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DEVELOPING A SUPPLIER SEGMENTATION FRAMEWORK FOR CLOSED-LOOP SUPPLY CHAINS – A CASE STUDY

Introduction

Introducing the circular economy is one of the leading trends in management science. It includes various activities related to material recovery to maximize reusing resources across supply chains. It is also related to building closed-loop supply chains to recover material resources generated during production or after use of the final products.

The identified research gap relates to determinants and recommendations for supplier segmentation in closed-loop supply chains. The purpose of this article is to identify such determinants and recommendations, with special emphasis on the used cooking oil (UCO) supply chain, and to propose a supplier segmentation framework for the companies operating in the UCO collection and recovery sector. The novelty of the article lies in the consideration of supplier segmentation in closed loop supply chains, which was also identified as a knowledge gap.

UCO is also known as waste cooking oil (WCO) or used vegetable oil (UVO). It is a food production waste and one of the main resources used to produce biofuels, e.g., biodiesel [Dzieniszewski, Krzaczek, 2011; van Grinsven et al., 2020]. Other resources that could be processed to biofuels are fresh vegetable oil, crude glycerin, tall oil, pome, sewage sludge, algae, and spent bleaching earth [van Grinsven et al., 2020]. The ongoing Russian invasion of Ukraine affects global UCO supply chains, because these two countries are the main global producers of edible oils [Sundram, 2022].

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In order to conduct long-term UCO collection and recovery, it is crucial to find sustainable sources of this production waste. Such sources might include food processing plants, restaurants, and consumers. Therefore, one of the problems related to UCO sourcing is supply fragmentation [Marchetti et al., 2020]. One of the possible solutions to this problem is supplier segmentation.

The research methods used include a literature review and a case study of a UCO collection and recovery company operating in Italy.

1. Characteristics of the UCO supply chain

The main activities in the UCO supply chain include generating UCO, collecting and transporting to a spot terminal, storing in a spot terminal, transporting to the filling terminal where UCO that originates from different sources is blended before recovery, storing in a filling terminal, transporting to the UCO recovery plant and processing UCO [*Used Cooking Oil – EUBIA*, 2022]. The UCO supply chain is illustrated in Figure 1.

Figure 1. UCO supply chain
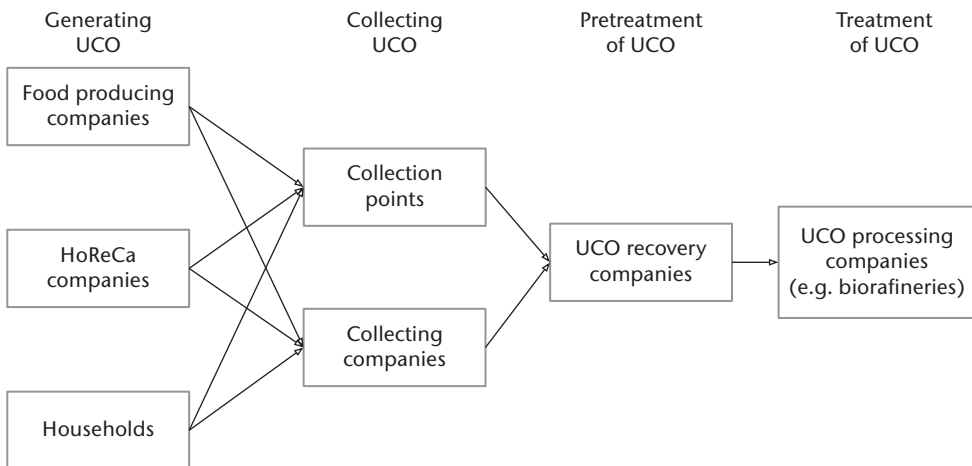
Source: own study based on Tsoutsos et al. [2016].

The UCO supply chain is not a closed-loop supply chain itself, since it is supposed to be processed to material goods, such as biofuel. However, it focusses on recovery activities performed on food waste (cooking oil waste), which is a crucial element of closed-loop supply chains. In fact, UCO collection and recovery companies are participants in both cooking oil supply chains and biofuel supply chains. These companies support closing the loop of cooking oil supply chain.

There are three UCO collection strategies that determine the UCO supply chain configuration: processor centralized collection, processor decentralized collection, and combined collection. In processor centralized collection parties that produce UCO deliver it to centralized collection points, where it is collected by the UCO collection and/or recovery company. In processor decentralized collection, the company that recovers UCO organizes door-to-door collection to collect UCO directly from source. In the combined collection company that collects and/or recovers UCO also provides companies generating UCO with fresh cooking oil [*Used Cooking Oil – EUBIA*, 2022].

2. Methodology

The scientific methods used in this research include a literature review and a case study of the company collecting and recovering UCO, operating in Italy. The research methodology is presented in Figure 2.

Figure 2. The research methodology
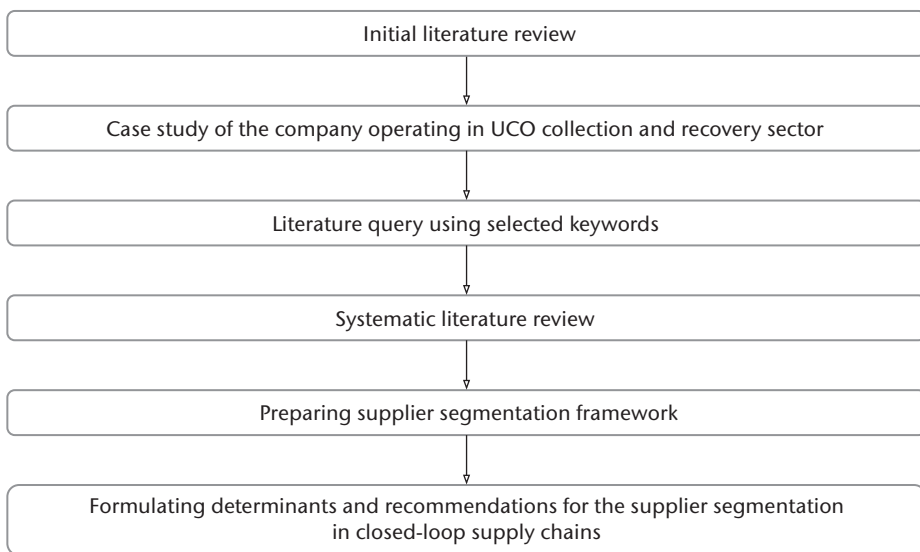
Source: own study.

Firstly, an initial literature review was carried out. It focused on sources related to circularity, the UCO market, and supplier segmentation.

Secondly, the case study of the company collecting and recovering UCO was carried out in September 2022. Its aim was to determine the characteristics of collection and recovery of UCO. Its results were presented in the earlier section of this paper.

The research questions regarding the literature and the case study are as follows.
1. What are the determinants for supplier segmentation in closed-loop supply chains?
2. What are the recommendations for supplier segmentation in closed-loop supply chains?

Next, the systematic literature review was conducted. The keywords used were divided into two groups. The first group included keywords related to circularity, and the second group included keywords related to supplier segmentation.

The Scopus was taken into account as the main database for the literature review that was conducted in June and July of 2023. No limitations were used with respect to the time of publication. The results are presented in Table 1.

Table 1. Results of the literature review

Phase	Searched phrase	Rationale	Scopus
I	TITLE-ABS-KEY (("closed-loop" OR "circular" OR "circularity") AND ("supplier segmentation" OR "supplier classification" OR "supplier management"))	The role of supplier segmentation in closed-loop supply chains	6
II	TITLE-ABS-KEY ("supplier segmentation") AND (LIMIT-TO (EXACTKEYWORD, "Supplier Segmentation") OR LIMIT-TO (EXACTKEYWORD, "Supplier Classification"))	The possible determinants of using supplier segmentation in closed-loop supply chains	34

Source: own study.

The systematic literature review was divided into two phases. Phase I aimed to determine the role of supplier segmentation in closed-loop supply chains. Phase II was aimed at identifying possible determinants of using supplier segmentation in closed-loop supply chains.

Due to the small number of sources found, no exclusion criteria were applied.

The results of both the case study and the literature review were used to propose a supplier segmentation framework for the UCO collection and recovery sector and to formulate recommendations for every segment.

3. Findings

The main findings are summarized in Table 2 and explained below.

Rezaei and Ortt [2012] defined supplier segmentation as "the identification of the capabilities and willingness of suppliers by a particular buyer in order for the buyer to engage in a strategic and effective partnership with the suppliers with regard to a set of evolving business functions and activities in the supply chain management". In this case, they focused on the capabilities and willingness of the suppliers, while treating these two characteristics as a way to group criteria for the supplier segmentation. Capabilities are related, among others, to price, quality, delivery, and repair service,

while willingness is related to, among others, attitude, impression, ethical standards, and long-term relationship. Several models proposed by different scholars are using the same approach [Bai et al., 2017; Boujelben, 2017; Dachyar, Maharani, 2019; Rajesh, Raju, 2021; Rezaei et al., 2015, 2022; Rezaei, Fallah Lajimi, 2018; Santos et al., 2017].

Table 2. The overview of the key sources

Sources	Key elements
[Bai et al., 2022]	The overview of circular procurement in practice
[Borges et al., 2022; Day et al., 2010; Rezaei, Ortt, 2012; Shiralkar et al., 2022; Valipour Parkouhi et al., 2019]	The overview of methods and/or dimensions used in supplier segmentation
[Hoek, 2020]	The impact of COVID-19 on supplier segmentation
[Boujelben, 2017; Dachyar, Maharani, 2019; Hudnurkar et al., 2016; Kaur, Prakash Singh, 2021; Li et al., 2014; Matshabaphala, Grobler, 2021; Rahayu, Ardi, 2020; Rezaei et al., 2015; Rezaei, Fallah Lajimi, 2018; Rezaei, Ortt, 2012; Santos et al., 2017; Valipour Parkouhi et al., 2019]	Classifying criteria for supplier segmentation
[Bai et al., 2017; Paybarjay et al., 2023; Segura et al., 2019]	Classifying criteria for sustainable supplier segmentation
[Boujelben, 2017; Dachyar, Maharani, 2019; Rajesh, Raju, 2021; Rezaei et al., 2015; Rezaei, Fallah Lajimi, 2018; Santos et al., 2017]	Developing two-dimensional supplier segmentation model
[Rezaei, Ortt, 2012]	Defining the supplier segmentation
[Bai et al., 2017; Rezaei et al., 2022]	Proposing two-dimensional supplier segmentation approach using environmental criteria

Source: own study.

4. Discussion

None of the sources found are directly related to circular economy or closed-loop supply chains. However, some sources are related to the sustainability concept and to limiting negative environmental impacts of suppliers [Bai et al., 2017, 2022; Paybarjay et al., 2023; Segura et al., 2019].

There are numerous criteria or dimensions taking into account to develop a supplier segmentation framework [Borges et al., 2022; Day et al., 2010; Rezaei, Ortt, 2012; Shiralkar et al., 2022; Valipour Parkouhi et al., 2019]. It should be noted that their choice might be related to the sector of operations.

Limiting the negative environmental impacts of suppliers is the common factor taken into account when making procurement decision. Such impacts include, among others, the use of recovered or recycled materials, the use of energy, waste emission, the carbon footprint, environmental performance evaluation and using environmental management systems [Bai et al., 2022].

Environmental impacts are also considered criteria for sustainable supplier segmentation [Paybarjay et al., 2023]. Other criteria for supplier segmentation include, among others, supplier capabilities, delivery cost and efficiency, country of operations, strength of buyer-supplier relationship, potential for buyer-supplier partnership [Borges et al., 2022] and carbon impact assessment [Rezaei et al., 2022].

Apart from criteria used, supplier segmentation may be one-dimensional or multidimensional [Rezaei et al., 2022]. There are multiple two-dimensional supplier segmentation models, "supplier segmentation matrixes" [Rajesh, Raju, 2021; Rezaei et al., 2022]. Other issues related to supplier segmentation include the impact of COVID-19 on supplier segmentation [Hoek, 2020].

5. Case study and development of the supplier segmentation framework

The focal company operates in Italy in UCO collection and recovery sector. Its suppliers are different kinds of organization that generate UCO. The UCO collection process was discussed. By default, it usually proceeds as follows.

1. A collecting company and a supplier company agree on the schedule for collecting UCO.
2. A collecting company provides a supplier company with an UCO container for free.
3. A collecting company organizes collection of UCO using its own means of transport.
4. A collecting company also provides a supplier with an invoice for UCO.

There are several observations that are crucial for developing the supplier segmentation framework:

1. UCO is a kind of waste generated from numerous sources, not always in bulk and not always regularly.
2. The source base of UCO is known, but fragmented.
3. It is difficult to forecast the UCO prices due to significant price fluctuations, hence fixing the price in contract is risky.
4. It is also difficult to forecast the quantity of available UCO as a result of fluctuations in fresh cooking oil consumption.
5. The full supplier capacity to generate UCO is usually unknown.
6. It is beneficial to acquire even a limited amount of UCO.
7. Problems with obtaining UCO might result from lack of waste recovery culture: waste is not treated as a valuable resource, despite the fact that it is changing with the introduction of circular economy practices in EU.

The ideas related to supplier segmentation include selecting suppliers for the use of reusable or intelligent packaging for UCO. Reusable packaging decreases

collection costs, and intelligent packaging could provide a real-time information on when collection should be scheduled [Roya, Elham, 2016].
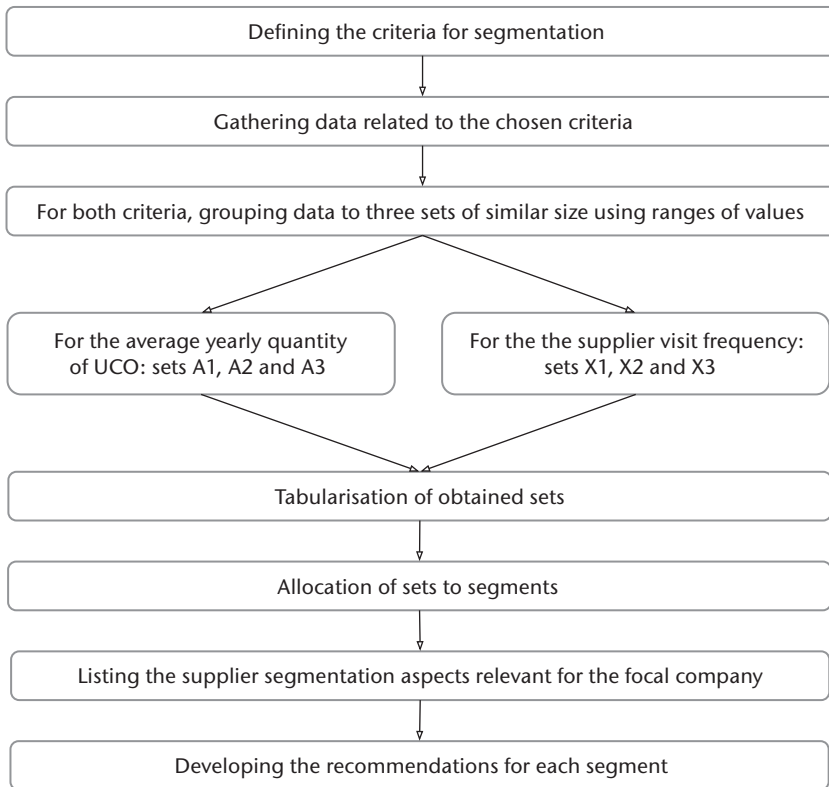
The criteria for the supplier segmentation framework were also discussed. The most crucial criteria for the focal company are:

Criterion 1: the average yearly quantity of UCO acquired per supplier per visit (in kg).
Criterion 2: the visit frequency per year per supplier.

The proposed supplier segmentation framework is a nine-quadrant matrix using these two criteria. Its development is visualized in Figure 3.

Figure 3. Developing the supplier segmentation framework for the focal company

Source: own study.

After defining the segmentation criteria, the data related to these criteria was gathered. The data used to develop the supplier segmentation framework cover one year of the focal company's operations.

Next, for both criteria, the data were grouped into three sets. Each supplier was assigned to one of the sets (for both criteria). The main assumption was that the sets should contain similar number of suppliers in order to simplify the process of

updating the supplier segmentation when the new data will be available. The sets for the average yearlyquantity of UCO are A_1 (low), A_2 (medium), A_3 (high), and the sets for the supplier visit frequency are X_1 (low), X_2 (medium), and X_3 (high). These sets were then compiled in tabular format.

Subsequently, the sets were allocated to the segments in the following manner:

1. Segment 1 (S_1, priority segment) contains suppliers positioned in at least one set with a (high) value and at least one (medium) value.
2. Segment 2 (S_2, attractive segment) contains suppliers positioned in sets with both (medium) values.
3. Segment 3 (S_3, auxiliary segment) contains suppliers positioned in the remaining sets.

Since there are no strict rules related to dividing the proposed sets (apart from a similar number of suppliers), the proposed supplier segmentation framework will be semiqualitative. The set classification and the proposed supplier segmentation framework are visualized in Figure 4.

Figure 4. Supplier segmentation framework

The average yearly quantity of UCO acquired per supplier per visit (in kgs)
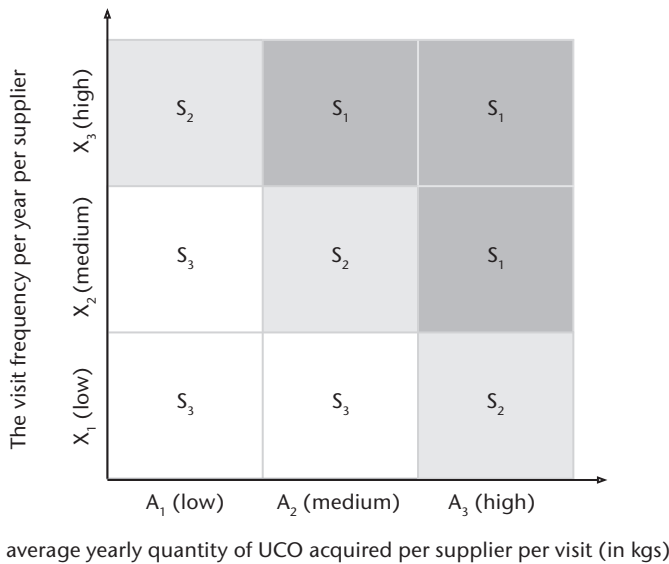
Source: own study.

Alternatively, this classification can be described as follows:

$$S_1 = (A_3 \cap X_3) \cup (A_2 \cap X_3) \cup (A_3 \cap X_2)$$
$$S_2 = (A_2 \cap X_2) \cup (A_2 \cap X_2) \cup (A_2 \cap X_2)$$
$$S_3 = (A_1 \cap X_1) \cup (A_1 \cap X_2) \cup (A_2 \cap X_1)$$

The next step was to formulate recommendations for each segment, based on results of the literature review and the case study. To do so, the aspects of buyer-supplier cooperation that are relevant for the focal company were taken into account.

Table 3. Recommendations for activities in specific supplier segments

	S_1	S_2	S_3
Signing formal agreement with supplier	recommendable	possible	not necessary
Scheduling regular collection	recommendable	recommendable	not necessary
Collecting UCO mainly on the occasion of other collections	not necessary	not necessary	recommendable
Using intelligent packaging	recommendable	possible	not necessary
Using reusable packaging	recommendable	recommendable	recommendable
Rewarding supplier for their performance	recommendable	possible	not necessary

Source: own study.

There are three types of recommendations for the described activities: "recommendable", "possible" and "not necessary". "Possible" depends on the communication and willingness of the specific supplier.

"Recommendable" means that this activity is recommended for this activity in this particular supplier segment. "Possible" means that this recommendation depends on the communication and willingness of the specific supplier. "Not necessary" means that there is no reason to perform this activity in this supplier segment.

Several aspects of buyer-supplier cooperation relevant for the focal company were not taken into account either because they were problematic from the legal point of view (e.g., exclusive contracts with suppliers) or they might not be beneficial economically (e.g., fixing the price of UCO in the formal agreement with supplier).

Since the classification of suppliers in the proposed supplier segmentation depends on the availability of the UCO provided and the frequency of collection, it depends on the suppliers' oil consumption and their willingness to cooperate with the focal company.

Conclusion

In summary, the conducted study resulted in the proposal of the supplier segmentation framework for UCO collection. The determinants and recommendations for supplier segmentation in closed-loop supply chains, with a special emphasis on the UCO supply chain, were identified and the recommendations were included in the proposed supplier segmentation framework.

The main limitation of the study conducted is the scarcity of sources on both sourcing in closed-loop supply chains and UCO collection and recovery. On the other hand, it indicates the research gap related to the practical implementation of circular economy.

The main implication for business is to build initiatives related to supplier segmentation and supplier management that would encourage reliable sourcing of recovered materials for production. It includes not only national sector initiatives related to UCO, but also multinational initiatives related to different business sectors.

The main implication for government is that introducing regulations that favor the use of recovered materials instead of virgin materials (e.g., tax exempts) might reduce emission of waste, drive building closed-loop supply chains, and therefore foster a transition towards circular economy.

The main recommendation for future research is identifying determinants of sourcing in closed-loop supply chains with special emphasis on companies that recover industrial and consumer waste. It might provide a valuable contribution to the transformation towards circular economy.

Acknowledgements

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Abstract

The purpose of this article is to identify the determinants and recommendations for supplier segmentation in closed-loop supply chains, with special emphasis on the used cooking oil (UCO) supply chain, and to propose a supplier segmentation. The research methods are the literature review and a case study of the company collecting and recovering UCO.

The study resulted in proposing the supplier segmentation framework for the companies operating in UCO collection and recovery sector.

The study conducted was limited by the scarcity of sources in both sourcing in closed-loop supply chains and UCO collection and recovery of UCO. On the other hand, it indicates the research gap related to the practical implementation of circular economy. The novelty of the article lies in the consideration of supplier segmentation in closed loop supply chains.

OPRACOWANIE STRUKTURY SEGMENTACJI DOSTAWCÓW DLA ZAMKNIĘTYCH ŁAŃCUCHÓW DOSTAW – STUDIUM PRZYPADKU

Streszczenie

Celem niniejszego artykułu jest określenie uwarunkowań i zaleceń dotyczących segmentacji dostawców w zamkniętych łańcuchach dostaw, ze szczególnym uwzględnieniem łańcucha dostaw zużytego oleju spożywczego (UCO), oraz zaproponowanie segmentacji dostawców. Metody badawcze to przegląd literatury i studium przypadku firmy zbierającej i odzyskującej UCO.

W wyniku badania zaproponowano strukturę segmentacji dostawców dla firm działających w sektorze zbiórki i odzysku UCO.

Przeprowadzone badanie było ograniczone niedoborem źródeł zarówno w zakresie źródeł zaopatrzenia w zamkniętych łańcuchach dostaw, jak i zbiórki i odzysku UCO. Świadczy to zarazem o luce badawczej związanej z praktycznym wdrażaniem gospodarki o obiegu zamkniętym. Oryginalność artykułu polega na uwzględnieniu segmentacji dostawców w zamkniętych łańcuchach dostaw.

Słowa kluczowe: gospodarka o obiegu zamkniętym; cyrkularność; zamknięty łańcuch dostaw; segmentacja dostawców; kwalifikacja dostawców; zarządzanie dostawcami

Kody klasyfikacji JEL: L14, M00, Q56