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Toward a circular supply chain: Understanding barriers from the perspective of recovery approaches

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ABSTRACT

The integration of the concept of the circular economy (CE) within the supply chain is known as the circular supply chain (CSC). Although various articles have identified barriers to implementing CE, no comprehensive study has investigated the impacts of barriers focusing on CSC. This study includes a systematic literature review to contextualize the impact of barriers from the perspective of 3R (i.e., reusing, remanufacturing, and recycling) recovery approaches. It classifies barriers into seven main groups in the context of CSC. The most often observed barriers hindering 3R recovery approaches are identified, and their impacts are discussed. The results demonstrate that barriers related to "economics and finance," "governments and regulations," and "society and culture" substantially impact the ability of organizations in the initial phase of adopting recovery approaches. In particular, key findings outline that consumer willingness to purchase recovered products impacts reuse, deficient supportive regulations impact 3R approaches (especially recycling), and a lack of support in the market impacts the ability of organizations to execute remanufacturing effectively. In addition, conducting empirical research is still desirable and creates a meaningful link between theory and practice. It helps to understand the barriers to remanufacturing, reusing, and recycling.

1. Introduction

Recent studies have shown that circular economy (CE), as a strategy, can help organizations shift from applying the traditional (linear) economic model to implementing a circular system (Merli et al., 2018; Shekarian, 2020). The CE is supposed to help industrial companies contribute environmentally to developing a sustainable economy in collaboration with a socially equal society. Studies that have focused on various applications of the CE have determined the substantial advantages of this economic system over the linear system. The CE concept has been operationalized in different fields, such as the construction sector (Ravindra et al., 2015; Smol et al., 2015), the service sector (Annarelli et al., 2016; Tukker, 2015), the supply chain (Zhu et al., 2010), and the manufacturing sector (Lieder et al., 2017; Linder and Williander, 2017). However, only a few studies have explored ways to implement CE in relation to supply chain activities (Aminoff and Kettunen, 2016; Genovese et al., 2017).

The effort made to revise the theory of supply chain management (SCM) led to the creation of concepts such as sustainable supply chain management (SSCM) (Seuring and Müller, 2008), green supply chain management (GSCM) (Ahi and Searcy, 2015; Kudinova et al., 2012), and the closed-loop supply chain (CLSC) (Shekarian, 2020; Souza, 2012). Although many companies have used these concepts to adopt sustainability and supply strategies, there are still shortcomings and gaps in their application (S. A. R. I.S. Khan et al., 2021). A new paradigm, the circular supply chain (CSC), creatively addresses these gaps by integrating the CE into SCM.

To ensure that all supply chain actors effectively adopt the CE concept, we need a new sustainability research domain that empowers circularity and all actors along the supply chain. In this regard, CSC is an applicable paradigm (Batista et al., 2018; De Angelis et al., 2018; Mishra et al., 2018). The CSC aims to prolong resource circulation in line with supply chain demands. It integrates the CE and SCM by extending the closed-loop boundary, and it recovers value from the original supply chains and secondary supply chains (Farooque et al., 2019). Moreover, the CSC transcends the borders of SSCM and GSCM and encompasses resources within supply chain systems to mitigate the use of virgin materials (Andersen, 2007; Genovese et al., 2017). It allows the CSC to

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reach zero waste and makes recovering end-of-life (EoL) products feasible, even for unwanted waste (Aminoff and Kettunen, 2016; Farooque et al., 2019). Batista et al. (2018) showed that CSCs stimulate growing recovery approaches in business ecosystems. CSC is one reason for the increasing interest in linking the supply chain to CE (Aminoff and Kettunen, 2016). Despite the benefits, Lahane et al. (2020) noted that in this context, there is still room to recognize bottlenecks and barriers to reaching a better version of CSC.

The absence of a comprehensive understanding of CSC barriers limits enterprises from quantifying circular initiatives or comparing circular alternatives with the current business models (Caldera et al., 2019; Kiefer et al., 2019). In other words, practitioners require an extensive understanding of circularity and its effect on business characteristics to adopt a circular model. The barriers vary based on firm size, geographic region, and governmental, managerial, financial, and social factors (Mangla et al., 2018; Tura et al., 2019). However, the literature lists a set of general barriers unrelated to any specified region (Gåvertsson et al., 2020; Ormazabal et al., 2018; Ranta et al., 2018).

The concept of circularity includes two essential approaches: the restorative approach and the regenerative approach. These approaches lead to circulation activities that encourage business models to minimize the demand for virgin materials. Regenerative approaches consider transforming materials to a new state (Akhlamadi and Goharshadi, 2021) or making good use of a product, such as fast-moving consumer goods with short or very short life spans (Gedam et al., 2021; MacArthur, 2013). Restorative approaches are activities that recover materials, components, and products for further use. Authors indicated that restorative approaches could be applied to tangible durable products, organizations, and industries (Stahel and MacArthur, 2019). Additionally, from the CSC perspective, preserving the economic and environmental value of "tangible durable products" in economic systems for as long as possible is crucial. Maintaining value happens by prolonging products' life cycles and reabsorbing them into the loop of use. (Den Hollander et al., 2017). Consequently, as we seek to enhance the transformation from a linear model to a circular model for industries that focus on tangible durable products (De Angelis et al., 2018; Elia et al., 2020), we must emphasize a surge in restorative approaches (e.g., repairing, refurbishing, remanufacturing, and recycling) that lengthen the life span of EoL tangible durable products.

At the firm level, the literature represents R-typologies, including "reusing," "remanufacturing," and recycling" (Batista et al., 2018; Geissdoerfer et al., 2017; Kirchherr et al., 2017). The European Union

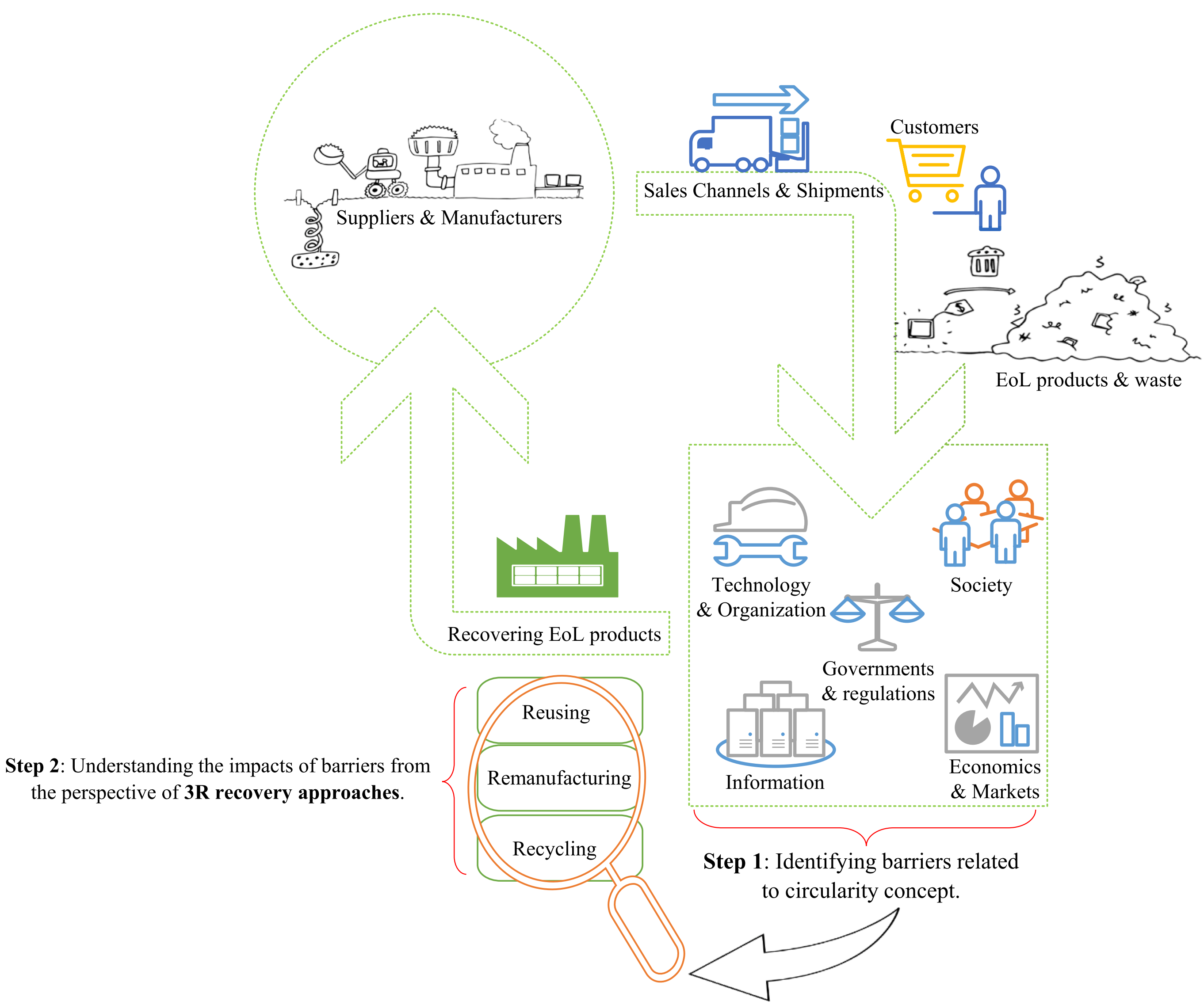

Fig. 1. Research steps employed to understand the barriers and their impacts on the recovery approaches.

(EU) introduced "recover" as the fourth R and used the 4R framework, which is the core of the EU Waste Framework Directive (EU-Commission, 2011). In the waste stream, recycling is the last solution when reuse or repair is impossible (Akhlamadi et al., 2021). Scholars have also introduced the 6R and 9R frameworks in addition to the 4R framework (Sihvonen and Ritola, 2015; van Buren et al., 2016). In this study, we focus on 3R (reusing, remanufacturing, and recycling) and consider extant and durable products. Therefore, perishable or deteriorating products are beyond the scope of this study. The literature provides the following definitions for 3R recovery approaches:

(1) Reusing: Extending the use-life of product and product possession is switched to another entity; consequently, there is no need to produce a new product (Kalmykova et al., 2018; Lu et al., 2018).
(2) Recycling: Turning products and components into raw materials that can be used in new products (Huang et al., 2018).
(3) Remanufacturing: A series of activities implemented by the original equipment manufacturer (OEM) or a third party to significantly boost the current quality of an EoL product to transform it into a like-new one (Kalmykova et al., 2018).

To the best of our knowledge, academic contributions to CSC barriers and recovery approaches are limited (Nasir et al., 2017; Shahbazi et al., 2016; Shekarian et al., 2021). Current studies maintain that many companies have apprehended the expanding need to transition toward circularity (Kayikci et al., 2021; Uhrenholt et al., 2022). Additionally, the literature provides models for managing supply chains in terms of adopting CSC strategically (Elia et al., 2020). However, the studies highlight both the importance of adopting CSC and the underlying problems of adopting it. The findings should offer direction to companies in their attempts to reduce material, redesign products, and reuse, remanufacture, and recycle products (Bjørnbet et al., 2021). Therefore, it is imperative to conduct an in-depth investigation of the challenges that prevent organizations from adopting CSC. We found that two aspects are absent in supporting CSC adoption. First, the barriers that influence the implementation of CE strategies in the supply chain have not been evaluated. Werning and Spinler (2020) asserted that applying a structural approach to these barriers requires industries to understand their impact. Second, there is a lack of understanding of the barriers' roles from the perspectives of different recovery approaches. Identifying the difficulties in adopting an appropriate recovery approach is crucial for industries that want to shift to CE initiatives.

Although these strategies are well established conceptually, they have limited industry adoption and operationalization. Therefore, this study employed a systematic literature review (SLR) to contribute to the abovementioned research gaps in two steps (Fig. 1). In the first step, we identify the barriers related to circularity. In the second step, we show the impact of the barriers on the 3R recovery approaches. The advantage of this study is that it provides new knowledge so that academia and enterprises can better understand the challenges and obstacles in adopting circular models in supply chains. To fulfil the aim of the study, we answered the following research questions:

(1) What are the barriers that hinder the implementation of CSCs?
(2) How can these barriers be classified?
(3) What are the most frequent barriers to 3R recovery approaches?

The rest of this paper is structured as follows. Section 2 explains the study's research methodology. Section 3 presents the SLR results and highlights the frequency of the barriers from the perspectives of recovery approaches, industries, and case size. Section 4 discusses the practical and theoretical implications and recommends topics for future research. Section 5 concludes the paper.

2. Methodology

The SLR method was used to investigate the research questions. It involves using well-defined and rigorous criteria to appraise and synthesize the extant literature and accomplish the study's objectives (Tranfield et al., 2003). After the research questions were identified, we followed the SLR procedure outlined by Seuring and Müller (2008). They developed four steps: (1) material collection, (2) descriptive analysis, (3) category selection, and (4) material evaluation.

2.1. Material collection

The Scopus was searched considering the keywords "circular economy," "barrier," "circular supply chain," and "barrier." Initially, 426 articles were extracted. Shortlisting a set of criteria delimitates the search to reach specific results (Seuring and Müller, 2008). We searched "English language" and "peer-reviewed" articles in the Scopus database. A combination of the strings "circular economy," "supply chain," and "circular supply chain" with the keywords "barrier," "limitation," and "challenge" were searched in the article title, abstract, and keywords. We also searched Web of Science (Social Sciences Citation Index) to improve the reliability of the selected studies. Consequently, 233 papers were extracted, and their content was checked. Before undergoing a full-text review, we defined the boundaries and criteria in three

Table 1
Boundaries for the research protocol.

Objective	Inclusion criteria	Exclusion criteria
Subject area	Any areas related to the circular economy, circular supply chain, and recovery approaches are included.	Unrelated areas, such as law, policy, biology, microbiology, and geography, are removed.
Title/abstract keyword	Title/abstract and keywords include any headings or cues on barriers, the circular economy, adopting circularity, sustainability, and/or supply chains.	Title/abstract does not include any direct cues related to barriers to adopting circularity. Moreover, abstracts that only refer to circularity adoption are not straightforward or clearly in line with barriers, adopting circularity, or recovery approaches.
Content discussion	The contents of a paper highlight a mutual discussion of barriers, recovery approaches, circularity, the supply chain, or empirically researched data on the abovementioned areas.	The content of the paper does not include any mutual discussion based on barriers, or the paper only discusses the principles of circularity, or has no direct output related to the barriers. Additionally, articles that only referred to the abovementioned areas as a future research paradigm were considered outside the scope of this review.

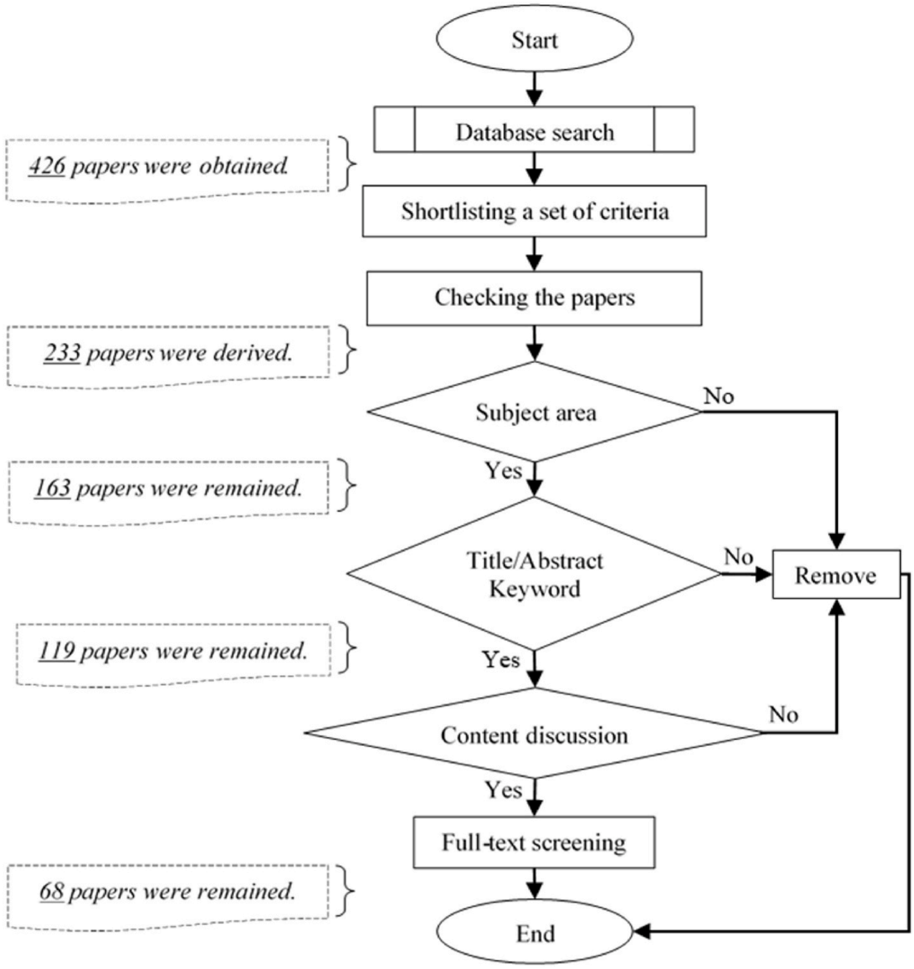

Fig. 2. Schematic overview of research methodology.

objectives to develop our research protocol (Table 1). The objectives described in Table 1 were carried out to identify papers that met the study's scope and to specify how papers were selected for full-text review (Fig. 2). Moreover, we derived a definition of "barrier" to establish a common ground of understanding for the term and any synonyms. In this study, "barrier" is defined as the reasons for limiting, hampering, or challenging the adoption of circular thinking or models. Therefore, any synonyms for barrier, such as limitation, challenge, obstacle, and hurdle, were also considered when screening papers.

Furthermore, once the articles were evaluated based on "title/abstract keyword" and "content discussion" (Table 1), we searched for connected papers to improve reliability of criteria (Tarnavsky Eitan et al., 2020). Fig. 3 shows the connections between paper interfaces within the sector to identify barriers and clustering. The clusters in the graph represent ranges of trends and interactions among older and newly published papers. The graph visualizes more important recent articles with darker nodes in color to show which papers are cited more often. Moreover, similar papers are clustered together in space and are connected by more vital lines. In analyzing the papers, this graph helped improve paper coding in the descriptive analysis and category selection sections. Clusters 1 (35 articles) and 2 (7 articles) depict highly overlapping papers positioned close to each other, even though the papers did not cite each other. Cluster 1 highlights major articles with high contributions. These articles helped us improve article categorization and identify research gaps. The centered articles in Cluster 1 (Ghisellini et al., 2016; Govindan and Hasanagic, 2018; Heshmati, 2017; Kalmykova et al., 2018; Masi et al., 2017) are papers that formed the basis for other studies' methods. Therefore, we refined our search using these articles and advanced our analysis of other articles through connected papers.

2.2. Descriptive analysis

A bibliometric scan was conducted to delineate article elements and publication scope. This scan circumscribed the most significant research areas that support the CE theme of barriers. To manage the sample, we used VOS Viewer software (Van Eck and Waltman, 2014). The output of the software is a map based on bibliographic data and for visualizing bibliometric networks. The output consists of nodes and edges determining the association between the keywords and the strength of the connection through the edges (Van Eck and Waltman, 2014). The distance between two nodes denotes their correlation. The more significant the node, the more it appears in the reviewed studies and the greater the number of links to other nodes. Fig. 4 presents the research areas related

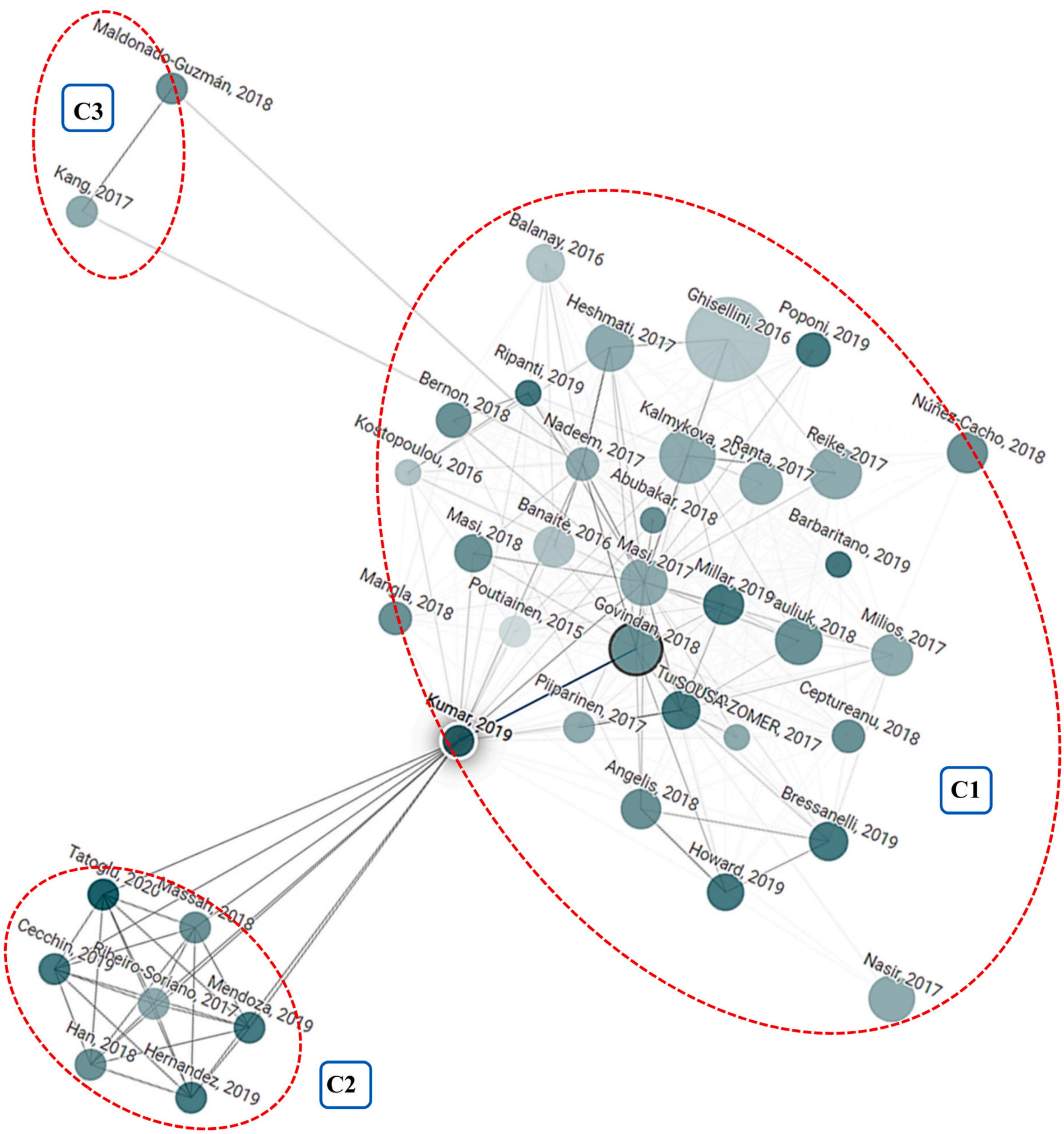

Fig. 3. Schematic overview of connected paper clustering to show papers with high contributions.

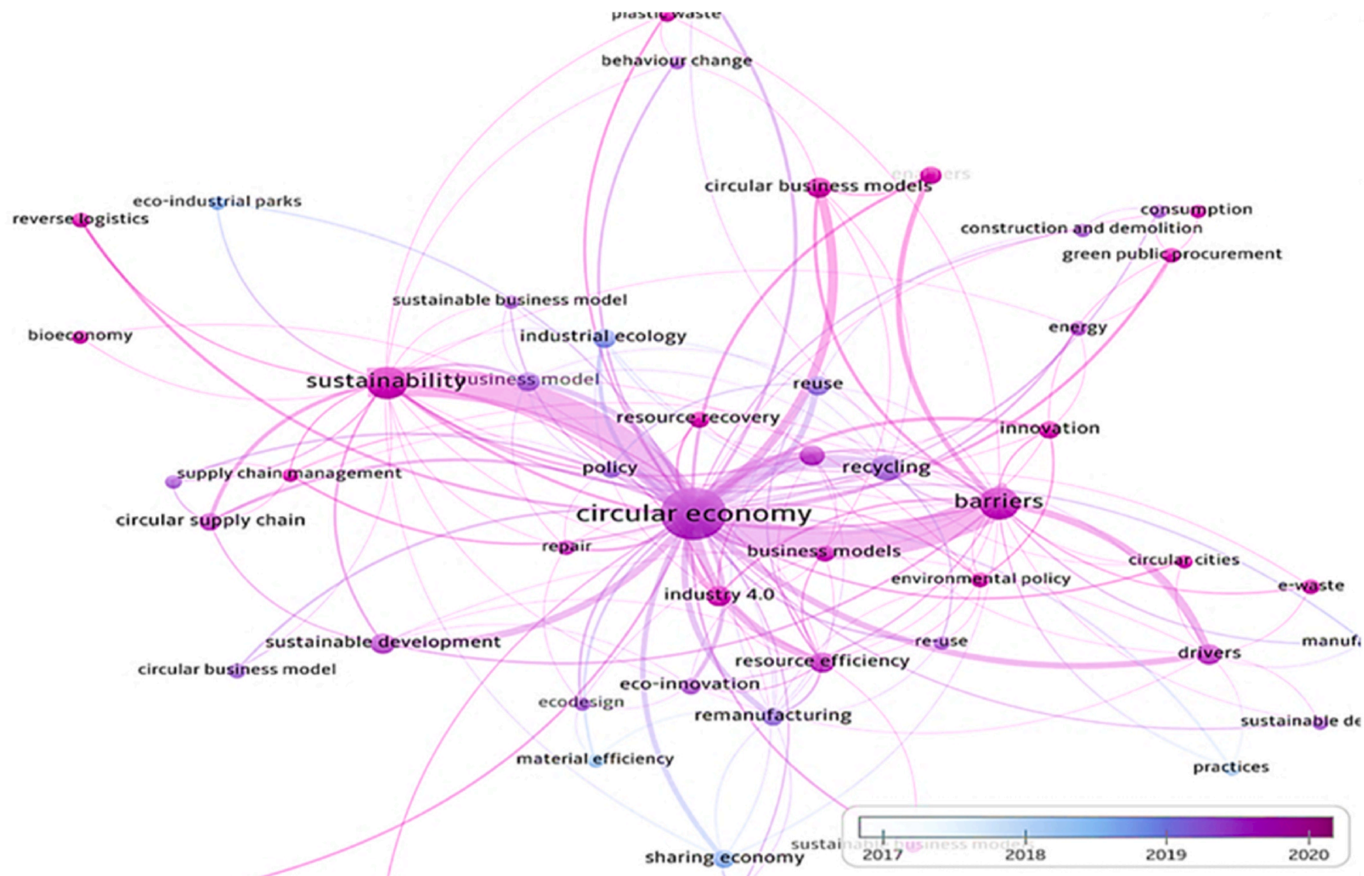

Fig. 4. Correlation between papers' keywords.

to circularity, co-occurrence of the keywords, and contemporary concentration of the topics in the literature. The analysis determined that very few studies have been conducted on CSC and barriers by establishing a weak link between these two concepts (Fig. 5). One crucial output is the absence of a bridge between the recovery approaches, barriers, and circular supply chain.

In addition, the circular supply chain and recovery approach clusters are not linked, implying that little research has been conducted on this subject.

To compare the selected articles, we identified the objective of each paper and the research method, and we assessed the quality of the papers (Seuring and Gold, 2012). Fig. 6 shows that the number of published papers (233 in total before the inclusion/exclusion screening) in the domain of circularity has increased since 2017. Furthermore, the authors reported that a growth trend occurred once the practitioners adopted circularity and participated more actively in related research. Accordingly, we focused on 68 articles that identified barriers to circularity after 2017. The 68 collected papers include a literature review, methodology, case studies, discussion, and reports. The research methodology included the approach, procedure, data collection, source, keywords, research aim, and industry settings.

We analyzed the research methodology to examine the articles. Many of the published articles deployed literature reviews, multiple case studies, interviews, reports, and conceptual frameworks. In addition, several papers adopted mixed methodologies to analyze barriers. Ivankova et al. (2006) developed a mixed methodology procedure that selected qualitative cases for an explanatory study and a quantitative method in two consecutive phases within one study. The adopted mixed methods included hybrid approaches to identify the causes and effects of barriers and rank barriers, such as the fuzzy Analytic Hierarchy Process (AHP) method, entropy method, and Fuzzy Delphi method (FDM). The analysis of the articles and their references sections demonstrated that scholars are more interested in circularity and conducting empirical studies. Empirical data were collected and analyzed according to recovery approaches, industry type, firm size, and geographic context. To be more specific, this study deployed following definitions to collect data and identify the impact of barriers on 3R recovery approaches:

(1) Reusing: Reusing a product without requalification for a second use life.
(2) Remanufacturing: A series of activities implemented by the OEM or a third party to change the quality of an EoL product into a like-new one.
(3) Recycling: Turning products and components into raw materials that can be used in new products.

The authors have adhered to two criteria at the product and industry levels to include or exclude articles. Product-level analysis included papers that studied already-produced products and excluded articles that only mentioned fast-moving consumer goods with a short or very short life span (MacArthur, 2013). The industries included electronical and electronic equipment (EEE), manufacturing, textile, and

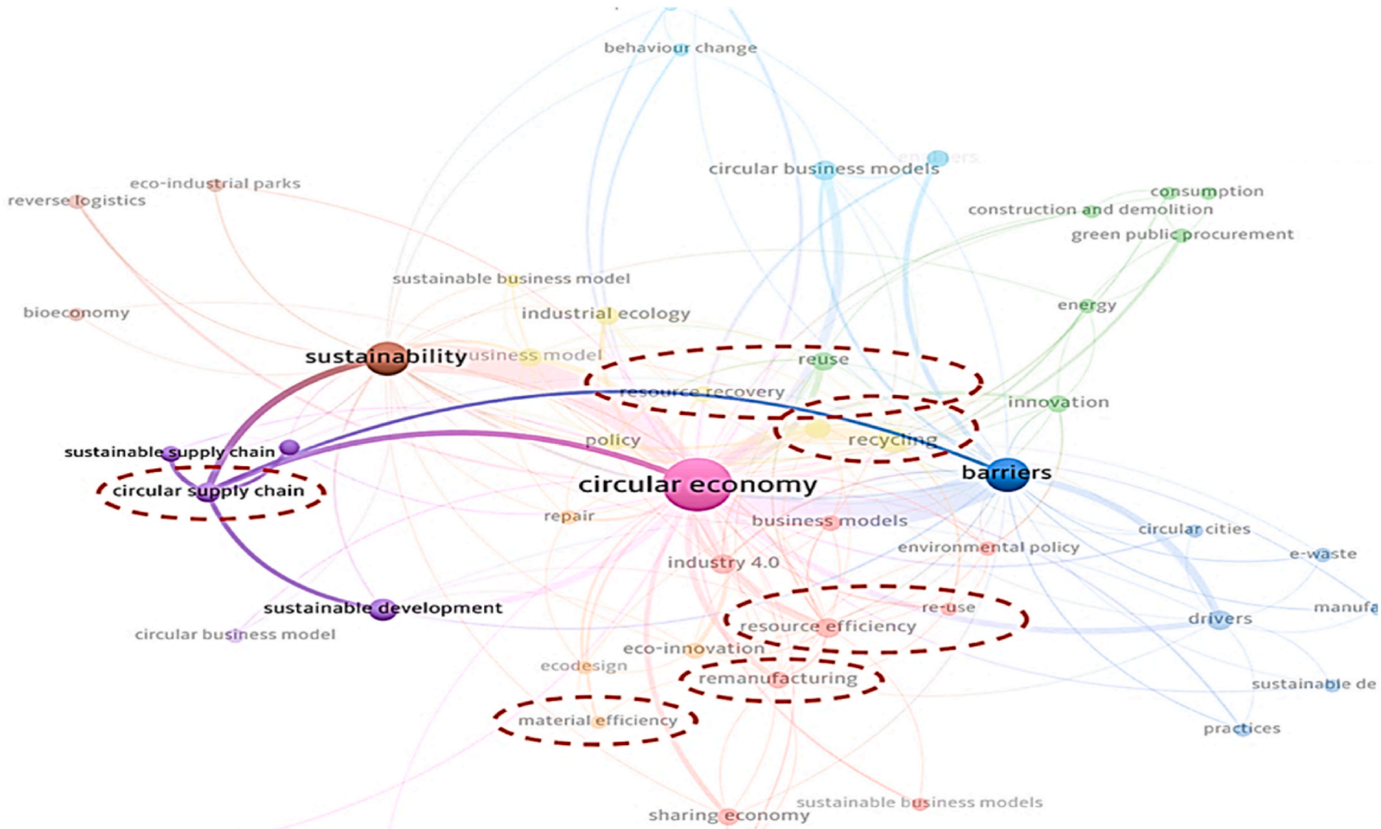

Fig. 5. Co-occurrence of keywords such as "circular economy" and "circular supply chains."

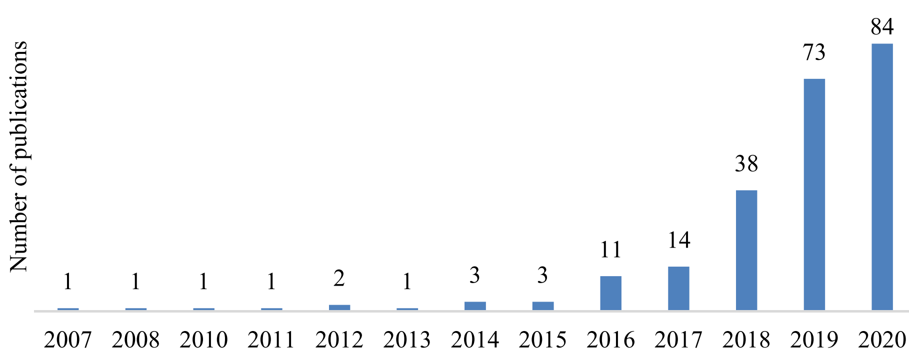

Fig. 6. Number of papers published from 2007 to 2020.

construction. The size of the organizations are large firms, small to medium-sized enterprises (SMEs), and cities. The geographic context involved the areas in which case studies were located. The authors separated regions by continent, specifically Asia, Europe, Africa, and North and South America. Case studies that involved more than two continents are referred to as "worldwide" (WW).

2.3. Category selection

In the final in-depth review, we categorized the papers into three groups (Fig. 7). We followed a set of criteria through the full-text review to ensure that the collected data could answer the formulated questions. Conceptual papers are expected to present the logic behind and reasons for adopting CE strategies. The empirical papers are expected to indicate the following:

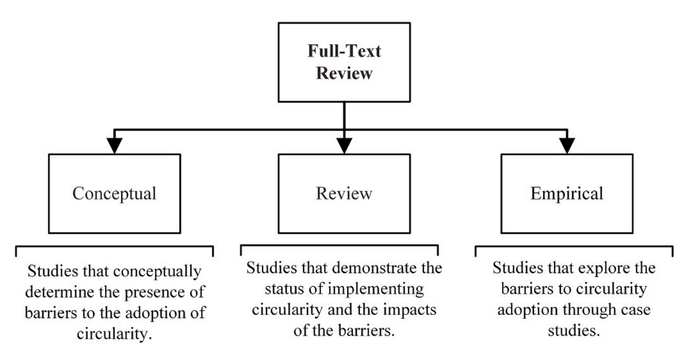

Fig. 7. Overview of the sorting and categorizing "full-text review" procedure.

Table 2
Main characteristics of papers.

Reference	Methodology	Main contribution	Continent	Industry	Size
Guo et al. (2017)	Mixed methodology	Significant investigation of adopting recovery approaches in China	Asia	CDW*	City
Hazen et al. (2017)	Qualitative analysis	Investigating the consumers' intentions regarding recovered products in the market	WW	EEE	LF
Linder and Williander (2017)	LR and Case study	Identifying barriers and reasons for reluctancy to adopt recovery approaches	EU	Man	SMEs
Mashhadi and Behdad (2017)	Quantitative methodology	Conducting a new sorting method and analyzing adopting recovery approaches	NA	EEE	LF
Tecchio et al. (2017)	Multiple case studies	Significant insight into barriers that hamper boost standard sustainable resource and resource use	EU	MI	LF
Yuan (2017)	Case study	Key challenges hindered adopting recycling approach and supporting ideas to overcome	Asia	CDW	City
Chamberlin and Boks (2018)	LR & multiple case study	Identifying marketing challenges for the recovered products	WW	Textile	NA
de Jesus and Mendonca (2018)	LR & Qualitative analysis	Significant insights into innovation, identifying barriers and drivers to move toward CE adoption	EU	MI	SME&LF
Hobson et al. (2018)	Multiple case studies	Significant insight into changing consumer intentions to adopt circularity	EU	EEE	LF
Huang et al. (2018)	LR & Multiple case studies	Methods to adopt recovery approaches and waste management	Asia	CDW	City
Kirchherr et al. (2018)	Survey	Significant insights and clustering of barriers	EU	MI	SMEs & City
Kumar and Dixit (2018)	LR & The ISM and DEMATEL	Analyzing and prioritizing significant barriers to manage e-waste and adopting reusing approach	Asia	EEE	City
Lu et al. (2018)	Mixed methodology	Analyzing and investigating e-waste management	Asia	EEE	LF
Mangla et al. (2018)	The ISM and MICMAC techniques	Clustering and identifying main barriers in India	Asia	Man	LF
Ormazabal et al. (2018)	Survey	Significant insight into barriers and drivers of adopting CE	EU	MI	SMEs
Queiroz and Telles (2018)	Survey	Understanding the barriers that firms faced in adopting circularity	SA	MI	LF, SMEs
Ranta et al. (2018)	Quantitative methodology	Significant insight into analyzing and identifying the barriers for adopting CE	WW	EEE	LF
Sousa-Zomer et al. (2018)	Case study	Identifying critical changes for firms to move toward circularity	SA	Man	NA
Whalen et al. (2018)	Multiple case studies	Analyzing barriers and opportunities to address adopting recovery approaches	EU	EEE	LF
Bhandari et al. (2019)	AHP and GTA	Prioritizing and indicating intensity degree of the barriers	WW	Man	LF
Bressanelli et al. (2019)	LR & Multiple case studies	Clustering main barriers	WW	MI	LF&SMEs
Caldera et al. (2019)	Qualitative methodology	Identifying enablers and barriers to understand the rapid contribution of SMEs in adopting circularity	WW	MI	SMEs
Agyemang et al. (2019)	Survey	Clustering barriers and drivers	Asia	Man	LF
Camacho-Otero et al. (2019)	LR& Multiple case study	Significantly insight into accepting circuitry from the perspective of customers	WW	Textile	LF
Campbell-Johnston et al. (2019)	Multiple case studies	Significant insights into barriers that hinder adopting circularity	EU	Man	City
Cole et al. (2019)	Multiple case studies	Clustering main barriers	EU	EEE	LF, SMEs, City
Fedotkina et al. (2019)	Mixed methodology	Significant insights into waste management	EU	NA	LF
Ferronato et al. (2019)	Qualitative method	Understanding main challenges in adopting circularity in cities with low-middle incomes	EU	MI	City
Gu et al. (2019)	Case study	Identifying the role of legislation management in adopting reusing approach	Asia	EEE	SMEs
Kumar et al. (2019)	Survey	Clustering barriers and opportunities	Asia	Man	LF
Lindkvist Haziri et al. (2019)	Multiple case studies	Cross-case analysis to identify barriers and methods to overcome barriers	EU	Man	LF
Milios et al. (2019)	Multiple case studies	Significant insight into understanding barriers to implement recovery approaches	EU	Man	LF
Peeters et al. (2019)	Case study & ISM	Clustering main barriers and prioritizing to adopt recycling	EU	MI	LF
Pini et al. (2019)	Multiple case studies	Understanding the impact of implementing reusing approach on adopting sustainability	EU	EEE	LF
Piyathanavong et al. (2019)	Survey	Investigating and analyzing barriers to adopt recovery approaches	Asia	Man	LF
Tura et al. (2019)	Multiple case studies	Significant insight into clustering and identifying barriers and drivers and providing managerial implications	EU	MI	LF
Vermunt et al. (2019)	Multiple case studies	Identifying and clustering key barriers for firms	EU	MI	SMEs & LF
Zhang et al. (2019)	Mixed methodology	Clustering and identifying barriers in adopting smart waste management	Asia	MI	City
Baig et al. (2020)	Multiple case studies	Clustering and identifying key barriers and firm performance to adopt sustainability and recovery approaches	India	Textile	SMEs
Bockholt et al. (2020)	Multiple case studies	Identifying and categorizing the main factors that hindered adopting recovery approaches	EU	Man	LF
Chen et al. (2020)	hybrid BWM and fuzzy TOPSIS	Clustering, analyzing, and prioritizing barriers in understanding recovery approaches	Africa	EEE	LF
Elia et al. (2020)	Multiple case studies	Identifying and clustering main barriers	WW	MI	LF
Frei et al. (2020)	Qualitative method	Identifying main barriers impacts on circular value propositions and analyzing adoption recovery approaches	EU	MI	LF
García-Quevedo et al. (2020)	Qualitative method	Significant insight into adopting reusing and remanufacturing approaches	EU	EEE	LF
Guldmann and Huulgaard (2020)	Multiple case studies	Analyzing and discussing barriers in different industries	EU	Man	SMEs & LF
Marke et al. (2020)	Survey	Significant insight into recovery approaches and clustering models to adopt circularity	Asia	EEE	LF
Mura et al. (2020)	Mixed methodology	Analyzing methods to adopt recovery approaches	EU	MI	SMEs
Nuβholz et al. (2020)	Multiple case studies	Indicating moving toward circularity is sustainable value creation	EU	CDW	LF
Rossi et al. (2020)	Mixed methodology	Developing a set of main indicators to adopt circularity in different industries	SA	EEE	LF
Singh et al. (2020)	Survey& qualitative analysis	Analyzing the significant challenges for collecting e-wastes	Asia	EEE	LF
Singhal et al. (2020)	LR& fuzzy DEMATEL	Clustering and identifying critical factors to adopt remanufacturing	Asia	Man	LF
Werning and Spinler (2020)	Multiple case studies	Clustering and prioritizing barriers.	WW	EEE	LF
Yadav et al. (2020)	LR& case study	Identifying challenges in adopting circularity and developing a framework	Asia	Man	LF

*Construction demolition waste (CDW); electronical and electronics equipment (EEE); large firm (LF); Literature review (LR); manufacturing (Man); multiple industries (MI); worldwide (WW).

1. An understanding of the relationship between the implementation of circularity and barriers.
2. Highlighting steps that the industries followed to implement circularity.
3. Representing the deficiencies that are revealed due to the barriers that are encountered.

Literature review articles are used to unify the details and knowledge needed to obtain vigorous answers. In screening the reviewed papers, we found that the literature categorized barriers based on soft and hard distinctions (de Jesus and Mendonca, 2018), hard and human-based barriers in accordance with their objective nature (Ormazabal et al., 2018), or the internal and external environment of the enterprises (Agyemang et al., 2019; Bianchini et al., 2019; Guldmann and Huulgaard, 2020), and the value chain covering (Heyes et al., 2018), and geographic areas (Sharma et al., 2019). In contrast, some papers did not make distinctions between specific barrier categories (Jaeger and Upadhyay, 2020) to prevent misunderstandings by sociology or political science readers. For instance, legislation is sometimes categorized as a soft barrier (de Jesus and Mendonca, 2018) and sometimes as a hard barrier (Ansell and Torfing, 2016). Distinguishing the characteristics of specific barriers makes it easy to analyze them and realize the drivers that impact them. Kirchherr et al. (2018), listed barriers based on contexts, such as culture, policy, economics, and technology. This paper grouped barriers into seven types based on context: (1) technology, (2) information, (3) economics and finance, (4) markets, (5) organization, (6) regulations, and (7) culture and society. Although Kirchher et al. (2018) categorized "market" and "economics and finance" barriers together, Zink and Geyer (2017) argued that separating barriers in areas related to "economics" and "markets" facilitates an understanding of the challenges of competition between new and recovered products. As seen in the Ellen MacArthur Foundation, a CE system was deployed to represent the flow of materials from consumers to collection points and from producers to consumers. However, due to the nature of economics, the CE system did not include all the markets that existed in every step of the CE process. These markets consist of EoL products, recovered products, discarded products, and even final goods (Zink and Geyer, 2017). Therefore, to conduct a comprehensive study, market barrier is independent from economics and finance.

The first barrier, technology, is presented in six sub-barriers to indicate elements linked through a lack of technology. The second barrier includes information, knowledge, and skills. Through eight sub-barriers, this barrier is concerned with data and integrating data to understand how to use it. The third barrier is related to financial and economic factors, such as the cost of adopting circularity. The fourth barrier is the market characteristics and challenges that currently hinder the implementation of a feasible market for recovered products. The fifth barrier is focused on organizations. The sixth is in line with regulations and governments. This barrier indicates the role of the absence of government support. The seventh barrier refers to the challenges that society might cause or face in adopting circularity.

2.4. Material evaluation

The defined structural dimensions are deployed to assess the material and identify the relevancy and interpretation of the outputs. This stage led us to obtain a level of reliability and validity, which the authors checked. The classifications were built using deductive and inductive approaches. The initial measurement was classifying manuscripts by the authors and then matching these articles to establish unanimity. The authors increased the reliability of the research using Web of Science, a comprehensive academic database (Neuendorf, 2016).

Table 2 presents the main characteristics of the studied empirical papers. The first column of the table shows the references to the papers. The second column describes the methodology deployed in the articles to construct the research. The third column highlights the main contributions of each paper. The fourth column notes continents. If a study included cases from more than two continents, it is referred to as WW. The fifth column shows industries. A few articles considered several industries, such as manufacturing and EEE, which are denoted as multiple industries. The last column shows the size of the organizations for which the articles studied barriers.

3. Results

This section discusses the output of the SLR, which concentrated on barriers to CSC adoption from the perspective of 3R approaches. As the first step, we answered the first question through an inductive classification of the barriers in seven subsections. Subsections 3.1.1 to 3.1.7 represent the barriers by introducing the sub-barriers in seven tables. Each row of the tables outlines a sub-barrier, the name of the sub-barrier, its description, and the references in which we identified these obstacles. Subsection 3.2 introduces the results of barriers from the perspectives of 3R approaches, industries, and organization size.

3.1. Barriers

3.1.1. Barrier 1: Technology

In the literature, the technological barrier includes obstacles to implementing circularity at the corporate level. The challenges are represented in relation to compatibility with circular design (T1), quality assessment and control of EoL products (T2), tracking take-back

Table 3
Categorization of the technology barriers (Barrier 1).

Technology		Description	Articles
T1	Compatible technology	Technology to (1) design recoverable products and (2) facilitate the design of products with more prolonged use life.	(Bhandari et al., 2019; Campbell-Johnston et al., 2019; de Jesus and Mendonca, 2018; Fedotkina et al., 2019; Hobson et al., 2018; Kinnunen and Kaksonen, 2019; Lindkvist Haziri et al., 2019; Mont et al., 2017; Ormazabal et al., 2018; Singhal et al., 2020; Werning and Spinler, 2020; Whalen et al., 2018)
T2	Quality assessment and control	Technology to assess the quality or control the condition of EoL products.	(Ghisellini et al., 2018; Govindan and Hasanagic, 2018; Hazen et al., 2017; Mashhadi and Behdad, 2017; Nuβholz et al., 2020; Werning and Spinler, 2020)
T3	Tracking take-back initiatives	Tracking (1) the take-back process of EoL products and (2) the in-process recovery step.	Ranta et al. (2018)
T4	Lack of mature technology for adopting a recovery approach	Mature technology makes it profitable to recover EoL products.	(Campbell-Johnston et al., 2019; de Jesus and Mendonca, 2018; Fedotkina et al., 2019; Frei et al., 2020; Gupta et al., 2020; Kinnunen and Kaksonen, 2019; Ormazabal et al., 2018; Piyathanavong et al., 2019)
T5	Sorting and collecting EoL products	Technology to (1) collect EoL products and (2) sort valuable waste during take-back initiatives.	(Fedotkina et al., 2019; Ferronato et al., 2019; Kinnunen and Kaksonen, 2019; V Kumar et al., 2019; Lindkvist Haziri et al., 2019; Mashhadi and Behdad, 2017; Padmanathan et al., 2019; Werning and Spinler, 2020)
T6	Mature technology for integrating data	Technology for integrating data and communications between the departments in firms.	(Campbell-Johnston et al., 2019; Lindkvist Haziri et al., 2019)

Table 4
Categorization of the information, knowledge, and skill barriers (Barrier 2).

Information, knowledge, and skills		Description	Articles
I1	Integrating data between entities.	The lack of knowledge and skills to create reliable channels, integrate data, or communicate between entities.	(Campbell-Johnston et al., 2019; Gupta et al., 2020; Kinnunen and Kaksonen, 2019; Lindkvist Haziri et al., 2019)
I2	Information about life use conditions	Inadequate knowledge of or information about a product's life cycle conditions limit EoL products' quality assessments. This barrier impacts take-back initiatives, such as developing adopted recovery approaches.	(Bhandari et al., 2019; Caldera et al., 2019; Campbell-Johnston et al., 2019; Gåvertsson et al., 2020; Mashhadi et al., 2019; Nuβholz et al., 2020; Singhal et al., 2020; Vermunt et al., 2019)
I3	Adopting a recovery approach	The lack of skills or practical knowledge (know-how) for adopting any recovery approach is a challenge that appears once the company focuses on operational activities rather than adopting recovery approaches.	(Caldera et al., 2019; Kinnunen and Kaksonen, 2019; Lindkvist Haziri et al., 2019; Ormazabal et al., 2018; Piyathanavong et al., 2019)
I4	Training workforces	The ability to (1) implement a recovery approach and (2) promote an upper-level recovery approach.	(Agyemang et al., 2019 Mura et al., 2020; Bhandari et al., 2019; Chamberlin and Boks, 2018; de Jesus and Mendonca, 2018; Ferronato et al., 2019; García-Quevedo et al., 2020; Milios et al., 2019; Mura et al., 2020; Piyathanavong et al., 2019; Whalen et al., 2018)
I5	Public sector education	Educating the public sector and understanding consumers' behaviors is challenging.	(Camacho-Otero et al., 2019; de Oliveira et al., 2019; Kumar and Dixit, 2018; Lieder et al., 2017; Lindkvist Haziri et al., 2019; Longo et al., 2019; Millette et al., 2020; Piyathanavong et al., 2019)
I6	Standards	The lack of information to provide standards limits the need to design a recoverable product or realize the necessity of recovering an EoL product.	(Huang et al., 2018; Lindkvist Haziri et al., 2019; Marke et al., 2020; Mura et al., 2020)
I7	Reliable information	Sharing information or providing reliable information about EoL products or recovered products between supply chain sectors curbs the ability to adopt circularity or accelerate its implementation.	(Agyemang et al., 2019; Ghisellini et al., 2018; Kinnunen and Kaksonen, 2019; Lindkvist Haziri et al., 2019; Ormazabal et al., 2018; Werning and Spinler, 2020; Yuan, 2017)
I8	Using feedback	A lack of feedback or difficulties using feedback inside an organization or firm impacts the adoption of circularity. These effects can be seen in designing a recoverable product or adopting circularity at the firm level.	(Bendul et al., 2017; Lindkvist Haziri et al., 2019; Marke et al., 2020)

initiatives (T3), well-developed technology (T4), sorting and collecting EoL products (T5), and collecting and integrating data (T6) (see Table 3).

3.1.2. Barrier 2: Information, knowledge, and skills

This barrier is comprised of obstacles that the literature identified in firms, supply chains, and governments. Both scholars and practitioners mentioned that information, knowledge, and skills are among the most prominent barriers, regardless of industry (Koutamanis et al., 2018). The obstacles of a reliable information system in supply chains (I1, I6, and I7), know-how to adopt or train the recovery approaches at the firm level (I2, I3, I4, and I8), and educating members of a society (I5) determine the presence of the obstacles that hamper circularity at all levels of a value chain (see Table 4).

3.1.3. Barrier 3: Economic and financial factors

The third barrier, economic and financial factors, identifies the limitations of adopting or continuing circularity, regardless of a partner's role in value chains (see Table 5). The risks of considering a circular business model include the difficulties of implementing circularity (E1 and E2) and the difficulties of continuing circularity (E3, E4, and E5). Some studies asserted that an enterprise dominated by the linear economy model hesitates to change the business model, except for startups founded on circular models. Two barriers in the literature are mentioned as being substantial: low incentives for investments and insufficient financial resources. Furthermore, Delmonico et al. (2018) maintained that the lack of a long-term vision for investors is a significant barrier to circularity. Sauvé et al. (2016) argued producers and consumers have low incentives to shift to a circular model because they

Table 5
Categorization of the economic and financial barriers (Barrier 3).

Economics and finance		Description	Articles
E1	Source/capability and incentive to invest	A lack of sufficient financial resources, intention to invest, and low priority to invest hamper circularity.	(Baig et al., 2020; Bhandari et al., 2019; Bockholt et al., 2020; Caldera et al., 2019; Campbell-Johnston et al., 2019; de Jesus and Mendonca, 2018; Ferronato et al., 2019; García-Quevedo et al., 2020; Jia et al., 2020; Mura et al., 2020; Ormazabal et al., 2018; Pini et al., 2019; Piyathanavong et al., 2019; Werning and Spinler, 2020; Whalen et al., 2018)
E2	Risk of low profits and long time to pass the break-even point	Passing the break-even point takes time, and the risk of low profits prevents investors.	(Baig et al., 2020; Bhandari et al., 2019; Caldera et al., 2019; Campbell-Johnston et al., 2019; Chen et al., 2020; de Jesus and Mendonca, 2018; Elia et al., 2020; Ferronato et al., 2019; Frei et al., 2020; García-Quevedo et al., 2020; Guldmann and Huulgaard, 2020; Jia et al., 2020; Marke et al., 2020; Mura et al., 2020; Ormazabal et al., 2018; Werning and Spinler, 2020; Whalen et al., 2018; Yadav et al., 2020)
E3	Cost of circularity	The cost of adopting circularity at different steps and parts of the process: (1) implementing a recovery approach, (2) continuing the recovery approach, (3) reverse logistics, and (4) small facilities or an insufficient number of facilities.	(Baig et al., 2020; Cole et al., 2019; de Oliveira et al., 2019; Frei et al., 2020; Ghisellini et al., 2018; Gupta et al., 2020; Kinnunen and Kaksonen, 2019; Lieder et al., 2017; Marke et al., 2020; Mura et al., 2020; Sousa-Zomer et al., 2018; Werning and Spinler, 2020; Whalen et al., 2018; Zayed and Yaseen, 2020)
E4	Final price of a recovered product	(1) The price of a new product is more economical (cheaper) than a recovered product. (2) The final price of recovered value with a less green approach is also cheaper than the greener approach.	(Baig et al., 2020; Cole et al., 2019; Gu et al., 2019; Jia et al., 2020; Marke et al., 2020; Queiroz and Telles, 2018; Sirilertsuwan et al., 2019; Whalen et al., 2018)
E5	The low cost penalties and surcharges	The low cost of landfilling discourages companies or end-users from switching to recovering any EoL products.	(Huang et al., 2018; Whalen et al., 2018)

Table 6
Categorization of market barriers (Barrier 4).

Market		Description	Articles
M1	Take-back challenges from other companies	The absence of a collection system and infrastructures to take back EoL products through reliable networks/formal sectors create the low level of core availability.	(de Oliveira et al., 2019; Fedotkina et al., 2019; García-Quevedo et al., 2020; Ghisellini et al., 2018; Hobson et al., 2018; Huang et al., 2018; Lindkvist Haziri et al., 2019; Milios et al., 2019)
M2	Standards for recovered products	The lack of standards in the market and between markets shows differences in willingness to circularity among various geographical regions.	(Cole et al., 2019; Fedotkina et al., 2019; Gåvertsson et al., 2018; Huang et al., 2018; Kumar and Dixit, 2018; Lindkvist Haziri et al., 2019; Nuβholz et al., 2020)
M3	Price gaps between the authorized and unauthorized market	Different prices for formal and informal collectors of EoL products impact on the availability levels of cores.	(Cole et al., 2019; de Oliveira et al., 2019; Ranta et al., 2018)
M4	The structured market for selling recovered EoL	An inadequately organized market to create an infrastructure for competing recovered EoL products with new products prevents CE implementation.	(Cole et al., 2019; de Jesus and Mendonca, 2018; Fedotkina et al., 2019; Frei et al., 2020; Werning and Spinler, 2020)
M5	Unpredictable supply and demand	Supply chain actors cannot collaborate to take back EoL products in different geographical areas.	(Cole et al., 2019; de Jesus and Mendonca, 2018; Frei et al., 2020; Marke et al., 2020; Werning and Spinler, 2020)
M6	Location of markets and consumers	The ability of different supply chain sectors to collaborate to take back EoL products fulfill core demand and provide services to customers.	Lindkvist Haziri et al. (2019)
M7	Brand issues and reputation	The recovered products and components can damage manufacturer's brand and reputation.	(Cole et al., 2019; Frei et al., 2020; Werning and Spinler, 2020)
M8	After-sale supports and lower lifecycle time	The lack of support for the after-sale of recovered products and the low reliability of a product's lifetime reduces the passion for any recovery approach and/or willingness to purchase.	(Cole et al., 2019; Frei et al., 2020)

do not meet environmental costs, the costs of using new resources, and energy costs. The cost of implementing circular strategies is a crucial concern that impacts a company's behavior. The literature emphasized the cost of several sub-groups, such as the costs of the take-back process and the lower price of virgin materials (Liu and Bai, 2014).

3.1.4. Barrier 4: Market

This section discusses the difficulties from the perspective of different types of markets and the feasibility requirements of the models (see Table 6). The obstacles—reasonable market values (M2 and M3), market structure (M1, M4, M5, and M6), and marketing strategies (M7 and M8)—are perceived by customers, enterprises, and supply chain parties.

3.1.5. Barrier 5: Organization

This barrier highlights challenges from the standpoint of organizational structure, strategies, and the harmonization of organizations with their supply chains (see Table 7). The organizational structure and strategies include challenges in terms of organizational leadership (O2 and O3), corporate operation, process, and asset (O5 and O7), organizational strategies (O6), and organizational harmonization with other parties (O1, O3, and O4).

3.1.6. Barrier 6: Government and regulations

The government and regulation barrier refers to the involvement of governments in policies that support and encourage different parties to move toward adopting circularity. A lack of rules and support is viewed through the lens of customers, enterprises, and supply chain partners (see Table 8).

Table 7
Categorization of the organizational barriers (Barrier 5).

Organization		Description	Articles
O1	Leadership and management	A lack of harmonized leadership/management among members of the value chain prevents successful side-stream utilization. It affects the public sector and supply chain partners.	(Bhandari et al., 2019; Frei et al., 2020; Huang et al., 2018; Huybrechts et al., 2018; Kinnunen and Kaksonen, 2019; Kumar et al., 2019; Ormazabal et al., 2018; Piyathanavong et al., 2019; Whalen et al., 2018)
O2	Priority of the organization	Having a higher priority in an organization or a strong anti-circularity culture prevents managers from moving toward adopting circularity.	(Frei et al., 2020; Kinnunen and Kaksonen, 2019; Kirchherr et al., 2018; Kissling et al., 2013; Lindkvist Haziri et al., 2019; Ranta et al., 2018; Whalen et al., 2018)
O3	Reliability along the supply chain	The absence of equal interests and reliability among the supply chain sectors, different departments, and stakeholders.	(de Jesus and Mendonca, 2018; Frei et al., 2020; Ghisellini et al., 2018; Marke et al., 2020; van Buren et al., 2016; Whalen et al., 2018)
O4	Simultaneous transition	Simultaneously commencing and cooperating along the entire supply chain is crucial to initiating and advancing take-back initiatives. All supply chain partners must show interest; otherwise, a firm cannot last for long.	(Frei et al., 2020; Karaman et al., 2020; Kinnunen and Kaksonen, 2019)
O5	Structure or communication methods	The lack of a robust method or infrastructure to communicate with or exchange feedback between internal or external departments influences take-back processes or redesign the products.	(Kinnunen and Kaksonen, 2019; Lindkvist Haziri et al., 2019; Werning and Spinler, 2020; Whalen et al., 2018)
O6	Reluctancy	While an enterprise may have the essential factors for implementing circularity, reluctance by any party or prioritizing other operations limits circularity.	(Cole et al., 2019; Frei et al., 2020; Kinnunen and Kaksonen, 2019; Piyathanavong et al., 2019; Ranta et al., 2018)
O7	Resource capacity	A lack of resources and capabilities at different levels, from the workforce to top managers.	(García-Quevedo et al., 2020; Kinnunen and Kaksonen, 2019; Piyathanavong et al., 2019)

Table 8
Categorization of the government and regulation barriers (Barrier 6).

Governments and regulations		Description	Articles
G1	Supportive regulations	An absence of regulations to support take-back initiatives along the value chain, such as reduced taxes.	(Caldera et al., 2019; Campbell-Johnston et al., 2019; de Jesus and Mendonca, 2018; de Oliveira et al., 2019; Frei et al., 2020; García-Quevedo et al., 2020; Huybrechts et al., 2018; Kinnunen and Kaksonen, 2019; Kumar et al., 2019; Mura et al., 2020; Nuβholz et al., 2020; Piyathanavong et al., 2019; Ranta et al., 2018; Singh et al., 2020; Su et al., 2013; Werning and Spinler, 2020; Whalen et al., 2018; Yuan, 2017)
G2	Legislating rules to define indicators and the evaluation system	A lack of effort to legislate standard systems or evaluation systems.	(Bockholt et al., 2019; Caldera et al., 2019; de Jesus and Mendonca, 2018; García-Quevedo et al., 2020; Ghisellini et al., 2018; Huybrechts et al., 2018; Kinnunen and Kaksonen, 2019; Mura et al., 2020; Ormazabal et al., 2018; Singh et al., 2020)
G3	Policy to drive society and evaluate its partnership	A lack of policy to direct the public's ecological accountability or evaluate a community's responsibility.	(Cole et al., 2019; de Jesus and Mendonca, 2018; Fedotkina et al., 2019; Frei et al., 2020; Huang et al., 2018; Ormazabal et al., 2018; Piyathanavong et al., 2019; Ranta et al., 2018; Whalen et al., 2018)
G4	Integrity between governments and management systems in a country or a region	An absence of frameworks to configure different members of governments and management systems.	(de Jesus and Mendonca, 2018; Huybrechts et al., 2018)
G5	A lack of adopting circularity	Governments and regulators do not trust the final quality of the recovered products.	(Ghisellini et al., 2018; Ranta et al., 2018; Whalen et al., 2018)
G6	The wrong focus of regulation	A lack of rules, including all 3R approaches, instead of focusing on a more green alternative, such as reusing and remanufacturing.	(Ranta et al., 2018)

Table 9
Categorization of the society and culture barriers (Barrier 7).

Society and culture		Description	Articles
S1	Consumers' unwillingness to choose recovered products	Consumers are concerned about the reliability, repair costs, and life span of a recovered product.	(Martin Agyemang et al., 2019; Campbell-Johnston et al., 2019; Chamberlin and Boks, 2018; Cole et al., 2019; de Jesus and Mendonca, 2018; Fedotkina et al., 2019; Gåvertsson et al., 2020; Ghisellini et al., 2018; Guo et al., 2017; Hobson et al., 2018; Kumar et al., 2019; Nohra et al., 2020; Ranta et al., 2018; Rossi et al., 2020; Singhal et al., 2020; Tecchio et al., 2017; Tura et al., 2019; Van Weelden et al., 2016; Whalen et al., 2018)
S2	Price sensitivity	Creates different preferences regarding the quality level of a product.	(Caldera et al., 2019; Cole et al., 2019; Gåvertsson et al., 2020; Hobson et al., 2018; Marke et al., 2020; Whalen et al., 2018)
S3	Security and reliability to return the EoL product	The lack of standards to secure consumers' ability to recover and delete personal information and data.	(Caldera et al., 2019; Cole et al., 2019; Gåvertsson et al., 2020; Hobson et al., 2018; Marke et al., 2020; Werning and Spinler, 2020; Whalen et al., 2018)
S4	Public education, awareness, and any social norms	The absence of social norms, awareness, and education makes it challenging to persuade people to act in an environmentally responsible way.	(Campbell-Johnston et al., 2019; Cole et al., 2019; de Oliveira et al., 2019; Fedotkina et al., 2019; Frei et al., 2020; Guo et al., 2017; Hobson et al., 2018; Kumar et al., 2019; Lu et al., 2015; Ormazabal et al., 2018; Piyathanavong et al., 2019; Ranta et al., 2018; Whalen et al., 2018)

3.1.7. Barrier 7: Society and culture

Given the lack of green awareness and intention to purchase recovered products, as well as inadequate information regarding the quality level of reused-type products, consumers show no tendency to substitute new products for "like-new" products (Gåvertsson et al., 2020). Consumer unwillingness (S1), price sensitivity (S2), reliability to turn back (S3), and public education (S4) are the obstacles highlighted in the literature from customers' perspectives (see Table 9).

3.2. Most frequent barriers in terms of recovery approach

This subsection presents barriers from the perspectives of 3R approaches, industries, and firm size. Fig. 8 represents the frequency of the seven barrier categories based on the findings. The three most common barrier categories are economics and finance (n = 60 mentions), government and regulations (n = 50 mentions), and society and culture (n = 49 mentions). Fig. 9 depicts the frequency of barriers from the perspective of the recovery approaches. This data establishes a meaningful link between frequency barriers and their impact on specific approaches. The analysis presents the observations of barriers in each recovery approach.

In terms of the observed sub-barriers (Fig. 10), "lack of supportive regulations" (G1), "unwillingness of consumers" (S1), and "cost of adopting 3R approaches" (E3) represented the most common challenges to implementing recovery approaches. C1 in Fig. 10 indicates that the "unwillingness of consumers" (S1) frequently hampered 3R approaches, particularly reusing. C2 highlights the frequency of a "lack of supportive regulations" (G1), especially in recycling. G1 affects many industries and not only impedes the recycling approach's adoption, but also hampers firms from improving current recovery approaches. C3, in turn, shows that the frequency of the "cost of adopting approaches" (E3) exceeds the frequency of both "lack of investment resources" (E1) and "low profit" (E2).

The fourth and fifth most frequent barrier categories include "information, knowledge, and skills" and "technology" (n = 44 and 40 mentions, respectively). As shown in Fig. 10, C4 and C5, "the lack of knowledge" (I3) and "lack of mature technology for adopting a recovery approach" (T4), were commonly observed in the reuse approach. Some researchers have argued that barriers related to knowledge, such as I3, impact the cost of circularity adoption and the rate of recovery of EoL products (Guldmann and Huulgaard, 2020; Kirchherr et al., 2018). The least frequent barrier categories include "market" and "organization" barriers (n = 34 and 38 mentions, respectively). C6 and C7 show that "the structured market" (M4) and "reluctancy" (O6) were commonly observed sub-barriers. M4 frequently hampered the remanufacturing approach. The low profit margin of remanufactured products and

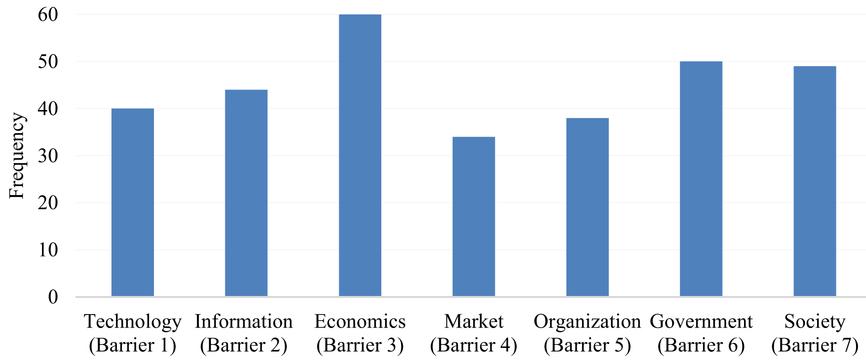

Fig. 8. Frequency of seven groups of barriers.

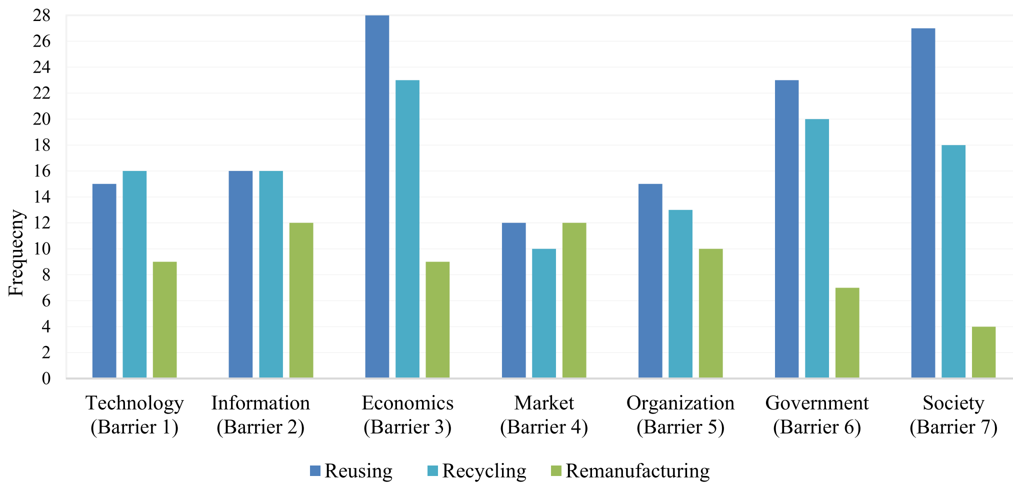

Fig. 9. Frequency of barriers from the perspective of 3R approaches.

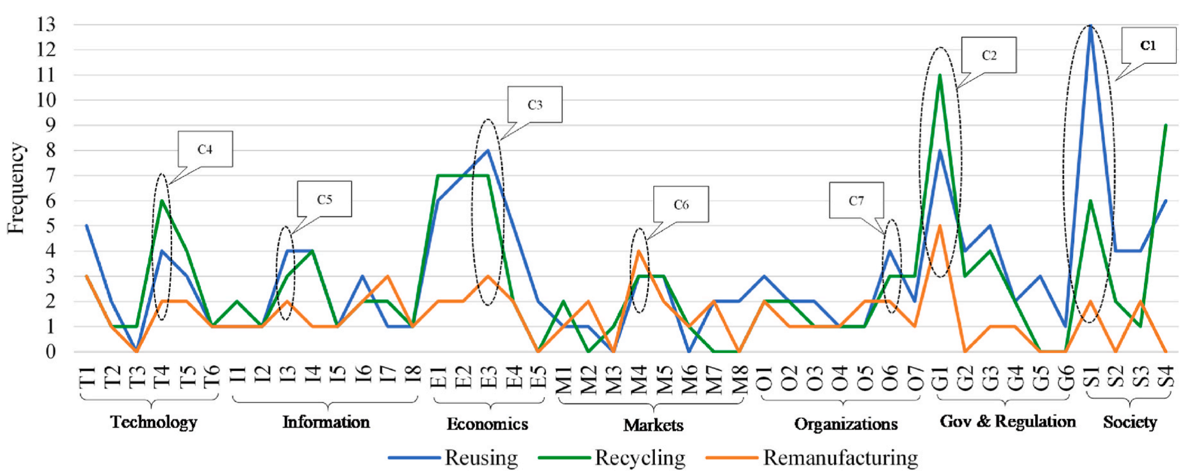

Fig. 10. Frequency of barriers in-depth (at the sub-barrier level) from the perspective of the 3R approaches.

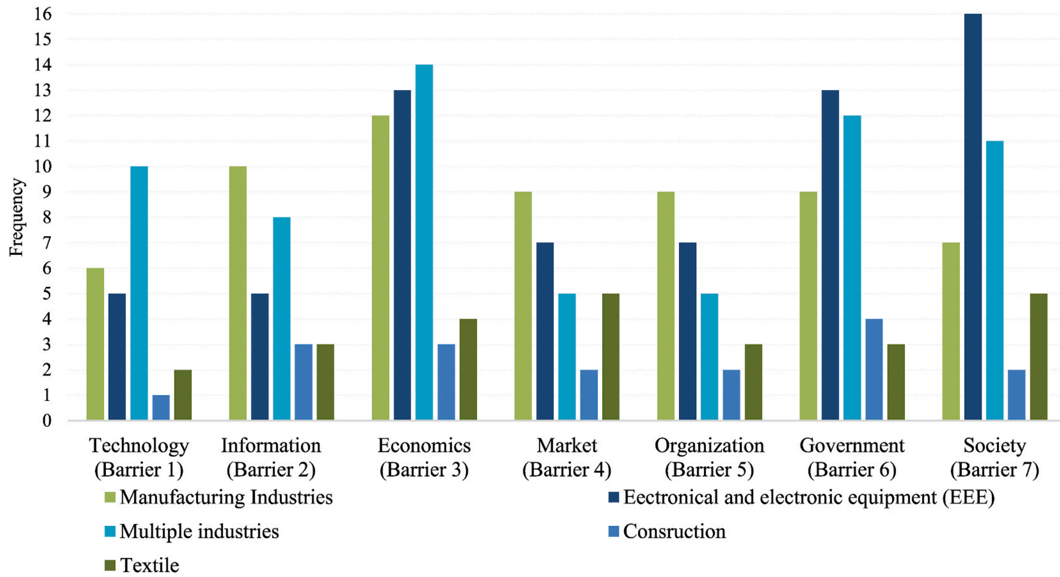

Fig. 11. Frequency of barriers from the perspective of industrial sectors.

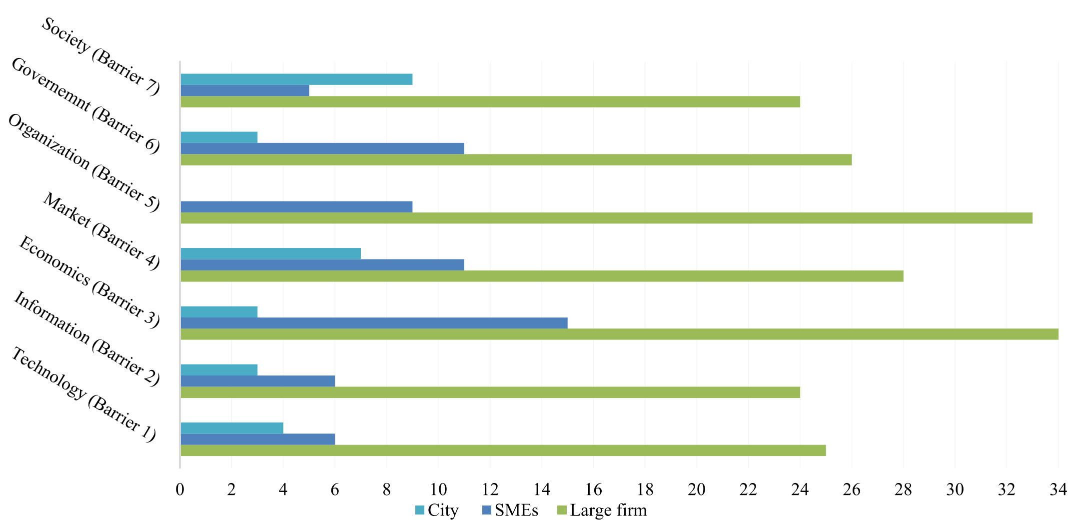

Fig. 12. Frequency of barriers by organization size.

cannibalization are challenges that make firms apathetic toward remanufacturing (Frei et al., 2020; Lindkvist Haziri et al., 2019).

Classifying barriers by industry and organization size also enhanced understanding of occurring barriers for practitioners and scholars. Fig. 11 shows a somewhat even distribution of the observed barriers in different industries. It shows that the industrial sectors all realized the advantages of implementing recovery approaches. The manufacturing and (EEE) industries observed societal, government, and economics-related barriers. "Multiple industries" indicate different industries that have been explored in the literature, including manufacturing, EEE, construction, and textiles. Fig. 12 shows the frequency of barriers according to organization size. The case studies were mostly large firms, which is reflected in the high number of barriers observed, especially in the economics, organization, and market categories.

4. Discussion

In the previous section, we identified and distinguished the most frequently occurring barriers to implementing 3R approaches in practice. It helps businesses transition from a linear supply chain to a circular one. The findings are discussed practically and theoretically in the following subsections, and future directions are explained.

4.1. Practical implications

Among the seven identified categories of barriers, "economics and finance," "government and regulations," and "society and culture" are most frequently identified in the literature. From practitioners' viewpoints, these barriers have several implications and require multilevel actions involving societal, industrial, corporate, and individual actors

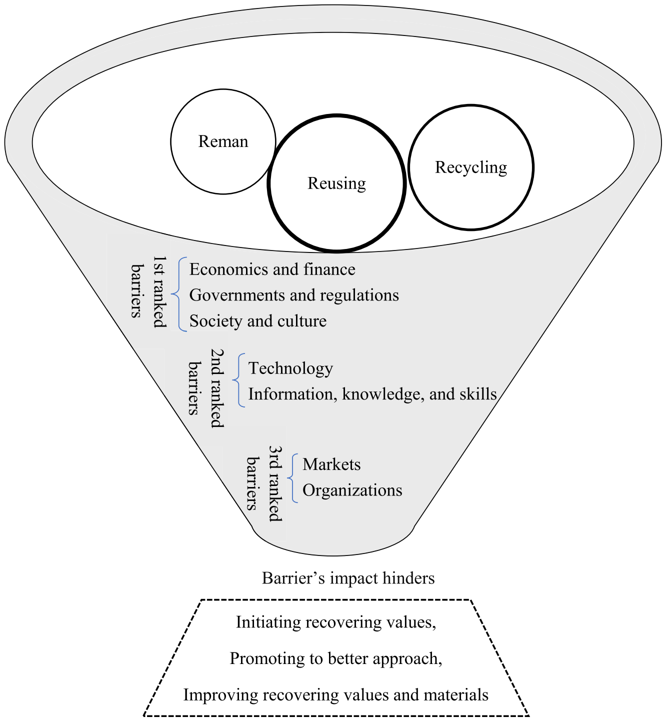

Fig. 13. A comprehensive framework to show the main impact of barriers on adopting 3R approaches.

and should, therefore, be considered from a systemic perspective. The funnel in Fig. 13 represents the influence of the seven barrier categories on implementing the 3R recovery approaches. It highlights three significant impacts of all barriers. The first three barriers hamper approaches at an early stage and primarily block companies from adopting CSC at scale. The firms discussed in the literature never achieved the final execution stage and usually faced challenges in earlier stages. The more we go into the deep, the less the companies confront operational and market-oriented barriers. Thus, although other barriers can also have impeding impacts, as first-ranked ones do, they are less frequent. The framework underlines that initial transitions toward a mature CSC demand economic drivers, regulation, and cultural developments (de Jesus and Mendonca, 2018; Kirchherr et al., 2018). It also suggests that overcoming second- and third-ranked barriers to a larger extent will enable firms to accelerate, scale, and reach higher circular maturity levels.

Economics and finance barriers involve firms' concerns about initiating circularity, including, for example, long-term investments, the cost of implementing recovery approaches, and the price of a new product compared to a recovered one. From an economic point of view, remanufacturing hinges on using the labor-extensive manual disassembly process (Alliance, 2018). Therefore, this approach is not economically viable for firms, as it is a long-term investment in an expensive process. Risks such as cannibalization and market structure also disincentivize firms from remanufacturing (Liu et al., 2018). Additionally, large firms often perform in different locations, which is challenging for remanufacturing (Rönkkö et al., 2021). Based on the findings, reusing and recycling are often impacted by economic barriers. These approaches are challenged once firms decide to start implementation. "Incentive to invest," "low profit," and "cost of circularity" are frequently occurring difficulties.

Studying rule and governmental regulation barriers reveals that legislation is required to expedite the circular process. With supportive regulation and standards, the risk of low profits in circular initiatives decreases, organizations become more willing to adopt CSC, and customers find recovered products reliable. The findings asserted that implementing recycling and waste management is hampered by government rules and regulations, which is further exacerbated by a lack of supportive and effective regulation (de Jesus and Mendonca, 2018; Ferronato et al., 2020). Although legislation should support circular processes, legal inconsistencies should still be modified. These inconsistencies affect not only recycling but also other approaches. They make recycling and waste management complex and prevent the use of optimal approaches. Other complexities include management systems, information sharing, and technology deployment. Using an optimal approach includes a firm's decision to switch from recycling to reusing or remanufacturing. For instance, reusing EoL products in the EEE industry is more appropriate for the environment than recycling. However, researchers have argued that many firms are reluctant to transition from recycling to reusing without supportive regulations (Lu et al., 2018; Ziout et al., 2014). Therefore, governments and regulators should consider designing and implementing friendlier policies and rules for all recovery approaches. Revising tax regulations and rules for transporting EoL products (Ghisellini et al., 2016; Bockholt et al., 2020) to motivate remanufacturing is necessary.

Social and cultural barriers mainly comprise a lack of consumer willingness to purchase and trust recovered products. At the sub-barrier analysis level, consumers' unwillingness highlights that adopting 3R recovery approaches depends not only on industries but also on consumer actions. For instance, industries such as EEE and manufacturing can adopt reusing when consumers' preferences switch from new products to recovered ones (Hazen et al., 2017), or at least when consumers consider the performance of a high-quality remanufactured product as equal to a new product. This study identified other society and culture-related elements that hinder potentials, such as price sensitivity, product life span, and reliability. In Fig. 10, consumer unwillingness is positioned at center stage for implementing reusing; therefore, influencing consumers toward circularity and demonstrating the advantages of reuse is necessary. Reuse prolongs products' life cycles, and focusing on this approach extends advantages to the environment and society. In this regard, promoting a reward mechanism to incentivize consumers and change cultural traditions is essential.

4.2. Theoretical implications

Our study provides findings that help comprehensively and systemically understand CSC barriers to specific recovery approaches. In theory, studies have utilized qualitative or hybrid methods to analyze and prioritize the barriers and determine the factors that influence the adoption of circularity. It makes sense due to the pre-paradigmatic nature of the conceptual foundations. The problem's multi-level and systemic nature makes it a complex research object. Indeed, implementing circularity is realizable once we create meaningful linkages between theories and practices (Lahti et al., 2018). Relying on the frequency of the observed barriers, we identified the absence of a comprehensive contingency for testing and developing theory in the empirical interpositions through the articles. The outcomes of empirical studies ought to drive and apprise efforts to construct, improve, or refuse theoretical advancements. The essential research implication is the need for systemic and multi-level research because there are so many factors involved in studying circular systems, and we lack an understanding of their interactions and interdependencies. We suggest that there may exist a pattern in which some barriers are more prominent at some stages of the evolution toward circularity than at others.

This research also contributes to a more holistic understanding of the relationship between barriers and firm size. Scholars have stated that investigating firm size enhances the CE mindset (De los Rios and Charnley, 2017; Primc et al., 2020). Our findings demonstrate that most of the identified challenges for large firms come from "economic" and "organization" barriers. It is also clear that large firms understand the advantages of implementing circularity, including cost reductions arising from recovering values of EoL products, effectively deploying environmental regulations, and growing market share of recovered products (Bassi and Dias, 2019; Demirel and Danisman, 2019). The institutional setting of large firms, the public eye, customers, regulators, and industrial boards create more pressure on top managers and consequently provide more intensive environmental practices. At the "organization" sub-barrier level, large firms faced many barriers to adopting reuse and recycling approaches.

4.3. Future research

Well-executed theories measure circularity implementation and highlight pathways for implementing recovery approaches. This paper's findings point out the lack of bridging between the theory and practice of implementing recovery approaches. Therefore, future research can deploy theoretical lenses to examining barriers from the perspective of implementing highest possible recovering values approaches such as reusing and remanufacturing or distinguishing people's behaviors in participation at the end of a product's use life. The low frequency of empirical studies related to identifying barriers of approaches, such as remanufacturing, provides evidence of the capacities for knowledge development for scholars. Analytical studies associated with economies of scale and horizontal implementation across supply chains and industries are other areas for future research. In this regard, deeper analysis is required to justify why innovative circular ideas are still immature and to create appealing economic and environmental values for practitioners. In this context, future research can be built on a comparison of revealing barriers and their impacts on value chains once a firm operates manufacturing and remanufacturing at different locations. It is also desirable for future experimental studies to analyze barriers in value chains by investigating the impacts of barriers on transitioning linear business models to circularity models. Concerning categorization, identifying and clustering barriers not only at the operational level but also at the strategic and tactical levels should be interesting. Moreover, future research can underline the role of regulations in creating a business environment for firms that have already initiated recovery approaches at small scales and seek to transition from early to mature stages. Finally, research requires steps to determine consumer participation at the end of the product's life cycle, including improving reliability, defining standards, and embracing circularity.

5. Conclusion

This study classified the barriers to moving towards a CSC based on recovery approaches. An SLR was used to understand the barriers that impede a circularity implementation in supply chains, how the barriers can be classified, and to derive the most frequent barriers regarding the 3R recovery approaches. The study examined the full text of 68 articles to answer the formulated research questions. The authors identified that after 2017, the publication trend in this area increased significantly. We classified the barriers into seven groups, and we investigated the effects of 44 sub-barriers on three recovery approaches: reusing, remanufacturing, and recycling. The results demonstrate that barriers classified as "economics," "governments and regulations," and "society and culture" were the most common that were observed in the studies. Regarding recovery approaches, consumer willingness to purchase recovered products primarily impacts the reuse approach, lack of supportive regulations impacts recycling, and the lack of support in the market impacts the ability to adopt remanufacturing.

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Declaration of competing interest

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References

Agyemang, M., Kusi-Sarpong, S., Khan, S.A., Mani, V., Rehman, S.T., Kusi-Sarpong, H., 2019. Drivers and barriers to circular economy implementation an explorative study in Pakistan's automobile industry. Manag. Decis. 57, 971–994.
Ahi, P., Searcy, C., 2015. An analysis of metrics used to measure performance in green and sustainable supply chains. J. Clean. Prod. 86, 360–377.
Akhlamadi, G., Goharshadi, E.K., 2021. Sustainable and superhydrophobic cellulose nanocrystal-based aerogel derived from waste tissue paper as a sorbent for efficient oil/water separation. Process Saf. Environ. Protect. 154, 155–167.
Akhlamadi, G., Goharshadi, E.K., Saghir, S.V., 2021. Extraction of cellulose nanocrystals and fabrication of high alumina refractory bricks using pencil chips as a waste biomass source. Ceram. Int. 47 (19), 27042–27049.
Alliance, G., 2018. Less in, More Out: Using Resource Efficiency to Cut Carbon and Benefit the Economy. London, UK.
Aminoff, A., Kettunen, O., 2016. Sustainable supply chain management in a circular economy—towards supply circles. In: International Conference on Sustainable Design and Manufacturing. Springer, pp. 61–72.
Andersen, M.S., 2007. An introductory note on the environmental economics of the circular economy. Sustain. Sci. 2, 133–140.
Annarelli, A., Battistella, C., Nonino, F., 2016. Product service system: a conceptual framework from a systematic review. J. Clean. Prod. 139, 1011–1032.
Ansell, C., Torfing, J., 2016. Handbook on Theories of Governance. Edward Elgar Publishing.
Baig, S.A., Abrar, M., Batool, A., Hashim, M., Shabbir, R., 2020. Barriers to the adoption of sustainable supply chain management practices: moderating role of firm size. Cogent Bus. Manag. 7, 1841525.
Bassi, F., Dias, J.G., 2019. The use of circular economy practices in SMEs across the EU. Resour. Conserv. Recycl. 146, 523–533.
Batista, L., Bourlakis, M., Smart, P., Maull, R., 2018. In search of a circular supply chain archetype–a content-analysis-based literature review. Prod. Plann. Control 29, 438–451.
Bendul, J.C., Rosca, E., Pivovarova, D., 2017. Sustainable supply chain models for base of the pyramid. J. Clean. Prod. 162, S107–S120.
Bhandari, D., Singh, R.K., Garg, S.K., 2019. Prioritisation and evaluation of barriers intensity for implementation of cleaner technologies: framework for sustainable production. Resour. Conserv. Recycl. 146, 156–167.
Bianchini, A., Rossi, J., Pellegrini, M., 2019. Overcoming the main barriers of circular economy implementation through a new visualization tool for circular business models. Sustainability 11, 6614.
Bjørnbet, M.M., Skaar, C., Fet, A.M., Schulte, K.Ø., 2021. Circular economy in manufacturing companies: a review of case study literature. J. Clean. Prod. 126268.
Bockholt, M.T., Hemdrup Kristensen, J., Colli, M., Meulengracht Jensen, P., Vejrum Wæhrens, B., 2020. Exploring factors affecting the financial performance of end-of-life take-back program in a discrete manufacturing context. J. Clean. Prod. 258, 120916.
Bockholt, M.T., Kristensen, J.H., Wæhrens, B.V., Evans, S., 2019. Learning from the nature: enabling the transition towards circular economy through biomimicry. In: 2019 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM). IEEE, pp. 870–875.
Bressanelli, G., Perona, M., Saccani, N., 2019. Challenges in supply chain redesign for the Circular Economy: a literature review and a multiple case study. Int. J. Prod. Res. 57, 7395–7422.
Caldera, H.T.S., Desha, C., Dawes, L., 2019. Evaluating the enablers and barriers for successful implementation of sustainable business practice in "lean" SMEs. J. Clean. Prod. 218, 575–590.
Camacho-Otero, J., Boks, C., Pettersen, I.N., 2019. User acceptance and adoption of circular offerings in the fashion sector: insights from user-generated online reviews. J. Clean. Prod. 231, 928–939.
Campbell-Johnston, K., Cate, J. ten, Elfering-Petrovic, M., Gupta, J., 2019. City level circular transitions: barriers and limits in amsterdam, utrecht and the hague. J. Clean. Prod. 235, 1232–1239.
Chamberlin, L., Boks, C., 2018. Marketing approaches for a circular economy: using design frameworks to interpret online communications. Sustainability 10.
Chen, D., Faibil, D., Agyemang, M., 2020. Evaluating critical barriers and pathways to implementation of e-waste formalization management systems in Ghana: a hybrid BWM and fuzzy TOPSIS approach. Environ. Sci. Pollut. Res. 27, 44561–44584.
Cole, C., Gnanapragasam, A., Cooper, T., Singh, J., 2019. Assessing barriers to reuse of electrical and electronic equipment, a UK perspective. Resour. Conserv. Recycl. X 1, 100004.

De Angelis, R., Howard, M., Miemczyk, J., 2018. Supply chain management and the circular economy: towards the circular supply chain. Prod. Plann. Control 29, 425–437.

de Jesus, A., Mendonca, S., 2018. Lost in transition? Drivers and barriers in the eco-innovation road to the circular economy. Ecol. Econ. 145, 75–89.

De los Rios, I.C., Charnley, F.J.S., 2017. Skills and capabilities for a sustainable and circular economy: the changing role of design. J. Clean. Prod. 160, 109–122.

de Oliveira, C.T., Luna, M.M.M., Campos, L.M.S., 2019. Understanding the Brazilian expanded polystyrene supply chain and its reverse logistics towards circular economy. J. Clean. Prod. 235, 562–573.

Delmonico, D., Jabbour, C.J.C., Pereira, S.C.F., de Sousa Jabbour, A.B.L., Renwick, D.W.S., Thomé, A.M.T., 2018. Unveiling barriers to sustainable public procurement in emerging economies: evidence from a leading sustainable supply chain initiative in Latin America. Resour. Conserv. Recycl. 134, 70–79.

Demirel, P., Danisman, G.O., 2019. Eco-innovation and firm growth in the circular economy: evidence from European small-and medium-sized enterprises. Bus. Strat. Environ. 28, 1608–1618.

Den Hollander, M.C., Bakker, C.A., Hultink, E.J., 2017. Product design in a circular economy: development of a typology of key concepts and terms. J. Ind. Ecol. 21, 517–525.

Elia, V., Gnoni, M.G., Tornese, F., 2020. Evaluating the adoption of circular economy practices in industrial supply chains: an empirical analysis. J. Clean. Prod. 273, 122966.

EU-Commission, 2011. Roadmap to a Resource Efficient Europe, vol. 571. COM.

Farooque, M., Zhang, A., Thurer, M., Qu, T., Huisingh, D., 2019. Circular supply chain management: a definition and structured literature review. J. Clean. Prod. 228, 882–900.

Fedotkina, O., Gorbashko, E., Vatolkina, N., 2019. Circular economy in Russia: drivers and barriers for waste management development. Sustainability 11, 5837.

Ferronato, N., Lizarazu, E.G.G., Tudela, J.M.V., Callisaya, J.K.B., Preziosi, G., Torretta, V., 2020. Selective collection of recyclable waste in Universities of low-middle income countries: lessons learned in Bolivia. Waste Manag. 105, 198–210.

Ferronato, N., Rada, E.C., Portillo, M.A.G., Cioca, L.I., Ragazzi, M., Torretta, V., 2019. Introduction of the circular economy within developing regions: a comparative analysis of advantages and opportunities for waste valorization. J. Environ. Manag. 230, 366–378.

Frei, R., Jack, L., Krzyzaniak, S., 2020. Sustainable reverse supply chains and circular economy in multichannel retail returns. Bus. Strat. Environ. 29, 1925–1940.

García-Quevedo, J., Jové-Llopis, E., Martínez-Ros, E., 2020. Barriers to the circular economy in European small and medium-sized firms. Bus. Strat. Environ. 29, 2450–2464.

Gåvertsson, I., Milios, L., Dalhammar, C., 2020. Quality labelling for Re-used ICT equipment to support consumer choice in the circular economy. J. Consum. Pol. 43, 353–377.

Gåvertsson, I., Milios, L., Dalhammar, C., 2018. Quality labelling for Re-used ICT equipment to support consumer choice in the circular economy. J. Consum. Pol. 43, 353–377.

Gedam, V.V., Raut, R.D., de Sousa Jabbour, A.B.L., Tanksale, A.N., Narkhede, B.E., 2021. Circular economy practices in a developing economy: barriers to be defeated. J. Clean. Prod. 127670.

Geissdoerfer, M., Savaget, P., Bocken, N.M.P., Hultink, E.J., 2017. The Circular Economy–A new sustainability paradigm? J. Clean. Prod. 143, 757–768.

Genovese, A., Acquaye, A.A., Figueroa, A., Koh, S.C.L., 2017. Sustainable supply chain management and the transition towards a circular economy: evidence and some applications. Omega 66, 344–357.

Ghisellini, P., Cialani, C., Ulgiati, S., 2016. A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. J. Clean. Prod. 114, 11–32.

Ghisellini, P., Ripa, M., Ulgiati, S., 2018. Exploring environmental and economic costs and benefits of a circular economy approach to the construction and demolition sector. A literature review. J. Clean. Prod. 178, 618–643.

Govindan, K., Hasanagic, M., 2018. A systematic review on drivers, barriers, and practices towards circular economy: a supply chain perspective. Int. J. Prod. Res. 56, 278–311.

Gu, F., Zhang, W.J., Guo, J.F., Hall, P., 2019. Exploring "Internet plus Recycling": mass balance and life cycle assessment of a waste management system associated with a mobile application. Sci. Total Environ. 649, 172–185.

Guldmann, E., Huulgaard, R.D., 2020. Barriers to circular business model innovation: a multiple-case study. J. Clean. Prod. 243, 118160.

Guo, B., Geng, Y., Sterr, T., Zhu, Q.H., Liu, Y.X., 2017. Investigating public awareness on circular economy in western China: a case of Urumqi Midong. J. Clean. Prod. 142, 2177–2186.

Gupta, H., Kusi-Sarpong, S., Rezaei, J., 2020. Barriers and overcoming strategies to supply chain sustainability innovation. Resour. Conserv. Recycl. 161, 104819.

Hazen, B.T., Mollenkopf, D.A., Wang, Y., 2017. Remanufacturing for the circular economy: an examination of consumer switching behavior. Bus. Strat. Environ. 26, 451–464.

Heshmati, A., 2017. A review of the circular economy and its implementation. Int. J. Green Econ. 11, 251–288.

Heyes, G., Sharmina, M., Mendoza, J.M.F., Gallego-Schmid, A., Azapagic, A., 2018. Developing and implementing circular economy business models in service-oriented technology companies. J. Clean. Prod. 177, 621–632.

Hobson, K., Lynch, N., Lilley, D., Smalley, G., 2018. Systems of practice and the Circular Economy: transforming mobile phone product service systems. Environ. Innov. Soc. Transit. 26, 147–157.

Huang, B.J., Wang, X.Y., Kua, H.W., Geng, Y., Bleischwitz, R., Ren, J.Z., 2018. Construction and demolition waste management in China through the 3R principle. Resour. Conserv. Recycl. 129, 36–44.

Huybrechts, D., Derden, A., Van den Abeele, L., Aa, S.V., Smets, T., 2018. Best available techniques and the value chain perspective. J. Clean. Prod. 174, 847–856.

Ivankova, N.V., Creswell, J.W., Stick, S.L., 2006. Using mixed-methods sequential explanatory design: from theory to practice. Field Methods 18, 3–20.

Jaeger, B., Upadhyay, A., 2020. Understanding barriers to circular economy: cases from the manufacturing industry. J. Enterprise Inf. Manag. 33, 729–745.

Jia, F., Zhang, T., Chen, L., 2020. Sustainable supply chain Finance: towards a research agenda. J. Clean. Prod. 243, 118680.

Kalmykova, Y., Sadagopan, M., Rosado, L., 2018. Circular economy – from review of theories and practices to development of implementation tools. Resour. Conserv. Recycl. 135, 190–201.

Karaman, A.S., Kilic, M., Uyar, A., 2020. Green logistics performance and sustainability reporting practices of the logistics sector: the moderating effect of corporate governance. J. Clean. Prod., 120718

Kayikci, Y., Kazancoglu, Y., Lafci, C., Gozacan, N., 2021. Exploring barriers to smart and sustainable circular economy: the case of an automotive eco-cluster. J. Clean. Prod., 127920

Khan, I.S., Ahmad, M.O., Majava, J., 2021. Industry 4.0 and sustainable development: a systematic mapping of triple bottom line, Circular Economy and Sustainable Business Models perspectives. J. Clean. Prod. 297, 126655.

Kiefer, C.P., Gonzalez, P.D., Carrillo-Hermosilla, J., 2019. Drivers and barriers of eco-innovation types for sustainable transitions: a quantitative perspective. Bus. Strat. Environ. 28, 155–172.

Kinnunen, P.H.M., Kaksonen, A.H., 2019. Towards circular economy in mining: opportunities and bottlenecks for tailings valorization. J. Clean. Prod. 228, 153–160.

Kirchherr, J., Piscicelli, L., Bour, R., Kostense-Smit, E., Muller, J., Huibrechtse-Truijens, A., Hekkert, M., 2018. Barriers to the circular economy: evidence from the European union (EU). Ecol. Econ. 150, 264–272.

Kirchherr, J., Reike, D., Hekkert, M., 2017. Conceptualizing the circular economy: an analysis of 114 definitions. Resour. Conserv. Recycl. 127, 221–232.

Kissling, R., Coughlan, D., Fitzpatrick, C., Boeni, H., Luepschen, C., Andrew, S., Dickenson, J., 2013. Success factors and barriers in re-use of electrical and electronic equipment. Resour. Conserv. Recycl. 80, 21–31.

Koutamanis, A., van Reijn, B., van Bueren, E., 2018. Urban mining and buildings: a review of possibilities and limitations. Resour. Conserv. Recycl. 138, 32–39.

Kudinova, G.E., Rozenberg, G.S., Yurina, V.S., 2012. Towards a "green" economy: the way to sustainable development and poverty eradication. UNEP, 2011. In: Nai-robi (Kenya), Geneva (Switzerland), Moscow (Russia), p. 738. Princ. Ecol. 4, 41–48.

Kumar, A., Dixit, G., 2018. An analysis of barriers affecting the implementation of e-waste management practices in India: a novel ISM-DEMATEL approach. Sustain. Prod. Consum. 14, 36–52.

Kumar, V., Sezersan, I., Garza-Reyes, J.A., Gonzalez, E., Al-Shboul, M.A., 2019. Circular economy in the manufacturing sector: benefits, opportunities and barriers. Manag. Decis. 57, 1067–1086.

Kumar, Vikas, Sezersan, I., Garza-Reyes, J.A., Gonzalez, E.D.R.S., Al-Shboul, M.A., 2019. Circular economy in the manufacturing sector: benefits, opportunities and barriers. Manag. Decis. 57, 1067–1086.

Lahane, S., Kant, R., Shankar, R., 2020. Circular supply chain management: a state-of-art review and future opportunities. J. Clean. Prod. 258, 120859.

Lahti, T., Wincent, J., Parida, V., 2018. A definition and theoretical review of the circular economy, value creation, and sustainable business models: where are we now and where should research move in the future? Sustainability 10, 2799.

Lieder, M., Asif, F.M.A., Rashid, A., Mihelič, A., Kotnik, S., 2017. Towards circular economy implementation in manufacturing systems using a multi-method simulation approach to link design and business strategy. Int. J. Adv. Manuf. Technol. 93, 1953–1970.

Linder, M., Williander, M., 2017. Circular business model innovation: inherent uncertainties. Bus. Strat. Environ. 26, 182–196.

Lindkvist Haziri, L., Sundin, E., Sakao, T., 2019. Feedback from remanufacturing: its unexploited potential to improve future product design. Sustainability 11, 4037.

Liu, Y., Bai, Y., 2014. An exploration of firms' awareness and behavior of developing circular economy: an empirical research in China. Resour. Conserv. Recycl. 87, 145–152.

Liu, B., Chen, D., Zhou, W., Nasr, N., Wang, T., Hu, S., Zhu, B., 2018. The effect of remanufacturing and direct reuse on resource productivity of China's automotive production. J. Clean. Prod. 194, 309–317.

Longo, C., Shankar, A., Nuttall, P., 2019. It's not easy living a sustainable lifestyle": how greater knowledge leads to dilemmas, tensions and paralysis. J. Bus. Ethics 154, 759–779.

Lu, B., Yang, J., Ijomah, W., Wu, W., Zlamparet, G., 2018. Perspectives on reuse of WEEE in China: lessons from the EU. Resour. Conserv. Recycl. 135, 83–92.

Lu, C., Zhang, L., Zhong, Y., Ren, W., Tobias, M., Mu, Z., Ma, Z., Geng, Y., Xue, B., 2015. An overview of e-waste management in China. J. Mater. Cycles Waste Manag. 17, 1–12.

MacArthur, Ellen, 2013. Towards the circular economy. J. Ind. Ecol. 2, 23–44.

Mangla, S.K., Luthra, S., Mishra, N., Singh, A., Rana, N.P., Dora, M., Dwivedi, Y., 2018. Barriers to effective circular supply chain management in a developing country context. Prod. Plann. Control 29, 551–569.

Marke, A., Chan, C., Taskin, G., Hacking, T., 2020. Reducing e-waste in China's mobile electronics industry: the application of the innovative circular business models. Asian Educ. Dev. Stud. 9 (4), 591–610.

Mashhadi, A.R., Behdad, S., 2017. Optimal sorting policies in remanufacturing systems: application of product life-cycle data in quality grading and end-of-use recovery. J. Manuf. Syst. 43, 15–24.
Mashhadi, A.R., Vedantam, A., Behdad, S., 2019. Investigation of consumer's acceptance of product-service-systems: a case study of cell phone leasing. Resour. Conserv. Recycl. 143, 36–44.
Masi, D., Day, S., Godsell, J., 2017. Supply chain configurations in the circular economy: a systematic literature review. Sustainability 9.
Merli, R., Preziosi, M., Acampora, A., 2018. How do scholars approach the circular economy? A systematic literature review. J. Clean. Prod. 178, 703–722.
Milios, L., Beqiri, B., Whalen, K.A., Jelonek, S.H., 2019. Sailing towards a circular economy: conditions for increased reuse and remanufacturing in the Scandinavian maritime sector. J. Clean. Prod. 225, 227–235.
Millette, S., Eiríkur Hull, C., Williams, E., 2020. Business incubators as effective tools for driving circular economy. J. Clean. Prod. 266, 121999.
Mishra, J.L., Hopkinson, P.G., Tidridge, G., 2018. Value creation from circular economy-led closed loop supply chains: a case study of fast-moving consumer goods. Prod. Plann. Control 29, 509–521.
Mont, O., Plepys, A., Whalen, K., Nußholz, J.L.K., 2017. Business Model Innovation for a Circular Economy: Drivers and Barriers for the Swedish Industry–The Voice of REES Companies.
Mura, M., Longo, M., Zanni, S., 2020. Circular economy in Italian SMEs: a multi-method study. J. Clean. Prod. 245, 118821.
Nasir, M.H.A., Genovese, A., Acquaye, A.A., Koh, S.C.L., Yamoah, F., 2017. Comparing linear and circular supply chains: a case study from the construction industry. Int. J. Prod. Econ. 183, 443–457.
Neuendorf, K.A., 2016. The Content Analysis Guidebook. Sage.
Nohra, C.G., Pereno, A., Barbero, S., 2020. Systemic design for policy-making: towards the next circular regions. Sustainability 12, 1–23.
Nußholz, J.L.K., Rasmussen, F.N., Whalen, K., Plepys, A., 2020. Material reuse in buildings: implications of a circular business model for sustainable value creation. J. Clean. Prod. 245, 118546.
Ormazabal, M., Prieto-Sandoval, V., Puga-Leal, R., Jaca, C., 2018. Circular economy in Spanish SMEs: challenges and opportunities. J. Clean. Prod. 185, 157–167.
Padmanathan, K., Govindarajan, U., Ramachandaramurthy, V.K., Rajagopalan, A., Pachaivannan, N., Sowmmiya, U., Padmanaban, S., Holm-Nielsen, J.B., Xavier, S., Periasamy, S.K., 2019. A sociocultural study on solar photovoltaic energy system in India: I Stratification and policy implication. J. Clean. Prod. 216, 461–481.
Peeters, B., Kiratli, N., Semeijn, J., 2019. A barrier analysis for distributed recycling of 3D printing waste: taking the maker movement perspective. J. Clean. Prod. 241, 118313.
Pini, M., Lolli, F., Balugani, E., Gamberini, R., Neri, P., Rimini, B., Ferrari, A.M., 2019. Preparation for reuse activity of waste electrical and electronic equipment: environmental performance, cost externality and job creation. J. Clean. Prod. 222, 77–89.
Piyathanavong, V., Garza-Reyes, J.A., Kumar, V., Maldonado-Guzman, G., Mangla, S.K., 2019. The adoption of operational environmental sustainability approaches in the Thai manufacturing sector. J. Clean. Prod. 220, 507–528.
Primc, K., Kalar, B., Slabe-Erker, R., Dominko, M., Ogorevc, M., 2020. Circular economy configuration indicators in organizational life cycle theory. Ecol. Indicat. 116, 106532.
Queiroz, M.M., Telles, R., 2018. Big data analytics in supply chain and logistics: an empirical approach. Int. J. Logist. Manag. 29 (2), 767–783.
Ranta, V., Aarikka-Stenroos, L., Ritala, P., Makinen, S.J., 2018. Exploring institutional drivers and barriers of the circular economy: a cross-regional comparison of China, the US, and Europe. Resour. Conserv. Recycl. 135, 70–82.
Ravindra, K., Kaur, K., Mor, S., 2015. System analysis of municipal solid waste management in Chandigarh and minimization practices for cleaner emissions. J. Clean. Prod. 89, 251–256.
Rönkkö, P., Ayati, M.S., Majava, J., 2021. Remanufacturing in the heavy vehicle industry—case study of a Finnish machine manufacturer. Sustainability 13, 11120.
Rossi, E., Bertassini, A.C., dos Santos Ferreira, C., do Amaral, W.A.N., Ometto, A.R., 2020. Circular economy indicators for organizations considering sustainability and business models: plastic, textile and electro-electronic cases. J. Clean. Prod. 247, 119137.
Sauvé, S., Bernard, S., Sloan, P., 2016. Environmental sciences, sustainable development and circular economy: alternative concepts for trans-disciplinary research. Environ. Dev. 17, 48–56.
Seuring, S., Gold, S., 2012. Conducting content-analysis based literature reviews in supply chain management. Supply Chain Manag. An Int. J. 17, 544–555.
Seuring, S., Müller, M., 2008. From a literature review to a conceptual framework for sustainable supply chain management. J. Clean. Prod. 16, 1699–1710.
Shahbazi, S., Wiktorsson, M., Kurdve, M., Jonsson, C., Bjelkemyr, M., 2016. Material efficiency in manufacturing: Swedish evidence on potential, barriers and strategies. J. Clean. Prod. 127, 438–450.
Sharma, Y.K., Mangla, S.K., Patil, P.P., Liu, S.F., 2019. When challenges impede the process for circular economy-driven sustainability practices in food supply chain. Manag. Decis. 57, 995–1017.
Shekarian, E., 2020. A review of factors affecting closed-loop supply chain models. J. Clean. Prod. 253, 119823.
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.
Sihvonen, S., Ritola, T., 2015. Conceptualizing ReX for aggregating end-of-life strategies in product development. Procedia Cirp 29, 639–644.
Singh, A., Panchal, R., Naik, M., 2020. Circular economy potential of e-waste collectors, dismantlers, and recyclers of Maharashtra: a case study. Environ. Sci. Pollut. Res. 27, 22081–22099.
Singhal, D., Tripathy, S., Jena, S.K., 2020. Remanufacturing for the circular economy: study and evaluation of critical factors. Resour. Conserv. Recycl. 156, 104681.
Sirilertsuwan, P., Hjelmgren, D., Ekwall, D., 2019. Exploring current enablers and barriers for sustainable proximity manufacturing. J. Fash. Mark. Manag. An Int. J. 22 (4), 551–571.
Smol, M., Kulczycka, J., Henclik, A., Gorazda, K., Wzorek, Z., 2015. The possible use of sewage sludge ash (SSA) in the construction industry as a way towards a circular economy. J. Clean. Prod. 95, 45–54.
Sousa-Zomer, T.T., Magalhães, L., Zancul, E., Cauchick-Miguel, P.A., 2018. Exploring the challenges for circular business implementation in manufacturing companies: an empirical investigation of a pay-per-use service provider. Resour. Conserv. Recycl. 135, 3–13.
Souza, G.C., 2012. Closed-loop supply chains: a critical review, and future research. Decis. Sci. J. 44, 7–38.
Stahel, W.R., MacArthur, E., 2019. The Circular Economy.
Su, B., Heshmati, A., Geng, Y., Yu, X., 2013. A review of the circular economy in China: moving from rhetoric to implementation. J. Clean. Prod. 42, 215–227.
Tarnavsky Eitan, A., Smolyansky, E., Knaan Harpaz, I., 2020. (Connected Papers [WWW Document]. Connect. Pap. About).
Tecchio, P., McAlister, C., Mathieux, F., Ardente, F., 2017. In search of standards to support circularity in product policies: a systematic approach. J. Clean. Prod. 168, 1533–1546.
Tranfield, D., Denyer, D., Smart, P., 2003. Towards a methodology for developing evidence-informed management knowledge by means of systematic review. Br. J. Manag. 14, 207–222.
Tukker, A., 2015. Product services for a resource-efficient and circular economy–a review. J. Clean. Prod. 97, 76–91.
Tura, N., Hanski, J., Ahola, T., Stahle, M., Piiparinen, S., Valkokari, P., 2019. Unlocking circular business: a framework of barriers and drivers. J. Clean. Prod. 212, 90–98.
Uhrenholt, J.N., Kristensen, J.H., Gil, M.C.R., Jensen, S.F., Waehrens, B.V., 2022. Circular economy: factors affecting the financial performance of product take-back systems. J. Clean. Prod. 130319.
van Buren, N., Demmers, M., van der Heijden, R., Witlox, F., 2016. Towards a circular economy: the role of Dutch logistics industries and governments. Sustainability 8.
Van Eck, N.J., Waltman, L., 2014. Visualizing bibliometric networks. In: Measuring Scholarly Impact. Springer, pp. 285–320.
Van Weelden, E., Mugge, R., Bakker, C., 2016. Paving the way towards circular consumption: exploring consumer acceptance of refurbished mobile phones in the Dutch market. J. Clean. Prod. 113, 743–754.
Vermunt, D.A., Negro, S.O., Verweij, P.A., Kuppens, D.V., Hekkert, M.P., 2019. Exploring barriers to implementing different circular business models. J. Clean. Prod. 222, 891–902.
Werning, J.P., Spinler, S., 2020. Transition to circular economy on firm level: barrier identification and prioritization along the value chain. J. Clean. Prod. 245, 118609.
Whalen, K.A., Milios, L., Nussholz, J., 2018. Bridging the gap: barriers and potential for scaling reuse practices in the Swedish ICT sector. Resour. Conserv. Recycl. 135, 123–131.
Yadav, G., Luthra, S., Jakhar, S.K., Mangla, S.K., Rai, D.P., 2020. A framework to overcome sustainable supply chain challenges through solution measures of industry 4.0 and circular economy: an automotive case. J. Clean. Prod. 254, 120112.
Yuan, H., 2017. Barriers and countermeasures for managing construction and demolition waste: a case of Shenzhen in China. J. Clean. Prod. 157, 84–93.
Zayed, E.O., Yaseen, E.A., 2020. Barriers to sustainable supply chain management implementation in Egyptian industries: an interpretive structural modeling (ISM) approach. Manag. Environ. Qual. Int. J. 32 (6), 1192–1209.
Zhang, A., Venkatesh, V.G., Liu, Y., Wan, M., Qu, T., Huisingh, D., 2019. Barriers to smart waste management for a circular economy in China. J. Clean. Prod. 240, 118198.
Zhu, Q., Geng, Y., Lai, K., 2010. Circular economy practices among Chinese manufacturers varying in environmental-oriented supply chain cooperation and the performance implications. J. Environ. Manag. 91, 1324–1331.
Zink, T., Geyer, R., 2017. Circular economy rebound. J. Ind. Ecol. 21 (3), 593–602.
Ziout, A., Azab, A., Atwan, M., 2014. A holistic approach for decision on selection of end-of-life products recovery options. J. Clean. Prod. 65, 497–516.