Key Performance Indicator Analysis Using Integrated SCOR-AHP: A Case Study of Indonesian's Reverse Supply Chain Industry

Yelita Anggiane Iskandar[1], Kenzie Dwianugerah Delu[2], Mirna Lusiani[3], Nur Layli Rachmawati[4], Adji Candra Kurniawan[5], Rahmad Inca Liperda[6]

{yelita.ai@universitaspertamina.ac.id[1], 102418128@student.universitaspertamina.ac.id[2], mirna.lusiani@universitaspertamina.ac.id[3], nl.rachmawati@universitaspertamina.ac.id[4], adjick@universitaspertamina.ac.id[5], inca.liferda@universitaspertamina.ac.id[6]}

Department of Logistics Engineering, Universitas Pertamina, DKI Jakarta 12220[1,2,3,4,5,6]

Abstract. Supplier performance directly affects an organization and consequently its supply chain therefore supplier evaluation is important to be designed. An Indonesian recycling company in the reverse logistics industry is considered here. This study proposes the Supply Chain Operations Reference (SCOR) model to identify the supplier performance indicators, and the Analytical Hierarchy Problem (AHP) method to calculate the importance level of every indicator. In developing the supplier performance metrics, the SCOR framework takes the plan, source, make, delivery, return, and enable processes which were then translated into several criteria known as Key Performance Indicators (KPI) based on five attributes of reliability, responsiveness, agility, costs, and assets. The primary data are collected using several serial surveys with the respective experts. The experiment results show that the most prioritized indicator is KPI-4: "Cost of goods and services" while the least lay on KPI-6: "Number of complaints" with values of 0.2805 and 0.04715 respectively.

Keywords: Recycling company, Supplier evaluation, Reverse logistics, SCOR, AHP

1 Introduction

The industrial era is still evolving, with technological advancements adding complexity and standards of business operations in many companies. One of the most important aspects of a company's growth is the integration of all processes within its business operations to create synergy to meet customer satisfaction, which is closely related to supply chain activities. To achieve commonly shared goals among actors, every process in a supply chain network should be coordinated.

Every year, the level of human consumption rises along with the diversification of requirements, which has an impact on the amount of waste created, including plastic waste. Over time, there has been a noticeable increase in the production of plastic around the world. According to the United Nations Environment Programme (UNEP), packaging is the primary industry associated

ICO-SEID 2022, November 23-24, Jakarta, Indonesia

DOI 10.4108/eai.23-11-2022.2339152

with the manufacturing of plastic as also stated by [1] that packaging accounts for 40% of all plastic produced; it is only used once and then wasted, around one every day per resident. Polyethylene Terephthalate (PET) plastic bottles are one of the packaging forms that are frequently used. The amount of waste produced by this exponential growth in the usage of plastic is further demonstrated by the fact that, up until now, the majority of plastic waste has been difficult or even impossible to degrade organically in the environment [2].

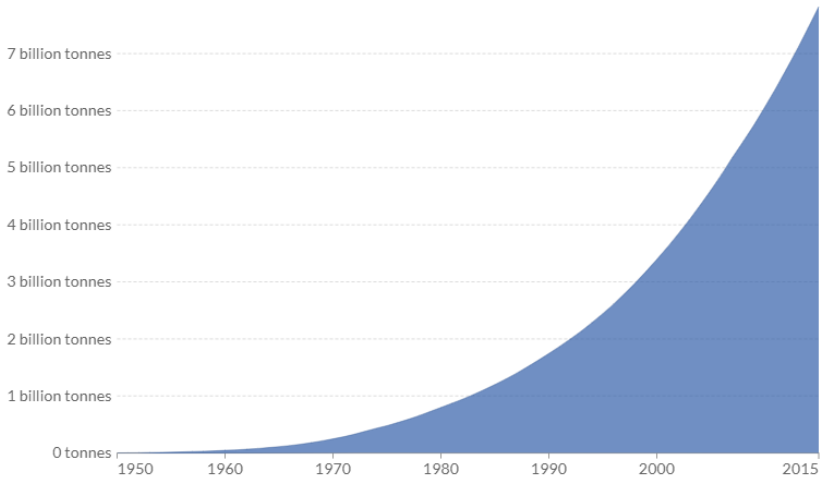

Fig. 1. Cumulative Global Plastics Production from 1950 to 2015 [3]

To maintain a sustainable and environmentally friendly supply chain, various countries have begun to apply green business models and recycle plastics into valuable products [2], this is known as the circular economy (CE). Repairing, remanufacturing, reconditioning, and recycling products or waste in the form of goods that no longer have a usage value are examples of circular economy activities [4]. The CE concept seeks to maintain the sustainability of materials, energy, and labor used in the production of goods by creating a long service life and facilitating the resource recovery process [5].

PT Tridi Oasis Group is a local recycling company founded in 2016. Because its main activity is recycling plastic waste into plastic flakes, which can be used as raw materials for various industrial products such as "clean" packaging, PT Tridi Oasis Group's business model is part of the circular economy.

Suppliers of Tridi Oasis' raw materials play a significant part in the company's goods processing. Suppliers deliver raw materials in the form of waste plastic, particularly recycled PET plastic bottles. The performance of the supply chain is influenced by performance variances caused by the product management strategies that each of the Tridi Oasis suppliers employs. These strategies can change, for instance, depending on the infrastructure and equipment used. Some suppliers perform poorly, as shown by the number of shipments of items that do not meet standards and the number of goods sent that is lower than average or not steady over an extended period. Problems arise when comparing supplier performance for decision-making due to variations in their performance. As a result, a supplier evaluation model must be settled. The Supply Chain Operations Reference (SCOR) framework and Analytical Hierarchy Process (AHP) method are used in this study.

The application of the SCOR concept enables the collection of information on supplier criteria as a whole through fact-based analysis [6] [7]. Because they take into account the supplier's role in the supply chain, the SCOR concept's resulting criteria are deemed acceptable. So that some of the identified criteria involve collaboration and coordination between supply chain actors.

The AHP method is used to obtain priority weights from the criteria that have been generated in the SCOR concept [8]. The outcomes of this procedure will serve as the company's criteria for selecting suppliers. Multiple outcome criteria with the highest priority weight will determine whether or not the supplier is chosen. In order for the combination of these concepts and methods to achieve the primary objective of this research, which is to obtain appropriate supplier criteria and support company goals, it is necessary to combine these concepts and procedures.

2 Research Methodology

Here we consider the problem of developing a supplier evaluation model for PT Tridi Oasis Group. **Figure 1** depicts the research methodology flowchart. The initial data collection process is required to form a framework for the SCOR model, and it is carried out using several questionnaires. The SCOR model has three levels: core or major processes (level 1), performance attributes (level 2), and process elements (level 3). The first data collection for the SCOR model is supplier core process mapping based on the SCOR framework at level 1, which includes the plan, source, make, deliver, return, and enable; and alignment of the company's mission with the raw material procurement process. The mapping of the supplier's core processes based on the SCOR framework clarifies and compiles the main management processes that have been running to meet customer demands. Aligning the company's mission with the raw material procurement process allows for evaluating raw material procurement processes and activities related to the company's mission, as well as collecting key indicators that describe future supplier performance. The next step is to determine the Key Performance Indicator (KPI). KPI is a performance measurement index that aims to identify priority performance aspects that affect the company's success and sustainability [9]. The KPI in this model is a SCOR model level 3 process element that serves to define the configuration of each process and activity. The third step is mapping KPIs with SCOR model performance attributes, which functions to map KPIs with SCOR level 2 performance attributes such as reliability, responsiveness, flexibility, cost, and assets.

Table 1. Likert Scale

Scale	Description
1	Strongly Disagree
2	Disagree
3	Moderately Agree
4	Agree
5	Strongly Agree

The developed SCOR model is validated using five-scale Likert questionnaires as shown in Table 1 to the seventeen stakeholders of the Tridi Oasis. The stakeholders must be involved in the raw material procurement process, namely the sourcing, quality control, warehouse, security, and finance sections. If several indicators are not appropriate, these indicators are then improved and adjusted.

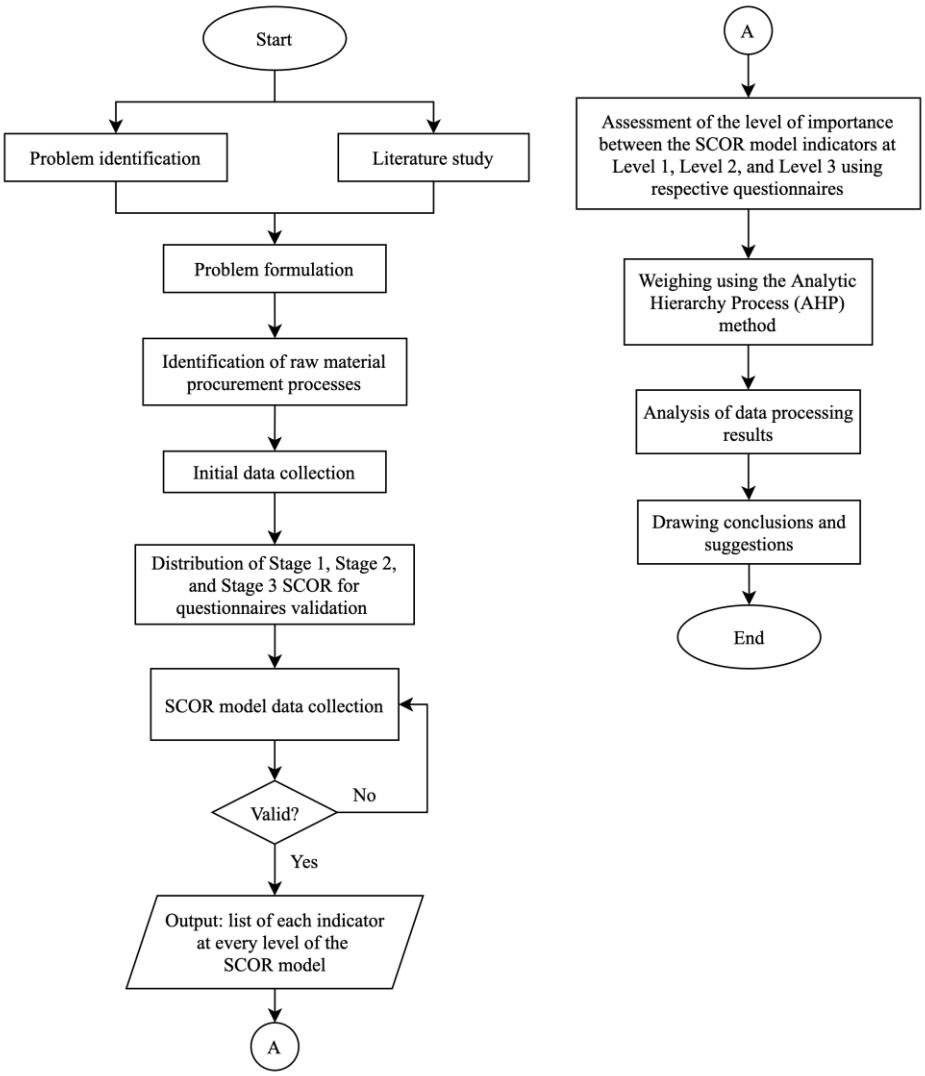

Fig. 2. Research Methodology Flowchart

Following the completion of the validation stage, the next step is to assess the level of importance between each attribute at each SCOR level using an importance level questionnaire, which will be completed by the targeted stakeholders. On all attributes compared at each level of the SCOR model, the level of importance is assessed using a scale of 1 to 9, with detailed descriptions shown in Table 2. Based on the responses, the questionnaire will assign a level of importance to each indicator.

Following the collection of the importance level questionnaire results, the indicators for each level of the SCOR model were weighted using the AHP method with a pairwise comparison approach assisted by the Expert Choice software. In this step, we also pay attention to the

inconsistency ratio value to ensure the expert judgment is consistent. If the inconsistency ratio is below 0.1 means the expert judgment is valid, otherwise not and we should regather the data. The weighing results from the AHP method emphasize the level of importance between indicators at each level of SCOR modeling. The weighing results can also be used to identify the indicators that have the greatest influence on the supplier's performance evaluation.

Table 2. Level of Importance Scale

Level of Importance	Description
1	Both attributes or indicators are equally important
3	Moderate importance of one over the other
5	Stronger in importance than the other
7	Very strong importance of the other
9	The absolute importance of the other
2,4,6,8	The importance of the two attributes or indicators is close

3 Basic Theory

3.1 Supply Chain Management

Supply chain management is a cross-functional business system that makes use of information technology (IT) to assist the company's operations and as a tool for managing the relationships between its key business partners, including suppliers, customers, and other business partners in the supply chain [10]. To the greatest extent possible, suppliers, manufacturers, distributors, retailers, and customers are integrated using supply chain management [11].

3.2 Circular Economy

The CE is an economic model that adapts biological and technical concepts of materials to maximize aspects of the use of materials or products by implementing recycling strategies such as repairing, remanufacturing, reconditioning, remanufacturing, and recycling [12].

Fig. 3. Circular Economy Cycle [13]

3.3 Supply Chain Operations Reference

Supply Chain Operations Reference (SCOR) is a management tool created by two leading supply chain organizations (Supply Chain Council and APICS), with SCOR version 12 being released in 2017 [14]. Through models, SCOR can provide a structured overview of supply chain performance. SCOR can display a company's supply chain process in order to identify supply chain performance indicators, which can be used as a reference for evaluating and improving the company's supply chain performance. The SCOR model measures and evaluates performance based on six core supply chain processes, they are plan, source, make, deliver, return, and enable. These six processes were manifested from suppliers to companies and finally end customers.

3.4 M**ulti-criteria Decision-making**

Multi-criteria Decision-making (MCDM) is a problem-solving strategy employing many comparison criteria [15]. The MCDM model plays an important role in decision-making problems by arranging these problems into a structured framework and then providing the best choice based on alternative solutions.

3.5 Analytical Hierarchy Process

The AHP assists decision-makers in organizing problems into hierarchical structures. According to research [16], the first level of AHP consists of main goals or objectives, followed by criteria and sub-criteria. The bottom level of the hierarchy is the alternatives. The AHP method weighs criteria and alternatives using a pairwise comparison matrix approach, where the criteria are compared with other criteria. The goal of comparing criteria is to determine how important the criteria are in achieving the higher goal and selecting the most fitted alternative [13].

4 Results

4.1 Data Collection

The identified KPIs can be used as indicators of supplier evaluation, with suppliers being ranked based on their performance scores. Ratings can be used as a source of information when evaluating suppliers. Each KPI has unique characteristics, and the KPI value is divided into two large groups based on the measurement's tendency, namely the KPI with the type "better if the value is higher (higher is better)" and the KPI with the type "lower value is better for the company (lower is better). Each KPI is important and plays a specific role. The impact of each KPI varies, and the impact is determined by the weight of each KPI. Following the completion of the data collection and data validation processes at each level of the SCOR model, Table 3 provides a description of the types or characteristics of KPIs identified using the SCOR framework.

Table 3. Validated Indicators for Each SCOR Tier

Core Process (Level 1)	Attribute (Level 2)	Key Performance Indicators (Level 3)	KPI Description	Unit	KPI Characteristic
Plan	Reliability	KPI-1 Accuracy of weighing goods	Percentage of accuracy when weighing at the starting point and weighing when arriving at the destination point	%	Higher is better
	Responsiveness	KPI-2 Goods transaction cycle time	The average time it takes to complete an item transaction	Hour	Lower is better
Deliver	Reliability	KPI-3 Number of requests fulfilled	The number of units of goods that can be delivered in a certain time	Kg	Higher is better
	Cost	KPI-4 Cost of goods and services	The total cost of the goods and services offered	IDR	Lower is better
	Assets	KPI-5 Geographical distance	Distance between point of departure and point of destination (distance between supplier and manufacturer)	Km	Lower is better
Return	Reliability	KPI-6 Number of complaints	Number of complaints received based on shipping, receiving, and checking goods in a certain time span	Time	Lower is better
		KPI-7 Percentage of rejected or defective goods	Percentage of rejected goods, not according to specifications, or defects received	%	Lower is better

All the KPI data details used in this study are as of January 2022. The utilization of these data has considered its availability and completeness, as data for other periods or months were not available and some data details were not completely recorded.

4.2 Data Processing

Indicators weighing is conducted based on the questionnaire results for each level of the SCOR model collected. The AHP method is used for weighing aided by the Expert Choice 11 software. Each indicator will be compared at each level of the SCOR model using the pairwise comparison approach. Weighing is used to determine the relative importance of one indicator versus another at each level of SCOR that has been validated by corresponding respondents

(stakeholders) as constructed hierarchically in **Figure 4**. Validation is accomplished by distributing questionnaires that will be evaluated by respondents using Likert scale with values ranging from 1 (strongly disagree) to 5 (strongly agree).

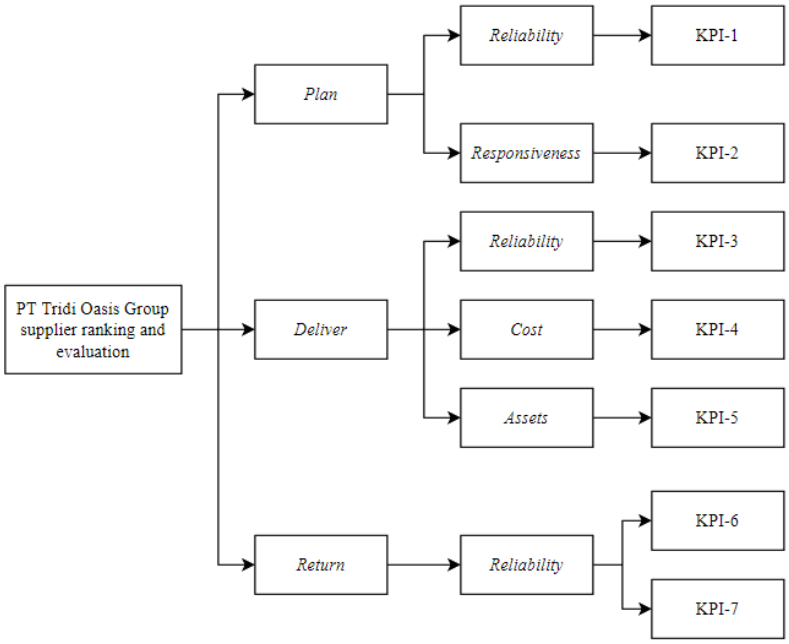

Fig. 4. Hierarchical Structure of the SCOR Model in Research

After data collection, they were processed using the Expert Choice software. This software produces weights and inconsistency ratio values as a result of data processing. The importance of the criteria "Plan > Deliver", and "Deliver > Return" is an example of how the inconsistency ratio works, but in the next statement "Return > Plan", the statement is said to be inconsistent. The inconsistency ratio is measured using a criterion limitation where the inconsistency ratio value is 0.1 [16]. If the inconsistency ratio value is less than 0.1, the criteria assessment is still said consistent and acceptable, but if the inconsistency ratio value is greater than 0.1, the criteria assessment is unacceptable and must be reassessed or improved because the inconsistency value can affect consistency [16]. These inconsistency ratios are shown in Table 4 while the weighing results and inconsistency ratio at each level of the SCOR model are shown in Table 5.

Table 4. Inconsistency Ratio

Level	Description	Inconsistency Ratio
1	Inconsistency Ratio at Level 1	0.02
2	Inconsistency Ratio at Level 2 Plan Criteria	0
	Inconsistency Ratio at Level 2 Deliver Criteria	0,03
3	Inconsistency Ratio at Level 3 Plan Criteria	0

Level	Description	Inconsistency Ratio
	Inconsistency Ratio at Level 3 Deliver Criteria	0,0034
	Inconsistency Ratio at Level 3 Return Criteria	0

Table 5. Weighing Results at Each Level of the Tridi Oasis SCOR Model

Core Process (level 1)	Weight	Attribute (Level 2)	Weight	Key Performance Indicators (Level 3)	Weight
Plan	0,209	Reliability	0,594	KPI-1 Accuracy of goods weighing	0,659
		Responsiveness	0,404	KPI-2 Cycle time of goods transaction	0,341
		Total	1	Total	1
Deliver	0,561	Reliability	0,290	KPI-3 Quantity of demand fulfillment	0,386
		Cost	0,589	KPI-4 Cost of goods and services	0,500
		Assets	0,121	KPI-5 Geographical distance	0,114
		Total	1	Total	1
Return	0,230	Reliability	1.000	KPI-6 Number of complaints	0,205
				KPI-7 Percentage of rejected or defective goods	0,795
Total	1	Total	1	Total	1

4.3 Discussion

The value of the “Deliver” weight is influenced by the high demand for Tridi Oasis raw materials because plastic shipments have a large volume while the actual weight of the cargo is much smaller than the volume, therefore, requiring many raw material shipments to meet Tridi Oasis's target tonnage. Because plastic suppliers are in high demand by companies much larger than Tridi Oasis, finding suppliers who can deliver raw materials in large quantities and at the right price is difficult. As a result, the “Deliver” criterion is critical in the Tridi Oasis supply chain. The low “Plan” weight value comes up because Tridi Oasis prioritizes the activities of raw material suppliers, which are all activities included in the process of delivering raw materials and not management activities and management of goods in the form of raw materials from suppliers. According to the results of global weighing on KPIs (level 3 of SCOR model), the highest global weight value is in KPI-4 “Cost of goods and services”, with a weight value of 0.2805, and the lowest global weight value is in KPI-6 “Number of complaints”, with a weight value of 0.04715. Because the indicators of supplier performance assessment are prioritized based on the tonnage of shipments by suppliers and the prices offered by suppliers, the highest global weight values of KPI-4 and KPI-3 are acceptable; these indicators are also in line with the main objectives of the critical “Deliver” criteria found before. The lowest global weight value of KPI-6 is interpretable due to the number of complaints is not a priority indicator in measuring Tridi Oasis suppliers' performance.

Based on these KPIs, Tridi Oasis can assess suppliers' performance, particularly raw material suppliers. The results of these performance measurements can improve the effectiveness of decision-making for raw material procurement activities, especially in the selection of suppliers.

5 Conclusion

Seven key performance indicators (KPI) were obtained after all levels of the SCOR model framework were validated, including KPI-1 "Accuracy of weighing goods", KPI-2 "Cycle time of goods transaction", KPI-3 "Total demand fulfillment", KPI-4 "Cost of goods and services", KPI-5 "Geographical distance", KPI-6 "Number of complaints", and KPI-7 "Percentage of rejected or defective goods". Unmet supplier performance can disrupt Tridi Oasis's stability and supply chain activities, such as delays in the fulfillment of raw materials or materials, production problems, and product quality issues therefore their performance measurements are required to do next, using the constructed indicators that have been designed and validated in this study.

In future studies, KPIs based on the SCOR model might be refined by increasing the number of supply chain actors involved from both upstream and downstream supply chains, for example, the company customers of plastic flakes as a result of the production process at Tridi Oasis or up to the end consumers. In addition, regarding the list of KPIs, there are still opportunities to be developed or added by involving broader respondents so that the information abstracted can be richer, more comprehensive, and closer to the observed real problems.

Acknowledgment This study was funded by Universitas Internasional Semen Indonesia with Research Contract No. 01a/KRIt.01.UISI/03-01.0V@.22.

References

[1] L. Parker, "Planet or Plastic? Fast Facts about Plastic Pollution," National Geographic, 20 December 2018. [Online]. Available: https://www.nationalgeographic.com/science/article/plastics-facts-infographics-ocean-pollution#:~:text=CALIFORNIA%2C%20SANTA%20BARBARA-,40%20percent%20of%20plastic%20produced%20is%20packaging,just%20once%20and%20then%20discarded.&text=almost%20one%20per%2.

[2] H. K. Webb, J. Arnott, R. J. Crawford, and E. P. Ivanova, "Plastic Degradation and Its Environmental Implications with Special Reference to Poly(ethylene terephthalate)", Polymers, pp. 1-18, 2013.

[3] H. Ritchie and M. Roser, "Plastic Pollution", September 2018. [Online]. Available: https://ourworldindata.org/plastic-pollution.

[4] N. Bocken, E. Olivetti, J. Cullen, J. Potting, and R. Lifset, "Taking the Circularity to the Next Level: A Special Issue on the Circular Economy", Journal of Industrial Ecology, pp. 476-482, 2017.

[5] Y. A. Alamerew, "Circular Economy and Reverse Logistics : An End-of-life Resource", Université Grenoble Alpes, 2020.

[6] G. Caristi, R. Boffardi, C. Ciliberto, R. Arbolino, and G. Ioppolo, "Multicriteria approach for supplier selection: Evidence from a case study in the Fashion Industry," Sustainability, vol. 14, no. 13, p. 8038, 2022. doi:10.3390/su14138038.

[7] C. N. Wang, V. T. Nguyen, J. T. Chyou, T. F. Lin, and T. N. Nguyen, “Fuzzy multicriteria decision-making model (MCDM) for raw materials supplier selection in plastics industry,” Mathematics, vol. 7, no. 10, p. 981, 2019. doi:10.3390/math7100981
[8] I. Kristianto, E. Rimawan, and D. S. Saroso, “Analysis of the Effectiveness of the Machining Equipment Supply Chain Network Using the Supply Chain Operation Reference (SCOR) and Analytical Hierarchy Process (AHP) Method at Industrial Equipment Supplier Companies,” International Journal of Mechanical Engineering, vol. 7, no. 1, pp. 1768–1777, Jan. 2022.
[9] APICS Inc., "Supply Chain Operations Reference Model SCOR Version 12.0", 2017. [Online]. Available: http://www.apics.org/docs/default-source/scor-training/scor-v12-0-framework-introduction.pdf?sfvrsn=2.
[10] D. Simchi-Levi, E. Simchi-Levi, and P. Kaminsky, "Designing and Managing Supply Chain", McGraw-Hill Higher Education, 2000.
[11] C.-N. Wang, H.-T. Tsai, T.-P. Ho, V.-T. Nguyen, Nguyen, and H. Ying-Fang, "Multi-Criteria Decision Making (MCDM) Model for Supplier Evaluation and Selection for Oil Production Projects in Vietnam", Processes 2020, 8, 134, pp. 1-13, 2020.
[12] Dialogue Cafe, "Dialogue Cafe", 19 April 2017. [Online]. Available: https://www.dialoguecafe.org/blog/2018/06/conference-on-circular-economy.html/fotolia-petovarga-circular-economy.
[13] M. D. Hadad, W. Santoso, E. Mardanugraha, and I. Dhaniel, "Pendekatan Parametrik Untuk Efisiensi Perbankan Indonesia", Working Paper Bank Indonesia, 2003.
[14] Y. Zhang and L. Feng, "Evaluation and Optimization of Children’s Recreational Center in Urban Green Public Space Based on AHP-TOPSIS", Journal of Applied Sciences13(6), pp. 895-900, 2013.
[15] Santoso, Statistik Parametrik, Jakarta: Gramedia, 2010.
[16] P. Agarwal, M. Sahai, V. Mishra, M. Bag, and V. Singh, "Supplier Selection in Dynamic Environment using Analytic Hierarchy Process", International Journal of Information Engineering and Electronic Business 6, pp. 20-26, 2014.