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Implementation of Reverse Logistics System in the Metal Industry Using Supply Chain Operation References (SCOR) Model with Analytical Hierarchy Process (AHP) Method

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A B S T R A C T

As a result of the physical characteristics of metals and their use on a large scale, the industry producing metal products is one of the most important in terms of volume when implementing reverse logistics practices. The relationship between suppliers and customers from the perspective of environmental demands, companies using metal materials are mapped into the Supply Chain operation Reference (SCOR) model. In this study there are Key Performance indicators (KPIs) which are categorized based on the performance attributes of SCOR, namely reliability, responsiveness, agility, cost, and assets management. Using the Analytical Hierarchy Process (AHP) method is an analytical method for the structure of a problem and is used to make decisions on an alternative that is useful for solving complex unstructured problems. The result of this research is that the performance value obtained is a yellow traffic light which means that the application of reverse logistics metal at PT. XYZ has not been implemented properly, so further research must be carried out with primary data in the form of a reverse logistics process each step by step.

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1. INTRODUCTION

With the increasing demand for metal materials as the main component in the electronics industry, including various other industries such as automotive, health, and construction, metals have become a major commodity with high demand in each sector (Davoodi et al., 2021; Mugurusi & Ahishakiye, 2022; Solodovnikov, 2019; Wibowo et al., 2017; Van den Brink et al., 2020). Therefore, logistics becomes the focus of the industry in meeting the demands of various consumers (Nugraha et al., 2020). However, in the distribution of products to retailers, there are often some defective or damaged products due to shocks during shipping (Mursyid & Wahyuni, 2020; Hidayati, & Pulansari, 2023). Another issue encountered by companies is the delay in product delivery, resulting in a decrease in customer trust (Nugraha et al., 2019). To maintain good relationships between companies, retailers, and consumers, the company strives to evaluate strategies regarding the actions they take when there are unusable products (Liputra et al., 2018). These problems are not including the growing environmental concerns, especially in the metal industry as a major e-waste producer, which has led environmental activists to criticize the metal and other industries as major contributors to environmental pollution (Jain & Singh, 2020; Javad et al., 2020; Kumar et al., 2018; Xun et al., 2022; Pinto & Diemer, 2020). This problem can be addressed by using a reverse logistics system (Lamba et al., 2020). The reverse logistics system involves efficient planning, implementation, and control of the flow of raw materials, work-in-progress, finished goods, and related information (Maheswari et al., 2016; Kuswandi et al., 2018; Valenzuela et al., 2021). The method that can be used to address this issue is the combination of SCOR (Supply Chain Operation Reference) and AHP (Analytical Hierarchy Process) (Marfuah and Mulyana, 2021).

Research in the field of reverse logistics is in a developing phase. Supply chain management issues, supplier selection, and sustainability in the supply chain using the AHP method (Azimifard et al., 2018). The AHP method was also used to select steel industry supplier countries at three levels. Yuliawati & Suroso (2021) improved the process using the AHP method, which can involve reselling or a series of activities such as collection, inspection, separation, and eventually reaching the remanufacturing or recycling process. Jain and Khan (2017) identified the main criteria for selecting Reverse Logistics service providers using the AHP method to prioritize Reverse Logistics services. Anindita et al., (2020) measured supply chain performance using the SCOR model as a reference for creating a supply chain performance measurement matrix and used the AHP method to evaluate and determine the weight of the measurement matrix. Research by Pulansari et al., (2022) discusses an analytical approach is used to measure the effectiveness of reverse logistics implementation by using a reverse logistics maturity framework. Meanwhile, research by Apriyani et al., (2021) discusses what are the barriers in implementing reverse logistics through a literature review. This research will produce new information about opportunities in future reverse logistics research. The novelty of this study is to discuss the relationship between suppliers and customers from the perspective of environmental demands, the companies that use metal materials are mapped into the Supply Chain Operation Reference (SCOR) and AHP models. Therefore, this research aims to analyze the application of reverse logistics in the metal industry at PT. XYZ to determine whether its implementation is already optimal or needs improvement. The results of these studies can serve as references for researchers to understand the implementation of Reverse Logistics at PT. XYZ.

2. LITERATURE REVIEW

Reverse logistics is the process of planning, implementing, and controlling the flow of raw materials, semi-finished products, and finished products from manufacturing locations, distribution centers, or customers to appropriate product recovery or disposal locations (Paula et al., 2020). Activities in reverse logistics encompass stages such as collecting products at collection points, sorting, reprocessing, and disposing of parts that cannot be reused. Effective management of each stage of reverse logistics must be carried out to realize the economic potential and environmental impact of these activities (Guarnieri et al., 2020). Logistics management plays a crucial role in the supply chain, which is the primary objective of integrated logistics and supply chain management. The supply chain is a network of various companies collaborating in the production and delivery of products to end consumers. This network consists of suppliers, manufacturers, distributors, stores, retailers, and various parties involved in supporting logistics (Lee et al., 2022). The supply chain is a physical network involving companies in supplying raw materials, products, or direct deliveries to end consumers.

One method for measuring supply chain performance is by using the SCOR (Supply Chain Operation Reference) method. SCOR is a performance measurement model that details a company's supply chain through indicators that align with the characteristics of that company (Hahn, 2020). This model was developed by a group of companies affiliated with the Supply Chain Council (SCC) to assist companies in improving and developing their supply chain processes. AHP (Analytical Hierarchy Process) is a decision support model developed by Thomas L. Saaty. AHP is used to address complex and unstructured problems and can be applied in various contexts such as planning, alternative selection, prioritization, policy determination, resource allocation, needs assessment, outcome forecasting, system design, performance measurement, and optimization (Kahn et al., 2022). This research utilizes the Supply Chain Operation Reference (SCOR) model with the Analytical Hierarchy Process (AHP) method. The advantage of the SCOR model compared to other approaches in the supply chain is its ability to directly measure balance in supply chain management.

3. RESEARCH METHOD

Identification of Operational Variable.

In this study, the use of variables is divided into 5 variables: plan, source, make, deliver, and return. Each variable is further divided into several sub-variables. For a clearer overview, refer to the following Table 1.

Table 1. Research variable

No	Variabel	Sub Variable (*Level* 2)	Sub Variable (*Level* 3)	Information
1	Plan	Reliability	1.1 Consumers contact the retailer to pick up the product. 1.2 Defective products require return.	Consumer awareness in managing leftover products or metal waste. Consumers contact the metal industry company due to product defects and require product returns.
2	Source	Responsiveness Cost Assets	2.1. Pickup Delivery lead time 2.2 Recycle process Cost 2.3 Payment Term	Average time taken to pick up products from consumers' hands. Cost of processing products into new products or new metal materials for further production processes. Average time between delivering waste products to the manufacturer from collectors or consumers to the time of payment to the collectors or consumers.
3	Make	Reliability Agility	3.1 Inspection of waste products. 3.2 Human error 3.3 Trend of product	Sorting products into recycle, reduce, or incineration categories at a safe location. Malfunction of the recycling process due to human factors or human errors. Producing products following demand or environmentally friendly industrial developments.
4	Deliver	Responsiveness	4.1 Delivery lead time 4.2 Production time process	Time from when the product is taken from the end user until it becomes a new product. Time required for the process of recycling new products.
5	Return	Reliability Responsiveness	5.1 Customer Complaint 5.2 Responsiveness to complaints.	Number of customer complaints about defective products. Time taken to resolve end-user complaints.

Data Collection Methods

Primary data is data taken directly from research objects by individual researchers and organizations including the results of interviews, observations and measurement results carried out on managers, supervisors, directors and assistant managers at PT. XYZ. The primary data needed is reverse logistics process data and metal industry supply chain charts. Secondary data, on the other hand, refers to data obtained indirectly from the research object. Usually, secondary data comes in the form of documents, files, archives, or company records. The necessary secondary data includes customer complaint data, recycle product data, and product return data.

Data Processing Method and Result Analysis

Data processing and analysis of the results are the core of any research. The method used is the Supply Chain Operations Reference (SCOR).

The SCOR Model is employed because it directly focuses on balanced Supply Chain Management measurements (Fauziyah et al., 2020). The data processing starts with the identification of the supply chain flow, the decomposition of processes based on the SCOR model (Hasibuan et al., 2018), validation of Key Performance Indicators (KPIs), and the hierarchical weighting of KPIs using the Analytical Hierarchy Process (AHP) method (Agrawal et al., 2016; Maryam et al., 2016).

AHP method is chosen because it groups system elements into different levels, where each level contains similar elements, making it suitable for decision-making that involves multiple criteria with different hierarchical levels (Prakash & Barua, 2015; Putri & Surjasa, 2018). AHP also provides a measurement scale and a method to obtain priorities for all hierarchical criteria, using scoring systems with Smax, Smin (Septifani et al., 2012; Sirisawat & Kiatcharoenpol, 2018). The overall performance index of the supply chain is calculated. The analysis of the supply chain performance is carried out using the Traffic Light System (Kuswandi et al., 2018), leading to an analysis of the implementation of reverse logistics for metal in Indonesia.

4. RESULT AND DISCUSSION

Supply Chain Performance Hierarchy

The measurement of supply chain performance can be represented by a hierarchical model that resembles a pyramid. This hierarchy has a main objective, which is to obtain performance values whereas the levels go down, the observations become more detailed. The following is the hierarchy of issues in this research (Figure 1).

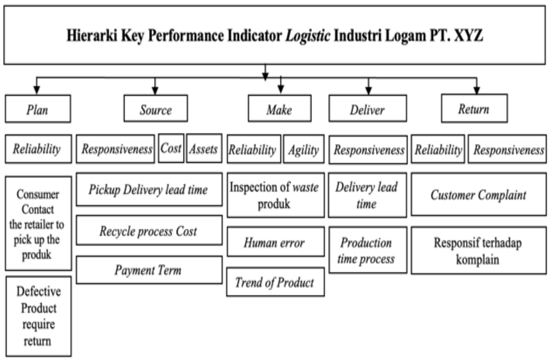

Figure 1. Supply chain performance hierarchy

Data Processing of Model Supply Chain Operation Reference (SCOR) Model

The weighting calculation is performed with a rating scale of 10-100, and each level must have an exact value of 100 (Rakhman et al., 2018). Below are the weighting results based on the researcher's research and data processing (Table 2).

Table 2. Calculation of SCOR weighting

No	Variable (*level* 1)	Weight	Sub Variable (*Level* 2)	Weig ht	Sub Variable (*Level* 3)	Weight
1	Plan	30	Reliability	30	1.1 Consumer Contact the retailer to pick up the produk	15
					1.2 Defective Product require return	15
2	Source	20	Responsiveness	10	2.1. Pickup Delivery lead time	10
			Cost	5	2.2 Recycle process Cost	5
			Assets	5	2.3 Payment Term	5
3	Make	10	Reliability	2,5	3.1 Inspection of waste produk	2,5
				2,5	3.2 Human error	2,5
			Agility	5	3.3 Trend of Product	5
4	Deliver	10	Responsiveness	10	4.1 Delivery lead time	7,5
					4.2 Production time process	2,5
5	Return	30	Reliability	15	5.1 Customer Complaint	15
			Responsiveness	15	5.2 Responsiveness to complains	15
Total		**100**		**100**		**100**

Standardization of Supply Chain Operation System

After the actual calculations have been performed, the next step is to implement the scoring system (Yusnawati et al., 2020; Sucipta, et al., 2016). The scoring system is divided into two parts: maximum standardization and minimum standardization (Paduloh et al., 2020). Maximum standardization is used when

higher values indicate better results, whereas minimum standardization is used when lower values indicate better results (Qurtubi et al., 2022). The formula used for scoring system calculations is as follows:
Smax = (actual/target) x 100……………....(1)
Smin = (target/actual) x 100…………….....(2)
Final Score = (Score x KPI weight) / 100....(3)

For the scoring system calculations in this table, the most recent data based on the researcher's research and analysis are used. Here are the results of the scoring system calculations can be seen in Table 3. After the standard normalization and final score calculations have been performed, the researcher can proceed to the next step, which is the calculation of the aggregate performance value (Saragih et al., 2021). This calculation is obtained from the total KPI values, followed by the process of the traffic light system, where the KPI values are evaluated based on their performance. Below are the three indicators of the traffic light system:
-Green, indicating that the target has been achieved or exceeded.
- Yellow, indicating that the performance value is close to the target but has not been fully met.
- Red, indicating that the performance value is below the target and requires immediate improvement.

Table 3. Calculation of scoring system

No.	Variable (level 1)	Weight	Sub Variable (level 2)	Weight	Sub Variable (level 3)	Weight	Target	Realization / year	Information	Score	Final Score
1	Plan	30	Reliability	30	1.1 Consumer Contact the retailer to pick up the produk	15	500.000	250.000	Waste	50	7,5
					1.2 Defective Product require return	15	200,000	120.000	Waste	60	9
2	Source	20	Responsiveness	10	2.1 Pick up delivery lead time	10	3	7	Day	42,86	4,29
			Cost	5	2.2 Recycle process cost	5	7	15	Billion rupiah	46,67	2,33
			Assets	5	2.3 Payment term	5	7	14	Hari	50	2,5
3	Make	10	Reliability	2,5	3.1 Inspection of waste produk	2,5	10	17	Percent	58,82	1,47
				2,5	3.2 Human error	2,5	10	12	Percent	83,33	2,08
			Agility	5	3.3 Trend of prduct	5	75	60	Percent	80	4
4	Deliver	10	Responsiveness	10	4.1 Delivery lead time	7,5	7	13	Day	53,85	4,04
					4.2 Production time prcess	2,5	2	5	Day	40	1
5	Return	30	Reliability	15	5.1 Customer Complaint	15	90	130	Call	69,233	10,38
			Responsiveness	15	5.2 Responsiveness to complains	15	90	75	Percent	83,33	12,5
Total		100		100		100		Total			61,1

Table 4. Calculation of Omax for sub-variable (level 3) and final score

No	Sub Variable (Level 3)	Omax {Weight sub-Variable x Weight Variable}	Final Score {(Realization / Target) x 100}
1.1	Consumers contact the retailer to pick up the produk	450	50
1.2	Defective products require return	450	60
2.1	Pickup delivery lead time	200	42,86
2.2	Recycle process cost	100	47,06
2.3	Payment term	100	200
3.1	Inspection of waste produk	25	17
3.2	Human error	25	12
3.3	Trend of product	50	80
4.1	Delivery lead time	75	185,71
4.2	Production time process	25	100
5.1	Customer complaint	450	144,44
5.2	Responsiveness to complains	450	83,33

Example calculation:
Consumers contact the retailer to pick up the product:
Omax = Sub-Variable Weight x Variable ….(4)
Weight = 15 x 30 = 450
Final Score = (Actual Value / Target Value) x 100 ………………………………………..(5)
Final Score = (250,000 / 500,000) x 100 = 50

Table 5. Calculation of Omax for sub-variable (level 2) and value indicator

Sub Variable (Level 2)	Omax ∑ (Omax Sub-Variable)	Indicator
Plan	900	**Green**
Source	400	**Yellow**
Make	100	**Red**
Deliver	100	**Red**
Return	900	**Green**

Example calculation:
Plan:
Omax = Σ (Omax Sub-Variable) ………..(6)
= 450 + 450 = 900 (Indicator Green)

Based on the calculations in the table above, it can be determined that the sub-variables "Plan" and "Return" with an Omax value of 900 fall into the green indicator, which means the target has been achieved or exceeded. Meanwhile, the sub-variable "Source" with an Omax value of 400 falls into the yellow indicator, indicating that the performance value is close to the target but not yet fully met. Lastly, the sub-variables "Make" and "Deliver" with an Omax value of 100 fall into the red indicator, meaning the performance value is below the target and requires immediate improvement.

Aggregate Performance Value

The calculation of the performance value is obtained by summing up the total value of KPIs for each section during one period. It can be expressed as:

$$N\ Aggregate = \sum lkpi \quad \ldots\ldots\ldots\ldots\ldots\ldots(7)$$

The calculation of the aggregate performance value in this research is based on the researcher's study using data collected over a period of 5 years from 2018 to 2022.

Table 6. Calculation of aggregate value performance

No	Year	Performanci Value					Value
		Plan	*Source*	*Make*	*Deliver*	*Return*	
1	2018	17,50	8,00	9,23	3,00	14,00	51,73
2	2019	16,40	7,50	8,75	4,00	16,50	53,15
3	2020	18,00	7,80	7,85	5,00	17,20	55,85
4	2021	17,30	8,30	7,70	4,70	18,50	56,5
5	2022	16,50	9,12	7,55	5,04	22,88	61,09

From the above performance values, the implementation of reverse logistics for metal in Indonesia has not been applied well, indicating the need for long-term improvement to enhance the metal industry's reverse logistics system. This is because the traffic light values are still in the yellow zone. So a reverse logistics process is needed involving a series of activities, from receiving product returns to repairing, returning or disposing of them appropriately. In this process, companies need to pay attention to aspects such as assessing product condition, managing returned stock, inspection and repair, as well as tracking and understanding the reasons and sources of returns.

Data Processing for Analytical Hierarchy Process (AHP) Importance Level

The weighting of attributes aims to determine the priority of the existing attributes. Attribute weighting uses questionnaire data input into a pairwise comparison matrix. After performing the calculation of the pairwise comparison matrix, it is followed by normalization and consistency calculation, as shown in the tables below.

Table 7. Attribute weighting in the return process

Criteria	Reliability	Responsiveness
Reliability	1.00	0.20
Responsiveness	5.00	1.00
Total	**6.00**	**1.20**

Table 8. Normalization of attribute in the return process

Criteria	Reliability	Responsiveness	Total	Priority	Eigen Value
Reliability	0.17	0.17	0.33	0.17	1.00
Responsiveness	0.83	0.83	1.67	0.83	1.00
Total	1	1	2	1	2

Table 9. Result of attribute weighting in the return process

Item	Value
CI	0.00
RI	0.00
CR	0.00

Because the Random Consistency Index (RI) for a Matrix Size of 2 is 0.00, and the obtained CR (Consistency Ratio) value is <=0.1, the result is consistent.

Table 10. Result of indicator weighting process

Process	Atribut	Weight	KPI	Weight	Actual (Si)	Final Weight	Normalization
Return	Reliability	6.00	*Customer Complaint*	1.00	69,23%	0.10	0.5
	Responsiveness	1.20	*Responsif* terhadap *complain*	1.00	83,33%	0.13	0.9

The results obtained in the return process for the attribute "Reliability" have a weight of 6.00, and for the KPI "Customer Complaint," the weight is 1.00. The actual SI (Systematic

Improvement) obtained is 69.23% with a final weight of 0.10 and a normalized result of 0.5. Additionally, for the results obtained in the return process for the attribute "Responsiveness," the weight is 1.20, and for the KPI "Responsiveness to Complaint," the weight is 1.00. The actual SI obtained is 83.23% with a final weight of 0.13 and a normalized result of 0.9. With these results, it is hoped that the issues at PT.XYZ can be addressed.

5. CONCLUSION

In this study, detailed data was not used, which makes the data susceptible to inaccuracies that may not align with the facts in the field. For instance, in the aggregate performance value data, the details up to sub-level 3 were not provided. The data obtained was based on the researcher's research and data processing. It is possible that the data used may not be a benchmark for assessment or research conclusions. The obtained performance values show a yellow traffic light, indicating that the implementation of metal reverse logistics at PT. XYZ has not been well applied. So a reverse logistics process is needed involving a series of activities, from receiving product returns to repairing, returning or disposing of them appropriately. In this process, companies need to pay attention to aspects such as assessing product condition, managing returned stock, inspection and repair, as well as tracking and understanding the reasons and sources of returns. Requiring further research with primary data in the form of the reverse logistics process step by step. With primary data, secondary data can be identified, such as the amount of scrap, recycle products, reduce products, and the use of parts used for other products through company data.

Future Research

As this study was conducted on a large and general scale, it lacks detailed case studies that can be used as benchmarks and references for metal manufacturing companies in implementing reverse logistics systems. Future research can be conducted on a smaller scale and with the use of more up-to-date data directly from the company, which can serve as a benchmark for the implementation of reverse logistics systems by companies. Further research can assess each level in more detail, especially with level 3 sub-variables that require actual data from the company.

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