: Pareto Chart of the Effectiveness to Difficulty Ratio of Action



3.6 Interpretive Structural Modeling (ISM)

The relationship between elements of preventive action (PAk) to mitigate the risk of RSC agroindustry palm sugar was obtained from expert opinion and compiled in the SSIM as shown in Table 5. Furthermore, the structural model is generated using the final RM.

Table 5: Structural Self-Interaction Matrix of RSC Risk Mitigation

Ri	Rj	PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	PA9	PA10	PA11	PA12	PA13	PA14	PA15	PA16	PA17	PA18	PA19	PA20
PA1		A	A	A	A	V	A	X	X	X	X	X	X	V	X	X	V	V	V	V	X
PA2			V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
PA3				X	X	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
PA4					X	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
PA5						V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
PA6							A	A	A	A	A	A	A	A	A	A	A	O	O	A	A
PA7								V	V	V	V	V	V	V	V	V	V	V	V	V	V
PA8									X	X	X	X	X	V	X	X	X	V	V	V	X
PA9										X	X	X	X	V	X	X	X	V	V	V	X
PA10											X	X	X	V	X	X	V	V	V	V	X
PA11												X	X	V	X	X	V	V	V	V	X
PA12													X	V	X	X	V	V	V	V	X
PA13														V	X	X	X	V	V	V	X
PA14															A	A	O	O	V	A	
PA15																X	V	V	V	X	
PA16																	V	V	V	X	
PA17																		O	O	A	
PA18																			O	A	
PA19																					A
PA20																					A

Table 6 shows that the highest driver power or critical element of risk mitigation in the RSC of the palm sugar industry is to build a RL information system in the form of a QR Code integrated with the database system in SMEs (PA2).

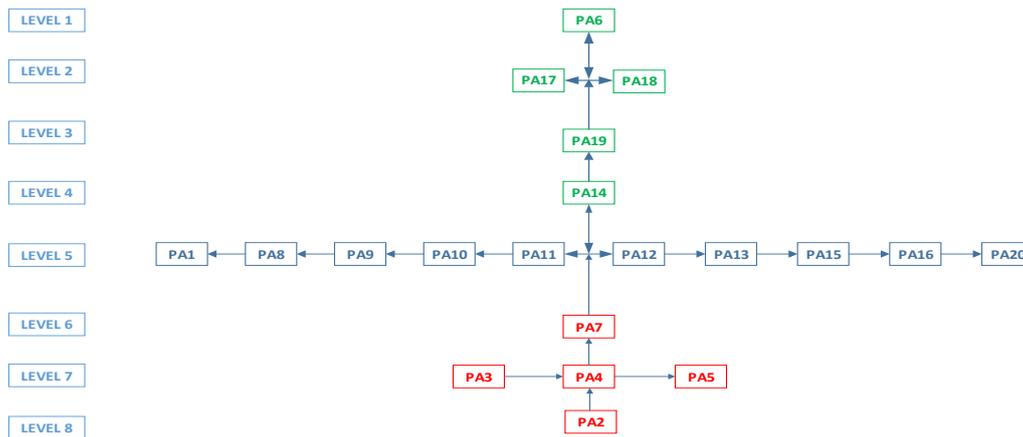
The implementation of PA2 will encourage increased collaboration between SMEs, suppliers, resellers, and other processing industries through cooperation contracts related to the acceptance of return products at an agreed price (PA3). And also encourage increased cooperation with resellers on the secondary market (PA4) and service improvement. Responsive to customer needs through offline and online marketing (PA5). The establishment of cooperation requires that SMEs, supplier, and reseller require certainty in a cooperation agreement to encourage the need for a penalty in the article of the cooperation contract agreement if one of the producers or resellers violates the contract agreement (PA7).

Table 6: Final Reachability Matrix RSC Risk Mitigation

NO	PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	PA9	PA10	PA11	PA12	PA13	P14	P15	P16	P17	P18	P19	P20	DP	R
PA1	1	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	15	4
PA2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	20	1
PA3	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	19	2
PA4	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	19	2
PA5	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	19	2
PA6	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7
PA7	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	3
PA8	1	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	15	4
PA9	1	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	15	4
PA10	1	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	15	4
PA11	1	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	15	4
PA12	1	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	15	4
PA13	1	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	15	4
PA14	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	3	5
PA15	1	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	15	4
PA16	1	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	15	4
PA17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	7
PA18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	7
PA19	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	6
PA20	1	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	15	4
D	15	1	4	4	4	18	5	15	15	15	15	15	15	16	15	15	16	16	17	15		
L	4	7	6	6	6	1	5	4	4	4	4	4	4	3	4	4	3	3	2	4		

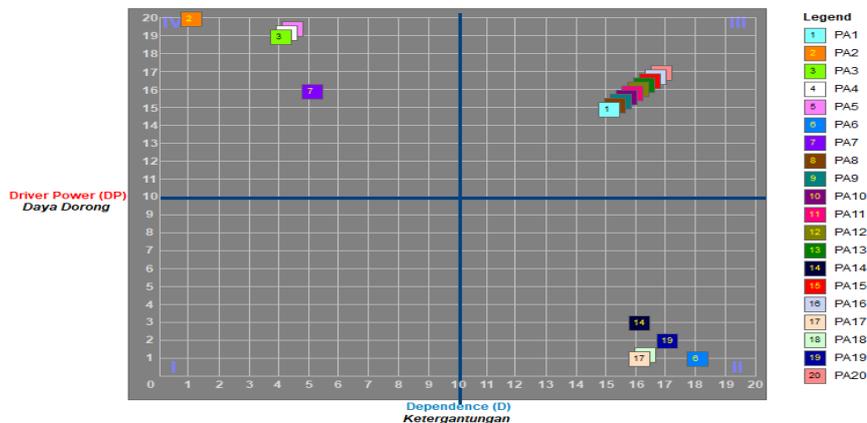
The five previous preventive actions (PA2, PA3, PA4, PA5, and PA7) will encourage the following preventive action. These preventative actions are: (PA1, PA8, PA9, PA10, PA11, PA12, PA13, PA15, PA16 and PA20). See Figure 4.

Figure 4: ISM Model Formulation of RSC Risk Mitigation



Next is Preventive action, which has a high level of dependence and low thrust. Procurement of transportation advice (PA11) encourages the need for routine vehicle maintenance (PA14). Improving customer service responsiveness through offline and online marketing (PA5) encourages the need for coordination with transporters (PA19) in product delivery and product return receipts. Training in the operation of production and packaging technology (PA18) is necessary to maintain product quality to enhance customer service responsiveness (PA5). To support the development of a RL information system in the form of a QR Code integrated with the database system in SMEs (PA1), it encourages the need for IT operations training activities to improve HR skills (PA6).

Figure 5: The cluster of RSC Risk Mitigation



The palm sugar RSC risk mitigation is divided into four groups; the AUTONOMOUS criteria, which have weak drivers and dependencies, make up the first cluster. These criteria have little effect on the system. Picture 9 shows that none of the preventive actions are included in cluster I (Autonomous). DEPENDENT criteria, which have significant dependencies but weak driver power, make up the second cluster. Five preventive actions fall into this cluster-dependent category: PA6, PA14, PA17, PA18, and PA19. The picture also shows that ten preventive actions are included in this linkage cluster, namely (PA1, PA8, PA9, PA10, PA11, PA12, PA13, PA15, PA16, and PA20). The variables in cluster 3 have linkage criteria with a strong driving force and dependency (LINKAGE). This criterion is unstable, and any action on it will affect other system variables. The PA2, PA3, PA4, PA5, and PA7 criteria make up the fourth cluster, the INDEPENDENT criteria, which has a high driving power but weak dependence. See Figure 5. Through the HOR 2 method, decision makers can prioritize risk mitigation actions based on the most considerable ETDk value that indicates the possibility of mitigation actions to be realized by looking at the effectiveness of mitigation actions and the availability of available resources. However, this action model has not considered how mitigation actions are related to other mitigation actions. Therefore, the HOR 2 method is combined with the ISM method to complete the model. Through the ISM method, decision makers can prioritize risk mitigation actions in cluster IV (Independent). In contrast, cluster IV is a cluster that has a strong driving force so that it can encourage mitigation actions in other clusters. The priority sequence of mitigation actions based on HOR 2 and ISM in managing RSC risk for palm sugar is: (PA2), (PA3), (PA4), (PA5), and (PA7).

4. CONCLUSION

The RSC on agroindustry products is one of the efforts in product recovery and providing added value to these products. Managing the RSC, there are not a few risks that occur. Risk management in RSC activities is carried out by mapping RSC activities in the RSCOR model consisting of Return (R), Plan (P), Source (S), Make (M), and Deliver (DR) as well as Logistic Information (LI). This study has developed the integration of HOR and ISM to identify and prioritize risks and mitigation. Although there is some literature available on RSC risk management, there is still little literature that discusses RSC risk management in the agroindustry. Also, no research has been conducted to mitigate Risk based on risk priorities and map the interactions between risk mitigation using HOR and ISM. The main contribution of this study lies in developing contextual relationships among RSC risk management identified through a systematic framework. This research provides a HOR-ISM-based RSC risk management model to determine risk priorities and mitigation based on risk priorities and understand the relationship between other mitigating action variables.

Based on the Pareto principle, twenty-four sources of Risk are the primary concern because they contribute to 80% of the risk occurrence. The Risks are A4 (Plan that does not predict uncertainty). A34 (Not yet built an integrated and real-time RL information system). A33 (No RL information system network has been made). A32 (Lack of communication and information between SMEs with suppliers, resellers with secondary market products). A3 (Lack of communication and information from customers). A11 (Factors of communication of raw

materials and additional materials in fulfilling orders). A1 (Unclear requests for information for the type of product). A35 (There is no contractual understanding regarding receiving defective/unsold printed products between retailers/resellers and SMEs). A10 (There is no cooperation contract for accepting returns for damaged palm sugar products). A2 (Slow response to customer requests). A19 (Lack of expertise in HR). A39 (Lack of awareness of environmental care, both from consumers and resellers). A38 (Violation of contractual agreements between advanced processing industries, retailers, and SMEs). A13 (Weaknesses in controlling product quality, both material quality, product, hygienic conditions of workers and production areas before the production process is carried out), A24 (Limited means of transportation/transportation facilities), A36 (Difficulty in negotiating prices with customers). A9 (Transportation disruption during the trip). A20 (The reliability factor of machine tools during the process). A15 (There is no requirement to carry out remanufacturing SOP). A28 (High humidity and lack of lighting in finished product storage and raw material warehouses). A37 (Downtime machines). A14 (Storage of remanufactured products and raw materials in one location). A7 (Less efficient machine) and A23 (Contamination occurs in the packaging during the storage and shipping process).

Through the HOR 2 and ISM methods, decision makers can prioritize mitigation actions in cluster IV, which have strong driver power to encourage mitigation actions in other clusters, and allow them to be realized. The priority sequence of mitigation actions based on HOR 2 & ISM in managing RSC risk for palm sugar are: (PA2) Building a RL information system in the form of a QR Code integrated with the database system in SMEs, (PA3) Increasing Cooperation between SMEs, Suppliers, Resellers, and Further processing industry through cooperation contracts related to the return of returned products at agreed prices, (PA4) Increased collaboration with resellers on the secondary market, (PA5) Improved customer service responsiveness through offline & online marketing, and (PA7) the existence of penalties in the agreement article cooperation contract if one of the producers or resellers violates the contract agreement.

Appendix

Table 7: Risk Event

Main Components	Sub-Process	Risk Event	Code	Severity
Return (R)	Legal Contract	There is no cooperation contract for the return of damaged/unsold palm sugar products between retailers/resellers and SMEs.	RE1	8
	Environment	The number of damaged sugar products, either expired or near expiration at the reseller/retailer level	RE2	8
	Product return	Disruption of the return of damaged sugar products from resellers	RE3	7
Plan (P)	Demand forecast	Error in determining the type of remanufactured product to be made	RE4	6

		Uncertainty in demand for remanufactured products	RE5	7
	Production planning	Error in estimating the number of new remanufactured products to be made	RE6	7
		The sudden change in the production plan	RE7	6
	Material inventory control	The imbalance between Supply and Demand	RE8	7
		Poor inventory management	RE9	7
	Financial planning	High cost for remanufacturing	RE10	7
Source (S)	Scheduling	Supply delays (raw materials and other additional materials)	RE11	7
	Delivery of raw materials from raw material sources	Shortage of supply (raw materials and other auxiliary materials)	RE12	7
		Supply Uncertainty	RE13	7
	Receipt of raw materials	Low level of inspection of raw materials and other materials	RE14	7
Make (M)	Product quality	The low quality of remanufacturing products	RE15	7
		Decrease in the quality of remanufactured products during storage	RE16	7
		Not implementing SOP in the remanufacturing process	RE17	8
	Production process	The occurrence of machine damage during the remanufacturing process	RE18	7
	Packaging and labeling	Packaging and labeling errors	RE19	6
	Human Resources	Low HR	RE20	7
	Storage Space	Mixing raw materials and remanufacturing products in one space	RE21	6
		Increased damage to raw materials and other additional materials in the raw material storage warehouse	RE22	6
	Machinery and Technology	Lack of production machine technology support	RE23	7
		Low engine capacity capability	RE24	7
Deliver (D)	Product delivery schedule	Delay in product delivery to consumers	RE25	7
		Error sending product to the consumer	RE26	7
	Transportation	Limited means of transportation/transportation facilities	RE27	6
		Product damage during transit	RE28	6
Logistic Information (LI)	Logistics information	Misinformation	RE29	6
		Inefficient RL Information System	RE30	7
	Price information	Price fluctuation	RE31	7

Table 8 : Risk Agent

Risk Agent	Code	Occurrence (Oj)
Unclear information on demand for product types	A1	6
Slow response to customer requests	A2	6
Lack of communication and information from customers	A3	6
Planning that doesn't take uncertainty into account.	A4	7
Natural disasters	A5	3
Additional costs are required for the collection of raw materials and the manufacturing process.	A6	5
Less efficient machine	A7	6
The use of machines with technology that is still simple	A8	6
Transportation disruption during the trip	A9	4
The absence of a return acceptance cooperation contract for damaged palm sugar products	A10	7
The reliability factor of raw materials and additional materials in fulfilling orders	A11	6
Lack of thoroughness in the reception of raw materials & other additional materials	A12	7
Weaknesses in controlling product quality (quality of materials, products, hygienic conditions of workers, and production areas before the production process is carried out)	A13	6
Storage of remanufactured products and raw materials in one location	A14	6
There is no requirement to carry out remanufacturing Standard operation procedures.	A15	5
Gas supply interrupted	A16	6
Lack of machine maintenance	A17	7
Availability of a limited number of HR	A18	6
Lack of HR expertise	A19	6
The reliability factor of machine tools during the process	A20	6
Lack of preparation when the production process will be carried out	A21	4
Lack of concentration during packaging and labeling	A22	5
Contamination occurs in the packaging during the storage and shipping process.	A23	4
Limited means of transportation/transportation facilities	A24	5
Limited production warehouse area	A25	7
Limited raw material warehouse area	A26	7
There is no separation between the raw material warehouse and the production warehouse.	A27	6
High humidity and lack of lighting in finished product warehouses and raw material warehouses	A28	7
High cost in engine and technology replacement	A29	6
A means of transportation that cannot protect the product from changes in the weather and the environment	A30	7
Lack of coordination between the shipping department and the warehouse	A31	5
Lack of communication and information between SMIs and suppliers, resellers, and the remanufacturing product market (secondary market)	A32	6
There is no RL information system network built yet.	A33	6
The RL information system has not been built in an integrated and real-time manner.	A34	7
There is no agreement on the cooperation contract regarding the return acceptance of defective/unsold printed palm sugar products between retailers/resellers and SMEs.	A35	7
Difficulty in negotiating prices with customers	A36	6
Downtime machine	A37	6
Violation of contractual agreements between advanced processing industries or retailers and SMEs	A38	6
Lack of awareness of environmental care (either from consumers or resellers)	A39	7

Reference

- Almaraj II, Trafalis TB. 2019. An integrated multi-echelon robust closed-loop supply chain under imperfect quality production. *Intern J Prod Econ.* 218 April:212–227. doi:10.1016/j.ijpe.2019.04.035.
- Alumur SA, Nickel S, Saldanha-Da-Gama F, Verter V. 2012. Multi-period reverse logistics network design. *Eur J Oper Res.* 220(1):67–78. doi:10.1016/j.biocontrol.2016.12.003.
- Amin SH, Zhang G. 2013. A multi-objective facility location model for closed-loop supply chain network under uncertain demand and return. *Appl Math Model.* 37(6):4165–4176. doi:10.1016/j.apm.2012.09.039.
- Ansari ZN, Kant R, Shankar R. 2020. Remanufacturing supply chain: an analysis of performance indicator areas. *Int J Product Perform Manag.*, siap terbit.
- Asim Z, Jalil SA, Javaid S. 2019. An uncertain model for integrated production-transportation closed-loop supply chain network with cost reliability. *Sustain Prod Consum.* 17:298–310. doi:https://doi.org/10.1016/j.spc.2018.11.010.
- Bakhshi A, Heydari J. 2021. An optimal put option contract for a reverse supply chain: case of remanufacturing capacity uncertainty. *Ann Oper Res.*, siap terbit.
- Biçe K, Batun S. 2021. Closed-loop supply chain network design under demand, return and quality uncertainty. *Comput Ind Eng.* 155 November 2020:107081. doi:10.1016/j.cie.2020.107081.
- Cardoso SR, Barbosa-Póvoa AP, Relvas S. 2016. Integrating financial risk measures into the design and planning of closed-loop supply chains. *Comput Chem Eng.* 85:105–123.
- Chileshe N, Rameezdeen R, Hosseini MR, Lehmann S, Consultancy D. 2015. Barriers to implementing reverse logistics in South Australian construction organisations *Supply Chain Management. Supply Chain Manag An Int J.* 20(2):179–204. doi:10.1108/SCM-10-2014-0325.
- Council SC. 2008. Supply chain operations reference model. *Overv SCOR version.* 5(0).
- Entezaminia A, Heidari M, Rahmani D. 2017. Robust aggregate production planning in a green supply chain under uncertainty considering reverse logistics: a case study. *Int J Phys Distrib Logist Manag.* 90(5–8):1507–1528. doi:10.1007/s00170-016-9459-6.
- Fazli-Khalaf M, Hamidieh A. 2017. A robust reliable forward-reverse supply chain network design model under parameter and disruption uncertainties. *Int J Eng.*, siap terbit. https://iranjournals.nlai.ir/handle/123456789/337326.
- Govindan K, Bouzon M. 2018. From a literature review to a multi-perspective framework for reverse logistics barriers and drivers. *J Clean Prod.* 187:318–337. doi:10.1016/j.jclepro.2018.03.040.
- Han X, Wu H, Yang Q, Shang J. 2016. Reverse channel selection under remanufacturing risks: Balancing profitability and robustness [Cited By (since 2016): 45]. *Intern J Prod Econ.* 182:63–72. doi:10.1016/j.ijpe.2016.08.013.
- Hatefi SM, Jolai F. 2014. Robust and reliable forward – reverse logistics network design under demand uncertainty and facility disruptions. *Appl Math Model.* 38(9–10):2630–2647. doi:10.1016/j.apm.2013.11.002.
- Heydari J, Ghasemi M. 2018. A revenue sharing contract for reverse supply chain coordination under stochastic quality of returned products and uncertain remanufacturing capacity. *J Clean Prod.* 197:607–615. doi:10.1016/j.jclepro.2018.06.206.
- Huang Y, Wang Z. 2018. Demand disruptions, pricing and production decisions in a closed-loop supply chain with technology licensing. *J Clean Prod.* 191:248–260.
- Jabbarzadeh A, Haughton M, Khosrojerdi A. 2018. Closed-loop supply chain network design under disruption risks: A robust approach with real world application. *Comput Ind Eng.* 116:178–191.

doi:10.1016/j.cie.2017.12.025.

Jindal A, Sangwan KS. 2014. Closed loop supply chain network design and optimisation using fuzzy mixed integer linear programming model. *Int J Prod Res.* 52(14):4156–4173. doi:10.1080/00207543.2013.861948.

Kuswandi RY, Ridwan AY, Ma'ali El Hadi R. 2018. Development of monitoring reverse logistic system for leather tanning industry using scor model. Di dalam: 2018 12th International Conference on Telecommunication Systems, Services, and Applications (TSSA). IEEE. hlm 1–5.

Ma L, Liu Yankui, Liu Ying. 2019. Distributionally robust design for bicycle-sharing closed-loop supply chain network under risk-averse criterion. *J Clean Prod.*, siap terbit.

Maiti T, Giri BC. 2015. A closed loop supply chain under retail price and product quality dependent demand [Cited By (since 2015): 148]. *J Manuf Syst.* 37:624–637. <https://www.sciencedirect.com/science/article/pii/S0278612514001095>.

Mohajeri A, Fallah M. 2016. A carbon footprint-based closed-loop supply chain model under uncertainty with risk analysis: A case study. *Transp Res Part D Transp Environ.* 48:425–450. doi:10.1016/j.trd.2015.09.001.

Moubed M, Boroumandzad Y, Nadizadeh A. 2021. A dynamic model for deteriorating products in a closed-loop supply chain. *Simul Model Pract Theory.* 108:102269. doi:<https://doi.org/10.1016/j.simpat.2021.102269>.

Nazari GA, Rafiei H, Rabani M. 2018. Modeling risk and uncertainty in designing reverse logistics problem. *Decis Sci Lett.* 7:13–24. doi:10.5267/j.dsl.2017.5.001.

Nguyen TLT, Tran TT, Huynh TP, Ho TKD, Le AT, Do TKH. 2018. Managing risks in the fisheries supply chain using House of Risk Framework (HOR) and Interpretive Structural Modeling (ISM). Di dalam: IOP Conference Series: Materials Science and Engineering. Volume ke-337. IOP Publishing. hlm 12030.

Papen P, Amin SH. 2019. Network configuration of a bottled water closed-loop supply chain with green supplier selection. *J Remanufacturing.*, siap terbit.

Paydar MM, Babaveisi V, Safaei AS. 2017. An engine oil closed-loop supply chain design considering collection risk. *Comput Chem Eng.* 104:38–55. doi:10.1016/j.compchemeng.2017.04.005.

Polo A, Peña N, Muñoz D, Cañón A, Escobar JW. 2019. Robust design of a closed-loop supply chain under uncertainty conditions integrating financial criteria. *Omega.* 88:110–132. doi:<https://doi.org/10.1016/j.omega.2018.09.003>.

Pujawan IN, Geraldin LH. 2009. House of risk: a model for proactive supply chain risk management. *Bus Process Manag J.*, siap terbit.

Rangel DA, De Oliveira TK, Leite MSA. 2015. Supply chain risk classification: Discussion and proposal. *Int J Prod Res.* 53(22):6868–6887. doi:10.1080/00207543.2014.910620.

Rezaei S, Ghalehkhondabi I, Rafiee M. 2020. Supplier selection and order allocation in CLSC configuration with various supply strategies under disruption risk. *Opsearch.* 57(3):908–934. doi:10.1007/s12597-020-00445-w.

Saxena A, Seth N. 2012. Supply chain risk and security management: an interpretive structural modelling approach. ... *J Logist Econ*, siap terbit.

Shekarian E, Marandi A, Majava J. 2021. Dual-channel remanufacturing closed-loop supply chains under carbon footprint and collection competition. *Sustain Prod Consum.* 28:1050–1075. doi:<https://doi.org/10.1016/j.spc.2021.06.028>.

Soleimani H, Govindan K. 2014. Reverse logistics network design and planning utilizing conditional value at risk [Cited By (since 2014): 171]. *Eur J Oper Res.* 237(2):487–497. <https://www.sciencedirect.com/science/article/pii/S0377221714001635>.

Sun D, Ma X, Wang D, Li J. 2019. Principal–agent problem for returns handling in a reverse supply chain with

one manufacturer and two competing dealers. *Appl Math Model.*, siap terbit. <https://www.sciencedirect.com/science/article/pii/S0307904X18304542>.

Ulfah M. 2016. Framework of Risk Mitigation of Management of Refined Sugar Supply Chain With The House of Risk Model. *Int J Eng Technol Sci Innov.*(04):400–414.

Vahdani B, Ahmadzadeh E. 2019. Knowledge-Based Systems Designing a realistic ICT closed loop supply chain network with integrated decisions under uncertain demand and lead time ☆. *Knowledge-Based Syst.* 179:34–54. doi:10.1016/j.knosys.2019.05.003.

Xiao R, Cai Z, Zhang X. 2012. An optimization approach to risk decision-making of closed-loop logistics based on SCOR model. *Optimization.* 61(10):1221–1251. doi:http://dx.doi.org/10.1080/02331934.2012.688827 PLEASE.

Yu H, Solvang WD. 2016. A general reverse logistics network design model for product reuse and recycling with environmental considerations. *Int J Adv Manuf Technol.* 87(9):2693–2711. doi:10.1007/s00170-016-8612-6.

Zeballos LJ, Méndez CA, Barbosa-Povoa AP. 2018. Integrating decisions of product and closed-loop supply chain design under uncertain return flows. *Comput Chem Eng.* 112:211–238.

Zhang Y, Diabat A, Zhang Z-H. 2021. Reliable closed-loop supply chain design problem under facility-type-dependent probabilistic disruptions. *Transp Res Part B Methodol.* 146:180–209. doi:https://doi.org/10.1016/j.trb.2021.02.009.

Zhou L, Naim MM, Disney SM. 2017. The impact of product returns and remanufacturing uncertainties on the dynamic performance of a multi-echelon closed-loop supply chain. ... *J Prod Econ.*, siap terbit. <https://www.sciencedirect.com/science/article/pii/S0925527316301748>.