

Supply Chain Optimization for End-of-Life Vehicle Recycling: A Preliminary Review

**Fatin Amrina A.Rashid, Hawa Hishamuddin, Mohd Radzi Abu Mansor, Nizaroyani
Saibani**

Department of Mechanical & Manufacturing Engineering,
Faculty of Engineering and Built Environment,
Universiti Kebangsaan Malaysia,
Selangor, Malaysia

p105521@siswa.ukm.edu.my, hawa7@ukm.edu.my, radzi@ukm.edu.my, nizar@ukm.edu.my

Abstract

End-of-life vehicles (ELV) has become a threat to the environment and could lead to severe environmental pollution. Implementing an efficient closed-loop supply chain system may assist in reducing the hazard caused by ELVs, as end-of-life strategies such as recycling can be conducted to process the used vehicle into raw material. However, the investigation of closed-loop supply chain systems for ELV recycling is still minimal. On that account, this paper investigates the problems in closed-loop supply chain optimization studies for end-of-life vehicle recycling by conducting a content analysis of the published articles in this area of research. The articles were reviewed, then, the main issue in each article was summarized and categorized into different classes, based on common issues found in the closed-loop supply chain optimization literature. In this case, there are five main issues in closed-loop supply chain optimization, which include network design, inventory management, supply chain coordination, production planning, and partner selection. Next, the publishing platform is listed in this paper to determine the main publication outlet in this area of research. Finally, this review provides a summary of the supply chain optimization problems in ELV recycling that will be a beneficial reference for researchers of similar interests.

Keywords

End-of-life vehicle, Recycling, Supply chain optimization, Content analysis

1.Introduction

Nowadays, preserving the environment becomes one of the most crucial missions. Numerous initiatives have been planned and implemented to secure the environment, but it is still a long way to go to provide overall protection for the environment from being polluted. End-of-life vehicle (ELV) has been recognized as one of the unwanted wastes that pollute the environment. There are plenty of studies that had been conducted to minimize the existence of ELV. Previous researchers found that ELV is a useful waste that can be reused, repaired, recycled, remanufactured, and refurbished (Chakraborty et al., 2019). Establishing a systematic closed-loop supply chain for ELV is supposed to be a solution to extend the life cycle of ELV at the same time, reduce environmental pollution.

However, several studies have noted that ELV management in developing countries is still in its infancy stage (Wong et al., 2018), and strong engagement from various parties is needed to establish a proper system in building a closed-loop supply chain for ELV. Previous studies discovered many risks and problems that affect the ELV reverse supply chain, such as illegal dismantling, improper handling, and inefficient collection system of ELVs (Xia et al., 2016). To solve these arising issues, researchers have proposed further studies on optimization models for ELV recycling.

Therefore, in this paper, the previous studies related to supply chain optimization for ELV recycling issues were reviewed to highlight the main issues being explored by researchers. Govindan et al. (2015) have classified the problems that have been studied in the closed-loop supply chain literature, and five of them are used in this study, namely network design, inventory management, supply chain coordination, production planning, and partner selection.

According to Chopra and Meindl (2016), network design consists of the distribution of related facilities, manufacturing centre, storage hub, logistics, and allocation capacity for each facility involved. Inventory can be interpreted as finished goods that are stored before the distribution process to meet customer demand (Taylor, 2016). Meanwhile, inventory management aims to plan the number of goods to be ordered at the best time to place an order, to reduce inventory costs, which consist of the holding, ordering, and shortage costs (Taylor, 2016). Production planning can be described as the process of handling the creation of goods from the raw material to the finished product (Heizer et al., 2017). Supply chain coordination is defined as maximizing profit for overall supply chain stages by sharing information to all key players in every stage of the supply chain network (Chopra and Meindl, 2016). Having a proper selection of a business partner is crucial since partner or supplier selection is essential in maintaining good financial performance (Chopra and Meindl, 2016).

For the past few years, several review papers have discussed ELV issues in various supply chain topics (Table 1). Karagoz et al (2020) discussed regarding ELV management issues and analysed the method used for the articles that had been published from 2000 until 2019. Simić and Dimitrijević (2019) reviewed the network design model in ELV management from research papers that were published from 2013 until 2019. De Almeida and Borsato (2019) analysed the published research articles from the year 2000 until 2018 and listed out the end of life (EoL) strategy proposed in the articles. Simic (2013) studied published articles from the year 2003 until 2012 in environmental engineering for the ELV recycling field.

Table 1. Summary of the related past review papers.

Authors	Year	Scope	Analysed period
Karagoz, et al.	2020	ELV management	2000-2019
Simić and Dimitrijević	2019	Logistics Network Design	2013-2019
De Almeida and Borsato	2019	End of Life strategy	2000-2018
Simic	2013	Environmental engineering in ELV Recycling	2003-2012

The abovementioned review papers do not include the overview of supply chain optimization problems in ELV recycling. A comparison of the supply chain optimization areas of study might assist in explaining the current focus of supply chain optimization problems for ELV recycling. Thus, this paper investigates current studies that explore the optimization problems of the supply chain for ELV recycling from 2016 until 2021. All collected articles are analysed and categorized into different classes of supply chain problems to get an overview of the current literature for enhancing the efficiency of the ELV recycling industry. In addition, a list of publishing platforms that have published supply chain optimization studies in ELV recycling is presented in this paper.

The remaining sections of this article is organized as follows: Section 2 discusses the methodology used in this review. Section 3 presents the results of the analysis conducted. The last section concludes the analysis conducted in this review paper.

2. Methodology

This study focuses on supply chain optimization for ELV recycling. Therefore, the keyword used to gather related publication for this review was “end-of-life vehicle” AND “recycling” AND “supply chain” and the papers was limited to the range of years 2016-2021 as to analyse the current trend in ELV recycling supply chain-related studies for the last five years. Publications in the year 2021 was not included since this review analysis is performed in the beginning of 2021. In the early phase of paper collection, as the keyword was entered in the Google Scholar search engine, 374 articles appeared in the search output. The search output was filtered, and related articles were extracted from several databases including, EmeraldInsight, Google Scholar, IEEE Xplore, Inderscience, SAGE journals, ScienceDirect, and SpringerLink. After the screening process, 29 papers were found to be under the specific area of study to be reviewed.

In conducting this study, a content analysis technique was implemented. Content analysis techniques are used to examine the crucial content in research by observing all contents captured in the articles systematically, which simultaneously assists in recognizing the different types of research focus (Pokharel and Mutha, 2009; Simić and Dimitrijević, 2019). The content in the selected article was observed to highlight the supply chain problem considered in each article. Consequently, the paper was categorized into five identified categories in supply chain

optimization and the content was critically discussed. Lastly, the publication platforms for the reviewed articles were listed and the primary publishers were identified.

3.Results and Discussion

As previously mentioned, a total of 29 articles were found that discussed supply chain optimization issues in ELV recycling for the past five years, whereby the articles are grouped into classes that represent the problem that is often being explored by the researcher for supply chain optimization in ELV recycling. Table 2 shows the division in supply chain optimization studies for ELV recycling that had been conducted before, which are network design, inventory management, supply chain coordination, production planning, and partner selection.

Table 2. Division of supply chain optimization studies for ELV recycling.

Author	Category of Studies				
	Network Design	Inventory Management	Supply Chain Coordination	Production Planning	Partner Selection
Kuşakcı, et al. (2019)	✓				
Xiao et al. (2019)	✓				
Chaabane et al. (2020)	✓				
Balcia and Ayvazb (2017)	✓				
Langarudi et al., (2019)	✓				
Demirel et al. (2016)	✓				
Deng et al. (2018)	✓				
Wan et al. (2020)	✓				
Dong et al. (2019)	✓				
Forouzanfar et al. (2018)	✓				
Sahcibjamnia et al. (2018)	✓				✓
Wang et al. (2019)	✓				
Sharma and Pandey (2020)		✓			
Mohan and Amit (2020)		✓			
Mohan and Amit (2021)		✓			
Simic (2016a)		✓			
Simic (2016b)		✓			
Simic (2016c)		✓			
Simic (2019)		✓			
Keivanpour et al. (2017)			✓		
Shankar et al. (2018)			✓		
Phuc et al. (2017)			✓		
Zhou et al. (2016)				✓	
Tian and Chen (2016)				✓	
Zhang et al. (2019)				✓	
Vulić et al. (2018)				✓	
Xia et al. (2016)				✓	
Zhou et al. (2016)					✓
Zhou et al. (2018)					✓

An analytical analysis was conducted, and an overview of the problems that are the focus of researchers in this field is shown in Figure 1. As can be observed, the network design problem attracts much more attention from researchers, in which 40% of the reviewed articles studied the network design problem to develop or sustain the ELV recycling business. This is particularly due to logistics and transportation aspects which play crucial roles in ELV recycling as ELV need to be collected from various regions before being processed. Thus, the costs of transporting and collecting ELVs are quite high. Chaabane et al. (2020) mentioned that the logistics cost for ELV recycling can be as high as half of the ELV purchased price or even higher than that. Therefore, the network design for transporting ELV should be well optimized to minimize costs and enhance the efficiency in the reverse logistics of ELV.

Inventory management is another supply chain problem that attracted the attention of researchers. From the analysis, 23% of the reviewed articles represent inventory management problems. Disruption in ELV supply and uncertain allocation of ELV is stated as the main cause of unstable inventory management for ELV recycling (Simic, 2016a, 2016b, 2016c, 2019). Uncertain ELV supply is a common problem faced by the ELV recycling industry all over the world, and the solution to optimize this problem varies across countries, which makes this area of study as a potential research gap to be investigated further.

The research on production planning for ELV recycling represents 17% of the reviewed articles. Most of the research conducted focused on the disassembly of ELV and concerned about supply chain issues that affect the production planning process. This shows that disassembly planning for ELV recycling should be taken seriously to ensure a good flow of ELV recycling production. Both supply chain coordination and partner selection represent 10% of the reviewed articles. Not many studies had been conducted concerning supply chain coordination and partner selection for the past five years. This might be due to the fact that more collaboration from various parties is needed to conduct studies for supply chain coordination and partner selection.

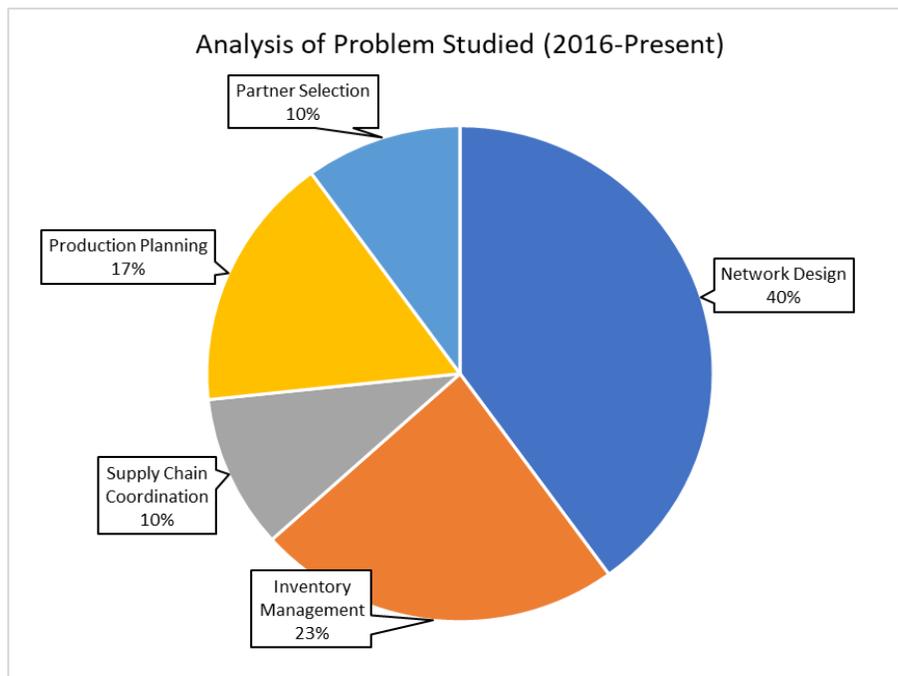


Figure 1. Analysis of ELV recycling studies in supply chain optimization field.

Finally, Table 3 lists the journals that published the reviewed articles in this study. From the table, the journal that published articles in supply chain optimization for ELV recycling is the Journal of Cleaner Production with a percentage of 20.69%, followed by Waste Management (13.79%), Sustainable Production and Consumption (6.9%), Journal of Industrial Engineering International (3.45%), Clean technologies and environmental policy (3.45%), Southeast Europe Journal of Soft Computing (3.45%), Annals of Operations Research (3.45%), Computers & Industrial Engineering (3.45%), Journal of Advances in Technology and Engineering Research (3.45%), Computers

and Industrial Engineering (3.45%), Journal of Industrial & Management Optimization (3.45%), Environmental Modeling & Assessment (3.45%), Resources, Conservation and Recycling (3.45%), International Journal of Production Economics (3.45%), Sustainability (3.45%), International Journal of Production Research (3.45%), Univ Politehnica Bucharest Sci Bull Ser C Electr Eng Comput Sci (3.45%), International Journal of Simulation: Systems, Science and Technology (3.45%), Progress in Industrial Ecology, an International Journal (3.45%), Journal of Advanced Transportation (3.45%). It can be concluded that the Journal of Cleaner Production is keen to publish articles in this area of study. It can also be shown that the main journals that contributed publications in this field of study are Journal of Cleaner Production, Waste Management and Sustainable Production and Consumption.

Table 3. List of journals for the published articles.

Journal	Distribution
Journal of Cleaner Production	20.69%
Waste Management	13.79%
Sustainable Production and Consumption	6.90%
Journal of Industrial Engineering International	3.45%
Clean technologies and environmental policy	3.45%
Southeast Europe Journal of Soft Computing	3.45%
Annals of Operations Research	3.45%
Computers & Industrial Engineering	3.45%
Journal of Advances in Technology and Engineering Research	3.45%
Computers and Industrial Engineering	3.45%
Journal of Industrial & Management Optimization	3.45%
Environmental Modeling & Assessment	3.45%
Resources, Conservation and Recycling	3.45%
International Journal of Production Economics	3.45%
Sustainability	3.45%
International Journal of Production Research	3.45%
Univ Politehnica Bucharest Sci Bull Ser C Electr Eng Comput Sci	3.45%
International Journal of Simulation: Systems, Science and Technology	3.45%
Progress in Industrial Ecology, an International Journal	3.45%
Journal of Advanced Transportation	3.45%

4. Conclusion

This paper analysed published articles that studied supply chain optimization for ELV recycling from 2016 until 2021. The analysis shows that there were five main problems that were explored by researchers, which are network design, inventory management, supply chain coordination, production planning, and partner selection. The analysis showed that 40% of the reviewed articles focused on the network design problem, followed by inventory management that represents 23% of the reviewed articles. Less engagement was observed in the production planning problem (17%), supply chain coordination problem (10%), and partner selection problem (10%). Hence, it can be concluded that network design is the main focus of the supply chain that has been optimized to improve the ELV recycling industry. Other than that, the publication platform of the reviewed articles was observed, and it is found that the Journal of Cleaner Production, Waste Management, and Sustainable Production and Consumption are the main publishing platforms for this field of study.

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Biographies

Fatin Amrina A.Rashid is a postgraduate student at the Department of Mechanical & Manufacturing Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Selangor, Malaysia. She earned

her Bachelor of Engineering Technology (Hons) in Mechatronics from Universiti Kuala Lumpur Malaysia France Institute and Master of Science (Industrial Engineering) from Universiti Teknologi Malaysia. Her research interests include sustainability, supply chain optimization, quality management, and safety management.

Hawa Hishamuddin is a senior lecturer at the Department of Mechanical and Manufacturing Engineering at the Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia. She earned her B.Sc. in Industrial Engineering from Purdue University, USA, and PhD in Computer Science from University of New South Wales, Australia. Her research interests include operations research, supply chain optimization, and disruption management.

Mohd Radzi Abu Mansor is a Researcher at the Department of Mechanical Engineering, Faculty of Engineering & Built Environment, Universiti Kebangsaan Malaysia (UKM). He graduated from Kyoto University Graduate School of Energy Science in 2013 and majored in the internal combustion engine, especially in hydrogen and diesel research. His interest includes alternative fuels, renewable energy, energy policy, CFD and vehicle safety. He is also Research Fellow at the Centre for Automotive Research, UKM.

Nizaroyani Saibani is a senior lecturer at the Center for Materials Engineering and Smart Manufacturing, National University of Malaysia. Her research interest Closed-loop Supply Chain, Supply Chain Performance, Measurement Work measurement, and Engineering Education.