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Multi-dimensional circular supply chain management: A comparative review of the state-of-the-art practices and research

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ABSTRACT

The circular economy (CE) concept has gained wide attention in practice as well as in academia in recent years. This paper reviews the state-of-the-art practices and research in “circular supply chain management” (CSCM), i.e., the integration of CE thinking into supply chain management (SCM) with the goal of achieving “zero wastes”. The review covers 68 real-life CE implementation cases collected by the Ellen MacArthur Foundation and 124 publications in well-established, high-ranking academic journals in operations and supply chain management. The comparative review shows that CSCM encompasses multiple dimensions, including closed-loop SCM, reverse SCM, remanufacturing SCM, recycling SCM, and industrial symbiosis. A multi-dimensional CSCM (MD-CSCM) framework is developed to synthesize their interrelationships and to categorize academic publications into multiple research themes. Based on the identified research-practice gaps and pressing research needs, this study discusses important directions for future studies to advance supply chain circularity.

1. Introduction

In the current era of increasing resource scarcity, the circular economy (CE) concept has been advocated by researchers, policy makers, and business leaders. The Ellen MacArthur Foundation (2015) defined CE as an economy that is restorative and regenerative by design. It aspires to a zero-waste vision by circulating resources through biological (natural decomposition) and technical (reuse, remanufacturing, refurbishing, and recycling) cycles (Farooque et al., 2019). It is much more sustainable than the dominant linear extract-make-use-dispose model. It can also be regarded as a good corporate social responsibility (CSR) practice (Liu et al., 2021).

The transition to a CE requires a transformation in supply chain management (SCM), which has given birth to a new concept, circular SCM (CSCM). Farooque, Zhang, Thürer, et al. (2019) defined CSCM as “*the integration of circular thinking into the management of the supply chain and its surrounding industrial and natural ecosystems*” (p. 884) with the goal of achieving “zero wastes”. The CSCM

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Table 1
A comparison of this review with other published CSCM review papers.

Other Related Review Papers	Topics/scopes	Review Types & Databases	Coverage	Outcomes
Govindan & Hasanagic (2018)	Drivers, barriers, and practices towards CE from a supply chain perspective	A systematic search in Scopus & Web of Science	60 journal articles published from 2000 to 2016	• A multi-perspective framework of CE drivers, practices, and barriers
Bressanelli et al. (2019)	Challenges in supply chain redesign for the CE	A systematic search in Scopus	63 journals articles & four business cases in the washing machine industry	• Categorization of CE challenges for supply chain redesign • Levers that could be used to overcome these challenges
Farooque, Zhang, Thürer, et al. (2019)	CSCM	A structured search in Scopus	261 journal articles published till 2018	• A definition of CSCM • Analysis of articles by supply chain functions • Future research directions
Lahane et al. (2020)	CSCM	A systematic search in Scopus	125 journal articles published between 2010 and July 2019	• Publications were evaluated against 13 pre-defined structural dimensions • Future research directions
This article	CE implementation in practice & academic research in CSCM	Ellen MacArthur Foundation's case studies collection & A structured search in Scopus	68 real-life CE implementation cases & 124 articles in high-ranking operations and supply chain journals till 2020	• A multi-dimensional CSCM framework • Research-practice gaps • Future research directions

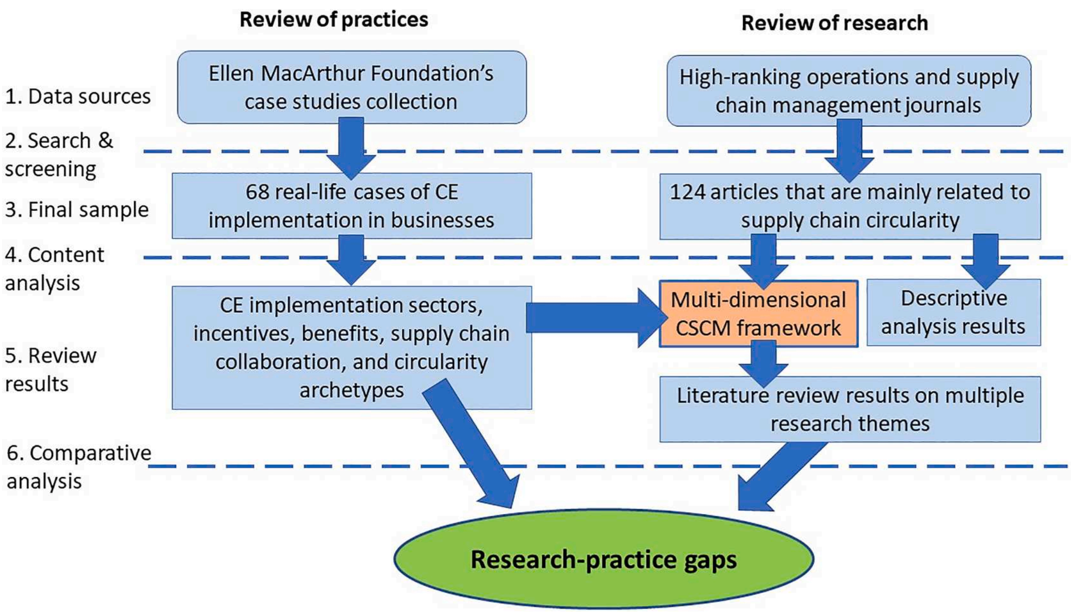

Fig. 1. Comparative review procedures.

concept extends the boundaries of closed-loop SCM (Guide & Van Wassenhove, 2006), green SCM (Srivastava, 2007), and sustainable SCM (Seuring & Müller, 2008). In comparison with these traditional concepts related to supply chain sustainability, the CSCM concept offers greater potential and clearer pathways for advancing supply chain circularity. For example, closed-loop SCM can rarely reuse/recycle all materials within the original supply chains, but CSCM enables value recovery across different supply chains with partnering firms in the same industrial sector and/or other sectors (Weetman, 2017; Genovese et al., 2017). Therefore, it can achieve a higher level of supply chain circularity.

Several recent review papers have looked into the emerging CSCM research domain. Table 1 compares our study with these CSCM review papers. For instance, Govindan and Hasanagic (2018) review drivers, barriers, and practices towards CE from a supply chain perspective. They uncover that, among various stakeholders, the government should have the greatest influence on the CSCM implementation through imposing pro-CE laws, policies, and tax levies. Bressanelli et al. (2019) categorize challenges in supply chain

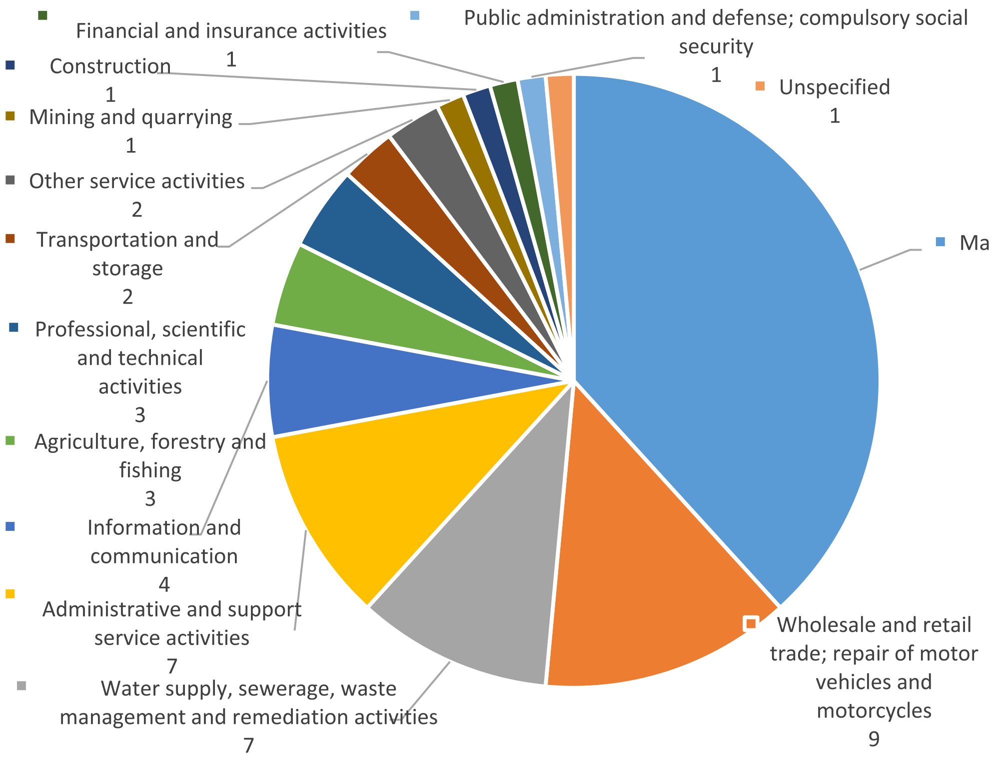

Fig. 2. The distribution of industry sectors in the sample (N = 68).

redesign for the CE and discuss four cases in the washing machine industry. They construct a framework to match supply chain redesign challenges with potential levers to overcome them. Farooque, Zhang, Thürer, et al. (2019) provide a comprehensive review of 261 journal articles on integrating the CE concept into individual supply chain functions and/or the whole supply chain system. They establish a definition of CSCM and advocate more studies in several important research directions. Likewise, Lahane et al. (2020) cover 125 journal articles on CSCM and discuss future research directions. These review papers analyze the latest CSCM research studies. However, none of them have comprehensively reviewed real-life CSCM practices, so there is little knowledge on the research-practice gap. Given the widespread criticism on the relevance gap in the management research (Tranfield & Denyer, 2004), this review paper aims to address the following research question:

What are the gaps between the state-of-the-art practices and research in CSCM?

Following the example of Choi et al. (2018), this paper reviews both academic research and practical implementation cases. Fig. 1 outlines our comparative review[1] procedures. Specifically, for the academic research, we review well-established, high-ranking academic journals on operations and supply chain management. Regarding the CSCM practical implementation, we comprehensively analyze the real-life CE case studies collected by the Ellen MacArthur Foundation, which represent the best-in-class practices. Drawing insights from comparing the best in research and in practice, this paper sheds unique insights on the multiple dimensions of CSCM and research-practice gaps.

This comparative review paper makes the following contributions to the literature. First, it makes an original contribution by establishing CSCM as a multi-dimensional concept. A multi-dimensional CSCM (MD-CSCM) framework is developed based on the content analysis (Neuendorf, 2019) of reviewed case studies and academic literature. The framework establishes the relationships between the multiple dimensions of CSCM. It is also used to categorize the review studies into multiple research themes. Second, our comparative review offers fresh insights into the research-practice gaps. To the best of our knowledge, no prior study has systematically identified research-practice gaps in the emerging CSCM domain. Last but not the least, we discuss future research directions for advancing supply chain circularity based on the pressing research needs.

The rest of this paper is organized as follows. Sections 2 and 3 review the state-of-the-art practices and research, respectively. Section 4 identifies the research-practice gaps and discusses future research directions. Section 5 concludes the research.

[1] The term "comparative review" is used because this review paper covers both practice and research, and compares them to identify the research-practice gaps.

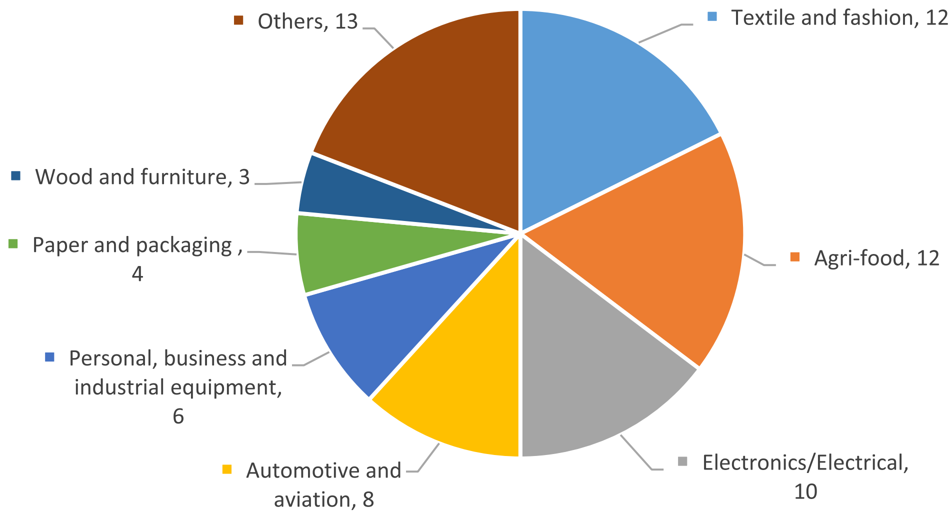

Fig. 3. The distribution of product sectors in the sample (N = 68).

2. Review of the state-of-the-art practices

Below, we first review the state-of-the-art CE practices. Section 2.1 outlines the review methodology on the case sampling and content analysis procedure. In Section 2.2, we present the case analysis results on the incentives of adopting the CE concept and adoption benefits for firms. We also categorize the types of supply chain collaboration and circularity archetypes observed in the CE implementation cases.

2.1. Review methodology

2.1.1. Case sampling

Our target population is the case studies collection of the Ellen MacArthur Foundation[2]. The Ellen MacArthur Foundation was founded in 2010 for accelerating the CE transition (Ellen MacArthur Foundation, 2015). It has played a significant role in promoting CE development in business, policies, and academia (Jabbour et al., 2018). Its published reports and data have been widely used in the literature (Govindan & Hasanagic, 2018; Masi et al., 2018; Stewart & Niero, 2018). As of December 2020, its case studies collection includes 89 cases with the most recent real-world CE initiatives at macro- and micro-levels, covering a wide range of companies, industries, countries, and CE strategies.

In this review, we focus on CE implementation at the firm and/or supply chain level(s). We exclude cases that merely address implementation at the municipal and national levels. This screening process results in a final sample of 68 CE business cases which are briefly summarized in Appendix A. The sample covers many industry sectors, classified according to the International Standard Industrial Classification (ISIC), as shown in Fig. 2. The top five industry sectors are manufacturing (26 cases; 39%), wholesale and retail trade, repair of motor vehicles and motorcycles (9 cases; 13%), water supply, sewerage, waste management and remediation activities (7 cases; 10%), administrative and support service activities (7 cases; 10%), and information and communication (4 cases; 6%). It is not a surprise that the manufacturing sector has the greatest number of cases because manufacturers perform production and remanufacturing activities and often have control over product design and material reuse. Distribution channels, as represented by the cases involving wholesale and retail trade and repair of motor vehicles and motorcycles, also make great contributions to supply chain circularity. Several cases involve renting and leasing business models, which are categorized in the "administrative and support service activities" industry.

As shown in Fig. 3, the top five product sectors are textile (12 cases; 18%), agri-food (12 cases; 18%), electronics/electrics (10 cases; 15%), automotive (8 cases; 12%), and personal and business equipment (6 cases; 9%). These product sectors generate a large amount of waste or have a relatively high residual value for resource recovery. As such, there is a strong incentive in these product sectors to implement the CE concept. Overall, Figs. 2 and 3 show that the CE concept has been implemented in a wide range of industries and product sectors.

2.1.2. Content analysis procedure

We use a content analysis approach (Neuendorf, 2019) to analyze cases, focusing on supply chain aspects. To provide a systematic framework for the current developments, we develop a list of key aspects after reading and re-reading the cases. These aspects include

[2] Detailed information on the case studies is available at https://www.ellenmacarthurfoundation.org/case-studies.

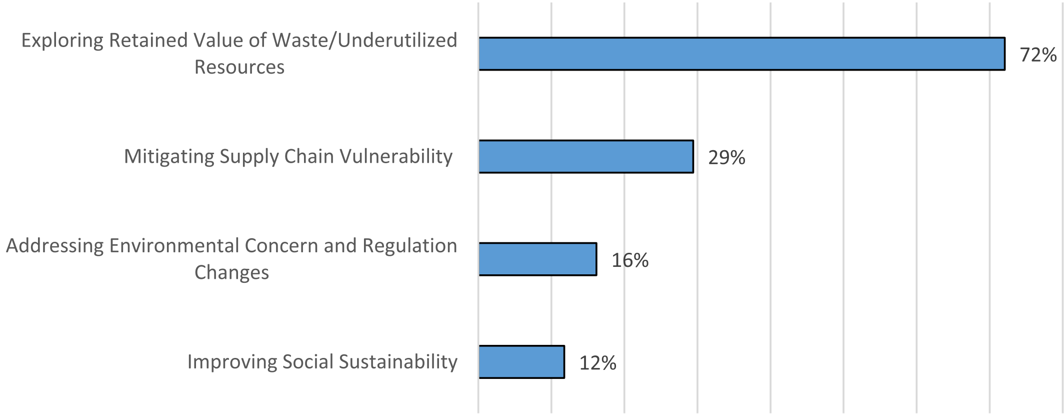

Fig. 4. The distribution of incentives.

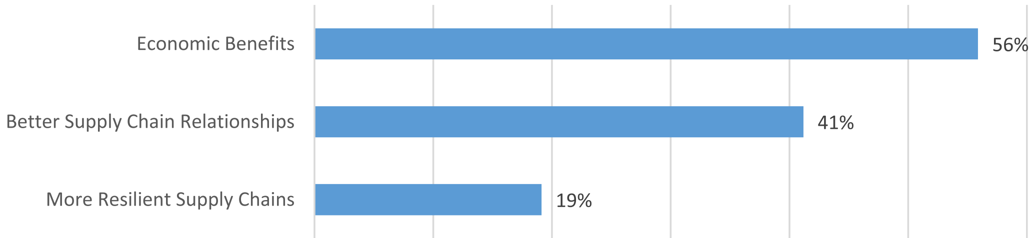

Fig. 5. The distribution of benefit categories.

"Incentives", "Benefits", "Supply Chain Relationships", and "Circularity Archetypes". We code each sample case against these aspects to produce an overall map of the CE practices. We then categorize the coding results under each key aspect by not only consulting the literature but also utilizing an abductive approach, which combines deduction and induction (Saunders et al., 2019). The specific categories under each key aspect are introduced in detail in the later sections.

We analyze each case to decide whether it falls into these specific categories, using a "mapping approach" suggested by Stewart and Niero (2018). Our unit of analysis is an individual case. We use a "binomial variable" for each category across cases as in a quantitative study (i.e., coded 1 for the cases which report a specific category). A case may be labeled with multiple categories under the same key aspect. For example, a case may be coded 1 for "more resilient supply chains" (one specific category under the aspect of "Benefit") and 1 for "better supply chain relationships" (another specific category under the aspect of "Benefit") if both were reported. Therefore, a case may be counted more than once in categorization. This coding approach allows us to map the overall distribution of the categories within each key aspect and to note the correlation between key aspects with their specific categories.

2.2. Case analysis results

2.2.1. Incentives

Fig. 4 reports the distribution of incentives for adopting the CE concept in business practices. The top incentive is to explore the retained value of waste or underutilized resources (72%). The circular model provides businesses with a new vision that wastes can be exploited as resources. The increasing development of the CE infrastructure at the regional, industry, and supply chain levels (e.g., marketplaces of wastes and by-products) also stimulates businesses to recover value from wastes.

About 29% of cases show companies implementing the CE concept to reduce supply chain vulnerability. The incentive is twofold. First, in a broad context, the depletion of finite natural resources raises concerns about raw material supply in the long run. Second, supply chains are increasingly complex and geographically dispersed (Zhang et al., 2013) in the pursuit of low costs and efficiency. Such developments increase supply chain risks in the event of operational disruptions and market uncertainties. A CE creates restorative and regenerative cycles of resources in a circular flow. Such a circular model provides firms with an effective approach to establish secure supply chains against, for example, price fluctuation, supply shortage, and resource depletion. The data show an interesting fact that businesses are using CE as an operations strategy to reduce supply chain vulnerability, although its primary contribution is in improving environmental performance.

Only 16% of cases show "addressing environmental concern and regulation changes" as an incentive. This suggests that although the environmental benefits of CE are widely recognized, most businesses do not jump into an implementation simply for the sake of environmental performance itself or for regulatory compliance. They are often pragmatic in their CE journey, starting an implementation where they can explore the retained value of waste or underutilized resources. Such a pragmatic approach is understandable

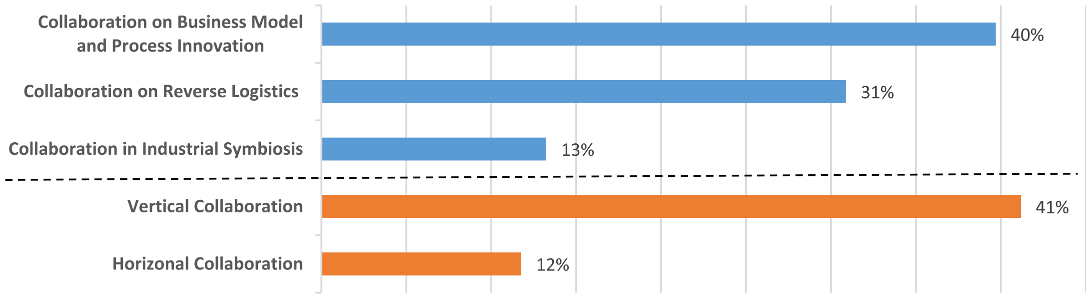

Fig. 6. The distribution of types of collaboration.

as most businesses are for profit. However, it may impede their long-term progress in the CE journey when there is a conflict between environmental and economic performance.

We find 12% of cases with an incentive of "improving social sustainability". For example, firms intend to use the circular approach to increase recycling and remanufacturing activities and thus create more local jobs (Braiform, 2017). The firms effectively use these job opportunities to improve labor diversity (Rede Asta, 2017). Also, companies use circular information systems to support fragmented local farmers to improve individual prosperity (e-Choupal, 2017). The implications of a CE for social sustainability provide additional insight on the role of CE in sustainable development.

2.2.2. *Benefits*

Fig. 5 reports the economic and operational benefits found in our sample cases. We intentionally omit CE's contributions to environmental performance as they have been widely discussed in the literature. In 53% of the examined cases, firms achieved economic benefits, mainly from reduced material and energy usage, increased resource utilization, and lower disposal costs. Some companies created new revenue sources by resale and by selling wastes and by-products. Interestingly, we find that businesses discover more cost savings by remanuring/refurbishing/reusing than by recycling. In the electronics and electrical equipment sector, refurbished products generated six times more value than recycled ones (eStoks, 2017). In the case of printing paper, the reusage of the paper by erasing the information rather than by traditional recycling would "provide cost savings without any upfront investment" (REEP Technologies Ltd., 2017, para 6). It demonstrates that with careful design for reverse engineering and technological support, "slowing resources loops" can be more cost-efficient than "closing resources loops" in business practices. Some cases show that CE could help lower market entry barriers. The circular uses of resources at industry and supply chain levels (e.g., a sharing economy) allow firms to conduct business without investing substantially in equipment. Consequently, it reduces the capital constraints and market entry barriers, which are especially critical to small and medium-sized enterprises.

Approximately 41% of the cases show that companies have developed better supply chain relationships through CE practices. Our data show two reasons for improved supply chain relationships. First, the development of the circular model opens new avenues for supply chain collaborations. Reverse logistics and engineering requires supply chain partners to work together to restructure material flows, design for disassembly, and share information for supply chain circularity. Our data show many manufacturers adopted the "Product Service System" (PSS), where businesses shift their tenets from the delivery of physical products only to providing integrated product-service offerings in the form of leasing or renting (Wang et al., 2020). Supply chain partners are more likely to create strategic relationships through long-term and customized maintenance and disposal services in a PSS. The use of regenerative energy/sources and restorative materials strengthens the continuity in resource supply and thus fosters trust between buying firms and their suppliers. The circular system drastically extends the supply chain operations to a wider scope (e.g., end-of-life product management) than those in a linear model, creating new opportunities to strengthen supply chain relationships. Material circularity also reduces purchasing costs and enables shared benefits of CE in supply chains. The increasing use of recycled/remanufactured/refurbished products substantially saves manufacturing costs and reduces purchasing costs. The favorable purchasing prices, in turn, strengthens the relationships.

We find that businesses develop supply chain resilience through CE practices (19% of cases). CE creates a more self-sustaining production system (Genovese et al., 2017), which protects resource flows from price fluctuation, seasonality, and supply disruptions. In addition to the risks of depleted virgin resources, the fast-changing market and external disruptive events (e.g., COVID-19 pandemic) impose a severe threat to supply chain stability. Our data show innovative uses of CE as an approach to develop supply chain resilience, in addition to the traditional mechanisms (e.g., operational slack) as discussed in the literature.

2.2.3. *Supply chain collaboration*

Fig. 6 categorizes the forms and natures of supply chain collaboration for a CE. The dashed lines demarcate two broad groups of collaborative relationships. The first group shows specific forms of supply chain collaborations. About 40% of them indicate supply chain collaborations for business model and process innovation, specifically, for developing modularity, innovative recovery processes, and PSS. Modularity is a traditional product design strategy (Cai and Choi, 2021), where modular products are designed for cross-compatibility of components and thus allow for flexible substitutions (Krikke et al., 2004). Our data show businesses' innovative use of modularity for efficient disassembly, re-configuration, and re-engineering. Manufacturers often collaborate with suppliers from

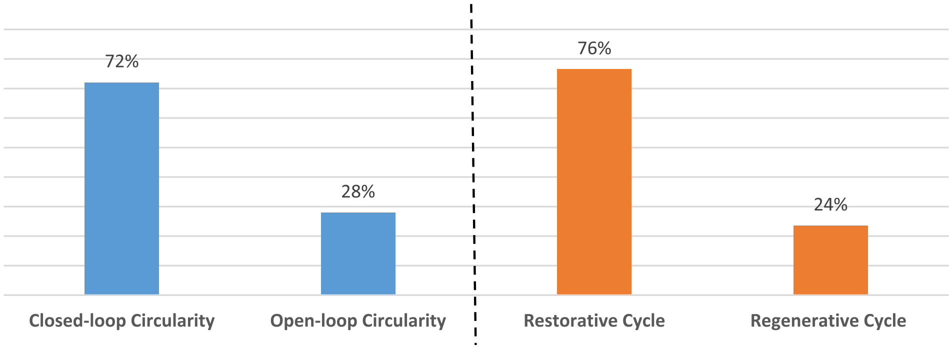

Fig. 7. The distribution of circularity archetypes.

the early design stage. Retailers increasingly initiate cooperation with manufacturers in modularity, primarily to support a sharing economy. Technology providers are an active party to support modularity by jointly redesigning with manufacturers or providing sector standardization. They also work with manufacturers, service providers, and material suppliers to develop innovative recovery processes (e.g., reuse in place of recycling).

We find that 31% of sample cases used collaboration to establish reverse logistics. In the management of product returns, manufacturers and retailers collaborate to develop effective channels for collections and redistribution. For example, a textile manufacturer develops a garment hanger solution across its supply chain, where retailers collect the hangers and send them back to the manufacturer's reuse centers for repackaging, recycling, and redistribution (Braiform, 2017). Manufacturers also collaborate with their material suppliers to improve the efficiency in collection and reprocessing. For instance, a packaging company that uses fully bio-based materials cooperates with local composting firms. These composting companies benefit from the additional feedstock in exchange for a commitment to collect the used containers from consumers (Já Fui Mandioca, 2017). We also find that supply chain partners strategically integrate their operations to improve the efficiency and effectiveness of reverse logistics. For example, Coca-Cola established two joint ventures with its plastic suppliers, focusing on increasing the regional collection rate and local reprocessing of the post-consumer PET plastic (Coca-Cola Enterprises, 2017).

About 13% of the examined cases collaborate in industrial symbiosis, which goes beyond immediate supply chain members to widening circular resource loops by enlarging partnerships. This means open-loop resource flows are created among businesses within the same sector or across different sectors, which overcomes the limitation of closed-loop SCM to maximize value recovery (Farooque, Zhang, Thürer, et al., 2019). One mechanism is to create a business-to-business sharing economy. The sharing platform shifts the existing vertical model to a horizontal model, which creates an additional relationship between industry peers to improve the capacity of circularity (FLOOW2, 2017). Moreover, we find a high level of involvement of third parties in establishing the industry clusters, including governments and logistics/technology service providers. The concern about direct competition is a major challenge in forming a partnership between industry peers, such as in group purchasing (Chen & Roma, 2011). Governments are effective and powerful stakeholders to manage conflicts of interest and motivate resource circularity. For example, the "Courtauld Commitment" is a public–private partnership that supports "pre-competitive collaboration" of the grocery industry to tackle the packaging and food waste in the United Kingdom (WRAP, 2017, para. 6). The British government invested and tasked a specialist organization to coordinate grocery retailers and suppliers in waste reduction. In another example, "Kalundborg Symbiosis" is a local public–private partnership in Demark, where public sector firms work with private partners to provide, share and reuse resources of energy, water, and materials in industrial symbiosis (Kalundborg Symbiosis, 2017).

We also code "vertical collaboration" and "horizontal collaboration" to provide a comparative analysis of the nature of supply chain collaboration. Our data show that businesses are more likely to establish vertical collaboration (41%) than horizontal collaboration (12%) in CE practices. Vertical collaboration focuses on developing circular resource flows in buyer–supplier relationships within focal companies' supply chains. We find that vertical collaboration is mostly beyond the supply chain dyads. Focal companies commonly cooperate with both downstream and upstream firms to optimize circular resource flows. Horizontal collaboration primarily takes place in the form of secondary marketplaces. Buying firms gain additional procurement channels and cost savings in exchanges of underutilized resources.

2.2.4. Circularity archetypes

Depending on how resources are looped back for reuse, circularity archetypes can be classified as closed-loop circularity and open-loop circularity (Genovese et al., 2017; Farooque, Zhang, Thürer, et al., 2019). Closed-loop circularity means returning after-use products to their original supply chains for value recovery. It represents 72% of the cases in the sample, as reported in Fig. 7. In an open-loop circularity archetype, various firms across different supply chains collaborate to maximize resource circularity (Genovese et al., 2017; Farooque, Zhang, Thürer, et al., 2019). Open-loop circularity archetype accounts for 28% of the cases in the sample. For example, while HP collaborates with its supplier, Flex, on reverse logistics and remanufacturing of discarded electronic equipment, both companies feed local supply chains the remainder of materials (e.g., metals) which cannot be put back into HP products (HP Brazil & Sinctronics, 2017).

Table 2
Literature search keywords and initial search results.

No.	Keywords including their derivatives	Scopus (selected journals)	After removing duplicates
1	Circular Economy	8	8
2	Closed-loop supply chain (117), closed-loop (179), clos* and loop (186)	484	184
3	Circular supply chain* (8), circular and supply chain (8), circular* and supply chain (0)	16	5
4	Supply chain AND Restor*	16	14
5	Supply chain AND Regenrat*	1	1
6	Supply chain AND Reus*	32	20
7	Supply chain AND Recycl*	39	19
8	Supply chain and Remanufact*	83	22
9	Supply chain AND Refurbish	1	1
10	Supply chain AND Recover	23	18
11	Reverse logistics	101	72
12	Supply chain AND Waste	57	30
13	Supply chain AND Zero-waste (0), zero waste (2)	2	2
Total articles retrieved		**865**	**396**

Sources: Farooque, Zhang, Thürer, et al. (2019); Authors.

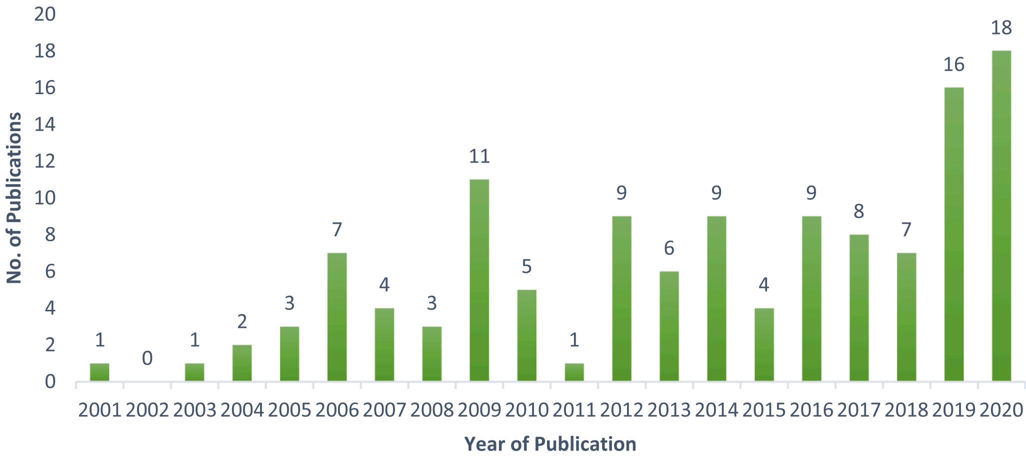

Fig. 8. Distribution of articles per year.

Circularity archetype can also be categorized by the nature of the involved processes: a restorative cycle is required for technical materials (e.g., metal and plastics), while a regenerative cycle is for biological materials (e.g., food waste). A restorative cycle represents 76% of the sampled cases, while the other 24% involves a regenerative cycle. This is not a surprise given that most products in the market use technical materials, which need reuse, repair, refurbishment, remanufacturing, and/or recycling to achieve resource circularity. In the case of regenerating biological materials, we find that businesses primarily focus on composting in the agri-food and packaging sectors. It is also observed that technology and logistics service providers play a significant role in exploring the regenerability of resources.

3. Review of the state-of-the-art research

In this section, we review the state-of-the-art research on CE in SCM. Section 3.1 explains the structured literature review methodology. In Section 3.2, we first present a descriptive analysis of the literature review results, and then develop a framework to synthesize the knowledge covered in the comparative review. After that, we summarize the findings in the eight research themes as identified in the academic literature.

3.1. Literature review methodology

We conducted a structured search via Scopus using a list of keywords (Table 2) which are implicitly or explicitly related to supply chain circularity and resource recovery from waste. Our literature search focuses on well-established, high-ranking operations and supply chain journals that are featured in the SCM Journal List (http://www.scmlist.com), Chartered Association of Business Schools' academic journal guide (ranked 4*/4 only), or Australian Business Dean Council's journal quality list (ranked A* only). The search was restricted to "Articles" published till 2020. Overall, this step retrieved 865 publications. After removing duplicates, 396 articles remained in the sample.

Table 3
Distribution of articles by selected journals.

Journal Name	No. of papers	Percentage
European Journal of Operational Research *(EJOR)*	53	42.74%
Transportation Research Part E: Logistics and Transportation Review *(TRE)*	28	22.58%
Production and Operations Management *(POM)*	16	12.90%
Journal of Operations Management *(JOM)*	8	6.45%
International Journal of Operations and Production Management *(IJOPM)*	5	4.03%
Management Science *(MS)*	5	4.03%
Decision Sciences *(DS)*	3	2.42%
Journal of Business Logistics *(JBL)*	2	1.61%
Journal of Supply Chain Management *(JSCM)*	1	0.81%
Manufacturing and Service Operations Management *(MSOM)*	2	1.61%
Operations Research *(OR)*	1	0.81%
Total	124	100.00%

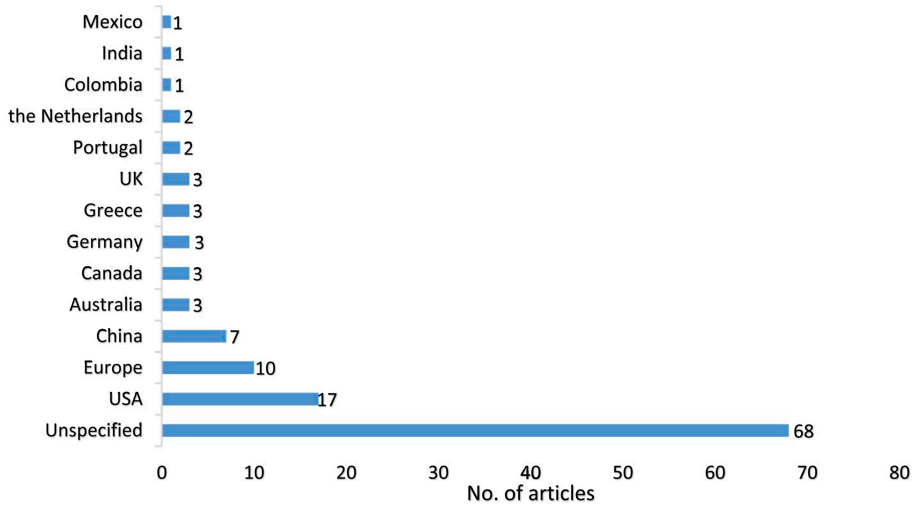

Fig. 9. Distribution of articles by country.

A screening by abstract, keywords, and full text (where appropriate) was performed with an objective of retaining the most relevant articles that cover aspects of CE in a SCM context. Articles on traditional concepts, such as "green supply chain management" (Li et al., 2020) which do not specifically focus on supply chain circularity, were not included in the final sample. Following this screening process, we retain 124 articles, which were then subjected to a descriptive and content analysis, following the guidelines by Seuring and Gold (2012).

3.2. Literature review results

3.2.1. Descriptive analysis

Fig. 8 presents the distribution of articles with respect to their publication years. It is evident that early studies around supply chain circularity and/or its associated research themes started almost two decades ago. Overall, the distribution suggests a continuing growth in the field and increasing research interest in recent years with a clear spike in the last two years.

Table 3 presents the distribution of reviewed articles across selected journals. EJOR (53) has published the highest number of relevant articles, followed by TRE (28) and POM (16). These three journals represent approximately 78% of the total articles included in the review.

The review results suggest that a vast majority of reviewed articles are modeling-based works (106 articles; 85%) while only a small percentage of articles use empirical (11 articles; approx. 9%) and conceptual/theoretical (7 articles; approx. 6%) methods. Given the methodological preferences of the selected journals, we expected that most reviewed papers would be modeling-based work. However, it is still a surprise to see the extent of underrepresentation of empirical work.

Fig. 9 presents the distribution of the number of articles by the countries where the research was conducted. Clearly, the United States of America (USA) tops the list of individual countries leading the CSCM research. However, Europe as a region (including publications mentioning Europe only besides specific countries such as the United Kingdom, Germany, Greece, Portugal, the Netherlands, etc.) surpasses the United States. China also plays an important role in the research domain. More than half of the reviewed articles do not specify a research context mainly because they are modeling-based work and do not report real-life

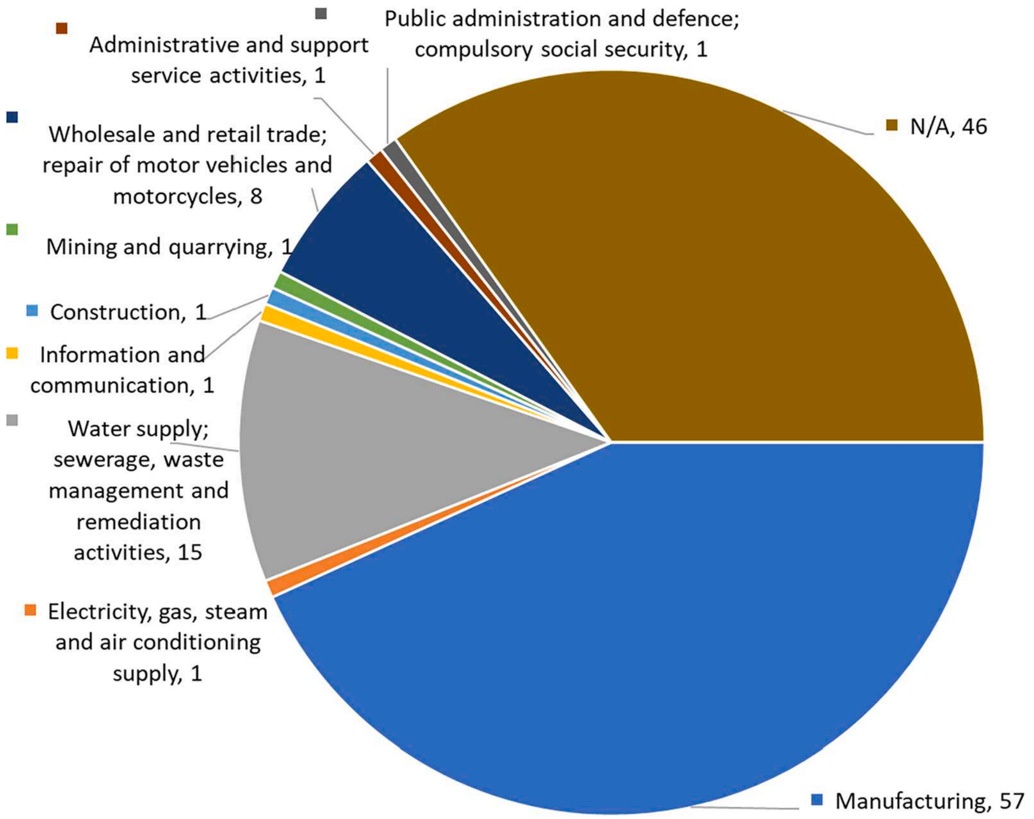

Fig. 10. Distribution of articles by industry.

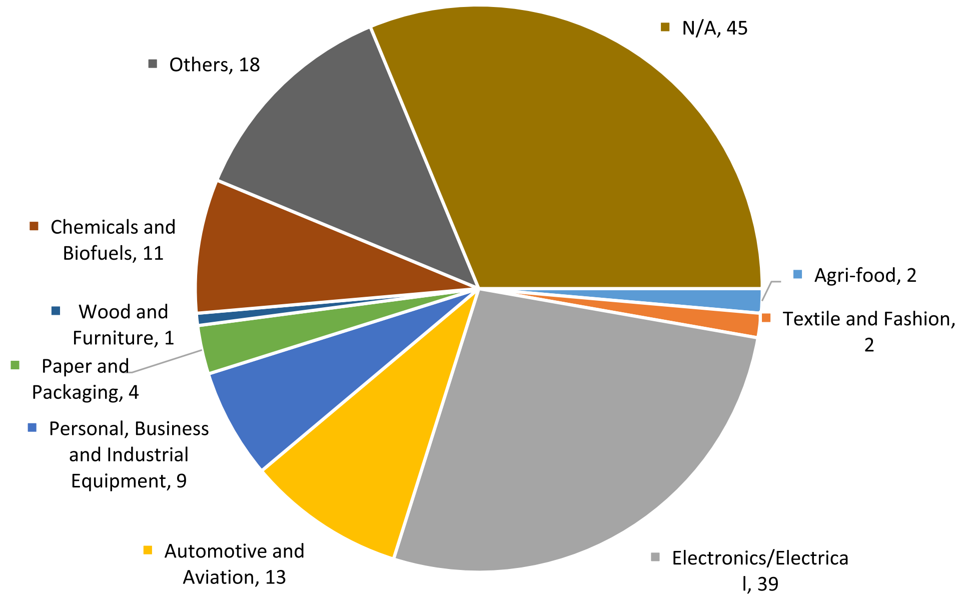

Fig. 11. Distribution of articles by product sector.

applications.

The industry-wide distribution of the reviewed articles is presented in Fig. 10. The results indicate that manufacturing (57) has been the most prominent industrial context of the reviewed studies. Other noticeable sectors include water supply, sewerage, waste management and remediation activities (15), wholesale and retail trade and repair of motor vehicles and motorcycles (8). Many

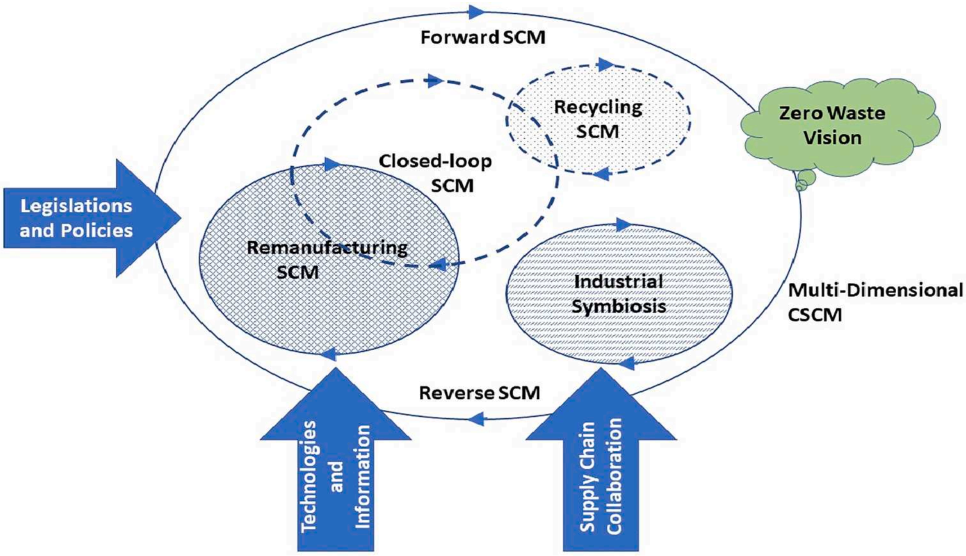

Fig. 12. A multi-dimensional CSCM (MD-CSCM) framework.

reviewed articles did not specify an industrial context.

Fig. 11 illustrates the distribution of articles by their relevant product sectors. Of the articles that specify a product sector context, electronics/electrical (39) receives the most attention, followed by automotive and aviation, chemicals and biofuel, and personal, business and industrial equipment.

3.2.2. Multi-dimensional CSCM framework

We follow the same content analysis approach (Neuendorf, 2019) as described in Section 2 to analyze each academic article included in the sample. Based on a synthesis of knowledge in the reviewed case studies and academic publications, we develop a multi-dimensional CSCM (MD-CSCM) framework, as shown in Fig. 12. The framework includes eight research themes that emerge from the content analysis and depicts the relationships between the related concepts. Each research theme includes a range of specific topics that are closely related to each other within the research theme. Five research themes are at the center of the framework, which correspond to the five dimensions of CSCM identified in the review; namely, closed-loop SCM, reverse SCM, remanufacturing SCM, recycling SCM, and industrial symbiosis. Each CSCM dimension has its distinctive pattern of resource flows for achieving resource circularity within and across supply chains. The framework also includes "legislations and policies" as a key driver of CSCM, and "technologies and information" and "supply chain collaboration" as two enablers. They jointly facilitate the multiple dimensions of CSCM to advance supply chain circularity toward a zero-waste vision.

The forward SCM has been the focus of traditional SCM research and practice, covering activities in a linear direction, i.e., from raw materials acquisition, inbound logistics, production, distribution, retail, to consumption. In contrast, the reverse SCM focuses on the management of reverse logistics and value recovery activities from commercial returns, end-of-use products, and end-of-life products (Guide & Van Wassenhove, 2009). Forward SCM and reverse SCM are represented by forward and reverse arrows, respectively, in Fig. 12. Obviously, CSCM, along with its dimensions of closed-loop SCM, remanufacturing SCM, recycling SCM, and industrial symbiosis, must integrate forward SCM and reverse SCM to realize supply chain circularity.

As mentioned in the review of the case studies in Section 2, circularity archetypes can be classified as closed-loop circularity and open-loop circularity depending on how resources are looped back for reuse. Supply chain circularity can be achieved by either closed-loop circularity or open-loop circularity, or a combination of both (Genovese et al., 2017; Farooque, Zhang, Thürer, et al., 2019). Closed-loop SCM recovers product values by reuse, repair, reconditioning, remanufacturing, recovering parts, and recycling materials (Guide & Van Wassenhove, 2009; Ellen MacArthur Foundation, 2013). However, the extent of value recovery in closed-loop SCM is often limited as it may not be realistic to reuse all materials embedded in the returns in the same supply chains (Farooque, Zhang, Thürer, et al., 2019). Therefore, there is a need to consider open-loop circularity, i.e., to go beyond the producer's original supply chains, to recover values across different supply chains with collaborating firms in the same sector or even in other sectors. For example, industrial symbiosis facilitates waste-to-resource exchanges of materials, energy, water, and/or by-products among organizations that are often in close proximity and which work in long-term partnerships (Bansal & Mcknight, 2009; Lombardi & Laybourn, 2012). With the additional open-loop circularity, CSCM offers greater scope and more opportunities for value recovery than the traditional closed-loop SCM (Bansal & Mcknight, 2009; Genovese et al., 2017; Farooque, Zhang, Thürer, et al., 2019). Therefore, it has a great potential for advancing supply chain circularity.

Remanufacturing SCM largely overlaps with closed-loop SCM because many, but not all, remanufacturing supply chains are closed-loop supply chains. The circularity archetype of a remanufacturing supply chain can be either closed-loop circularity or open-loop circularity or a combination of both. If a producer handles all remanufacturing activities in-house, the resulting remanufacturing

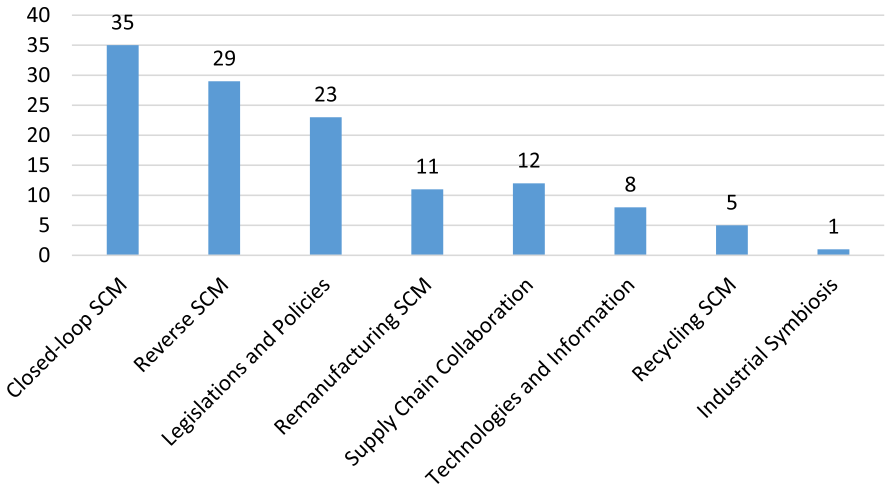

Fig. 13. Distribution of the articles by research theme.

supply chain is a closed-loop supply chain. If all remanufacturing activities are processed by one or more remanufacturers in the same sector, the resulting remanufacturing supply chain's circularity archetype changes to open-loop circularity. In cases where the original producer only remanufactures part of the returns, both circularity archetypes are present in the resulting remanufacturing supply chains.

Recycling SCM has some, but limited, overlaps with closed-loop SCM. This is because the recycling of many common materials is often not organized by the original supply chain members. Such a recycling supply chain is not a closed-loop supply chain. Nevertheless, some materials recycling activities do take place in closed-loop supply chains.

In alignment with the aforementioned key components of the MD-CSCM framework, we classify the reviewed articles into eight research themes, as summarized in Fig. 13. For an article that is related to more than one research theme, for example, both closed-loop SCM and remanufacturing SCM, it is categorized into its primary research theme. The following section analyzes each of these research themes and identifies its key contributions to the CSCM research domain.

3.2.3. Research themes

3.2.3.1. Closed-loop SCM. The closed-loop SCM concept has received considerable attention both in academia and practice for over 20 years (Van Wassenhove, 2019). It is defined as "the design, control, and operation of a system to maximize value creation over the entire life cycle of a product with dynamic recovery of value from different types and volumes of returns over time" (Guide & Van Wassenhove, 2009, p. 10). In closed-loop supply chains, products would have several useful lives, with remanufacturing steps in between, before being discarded and/or recycled (Guide & Van Wassenhove, 2003). Interested readers may refer to Guide and Van Wassenhove (2009) for an overview on the evolution of closed-loop SCM research. Nowadays, closed-loop SCM is seen in line with the CE philosophy (Fu & Meng, 2020; Ponte et al., 2019; Van Wassenhove, 2019) and constitutes an important part of CSCM (Farooque, Zhang, Thürer, et al., 2019; Genovese et al., 2017).

At the strategic level, the implementation of closed-loop SCM requires setting up appropriate logistics infrastructure to support its operations (Fleischmann et al., 2001). In this regard, the design of closed-loop supply chain networks, a crucial strategic decision, has attracted substantial scholarly attention. Past research has provided examples on the "generic" network design for closed-loop supply chains, see Yang et al. (2009) and Tao et al. (2020), as well as network design for specific product types such as aircrafts, automobiles, and large household appliances with different quality (Jeihoonian et al., 2016). The reverse flow of products in closed-loop networks induces greater levels of uncertainties at all levels of supply chain decisions compared to that of the forward flow. Consequently, researchers have made several attempts (Vahdani et al., 2012; Keyvanshokooh et al., 2016; Chan et al., 2018; Fu and Meng, 2020) to model uncertainties in closed-loop supply chains.

Note that Özceylan et al. (2014) argue that for strategic decisions, such as closed-loop supply chain network design, supply chain agents must also identify and integrate tactical and operations decisions to minimize the total cost or maximize the overall value generated. The extant literature has investigated integrated decision making in long-term capacity planning (Georgiadis and Athanasiou, 2013), inventory replenishing and capacity planning (Huynh et al., 2016), product architecture modularity (Kristianto & Helo, 2014), engineering design choices (i.e., integral versus modular design) and their implications on procurement and supplier competition (Aydinliyim & Murthy, 2016), and balancing disassembly lines (Özceylan et al., 2014).

Closed-loop supply chain operations may be viewed with a focus on the type of returns or recovery activities (Guide & Van Wassenhove, 2009). Product returns may occur for a variety of reasons over the product life cycle, including commercial returns, repair and warranty returns, end-of-use returns, and end-of-life returns (Guide & Van Wassenhove, 2006, 2009). Product recovery activities include acquisition management of used products (Cai and Choi, 2021), reverse logistics, product disposition, remanufacturing/repair, and remarketing (Guide & Van Wassenhove, 2003). Broadly, the extant literature considers two modes for the collection of used products from customers. These include: 1) direct collection by the manufacturer (or its supplier); 2) collection by a retailer or a third party (either coopetitive or competitive). In decentralized channel structures, providing appropriate incentives to retailers to induce used product collection is considered as the best option for original equipment manufacturers (OEMs) (Savaskan et al., 2004). Moreover, for the sake of convenience, manufacturers typically outsource the end-of-use product collection to retailers if they show equal levels of environmental and operational performances (De Giovanni and Zaccour, 2014).

However, the competition in the reverse channels of closed-loop supply chains is getting fierce because of the high salvage value of the end-of-use products (He et al., 2019). In general, manufacturers lack motivation for recovery operations such as remanufacturing due to their concerns related to cost (e.g., higher transportation and inventory costs) and brand image protection (Hong et al., 2017). This gives third-party remanufacturers an opportunity to become involved in remanufacturing which inevitably brings a competitive threat to the new products (Chen & Chang, 2012). In order to counter third-party competition, technology licensing by manufacturers using licensing strategies (fixed fee versus royalty licensing) offers a viable solution (Hong et al., 2017). Moreover, effective coordination via contract mechanism can also achieve optimal recovery efficiency in the closed-loop supply chain with competitive collections (He et al., 2019). On the other extreme, Ramani and De Giovanni (2017) present a model of an atypical closed-loop supply chain which is consistent with the Dell Reconnect project, where a manufacturer (Dell) sells new products and faces competition from a goodwill agency that acts a collector and sells used products. The study concludes that when a high "product resale value" option exists, the manufacturer should always collect through a goodwill agency.

3.2.3.2. Reverse SCM. Reverse SCM is defined as "the effective and efficient management of the series of activities required to retrieve a product from a customer and either dispose of it or recover value" (Prahinski & Kocabasoglu, 2006, p. 519). Reverse activities and reverse flows occur mainly due to commercial returns, warranty replacements, leased equipment renewals (Akçalı et al., 2009), or return of reusable articles (Vanga & Venkateswaran, 2020). Reverse activities include collection, inspection, sorting, disassembly, reprocessing/recycling, and disposal operations (Akçalı et al., 2009), whereas reverse flows start from customers and end in factory/recovery plants (Salema et al., 2010).

Several studies focus on network design decisions in the reverse channel. Interested readers may refer to Guide et al. (2006), Salema et al. (2010), and Alumur et al. (2012) for the important factors and principles for generic reverse supply chain network designs. On the other hand, industry-specific examples include designing a paper recycling network (Schweiger & Sahamie, 2013), end-of-lease computer products (Lee & Dong, 2008), and the warranty distribution network of a semiconductor company (Ashayeri et al., 2015). Reverse SCM decisions are also subject to uncertainties. First and foremost, the quality of returned products is usually uncertain, which inevitably affects the profitability of product recovery operations (Zikopoulos & Tagaras, 2007; Qin and Ji, 2010).

Similar to that of closed-loop SCM, retailer-managed collections remain a preferred reverse channel choice in various settings (Atasu et al., 2013; Savaskan & Van Wassenhove, 2006; Wu & Zhou, 2017), resulting in higher profitability through cost reduction and higher product recovery rates (Stock & Mulki, 2009). However, an increased volume of consumer returns presents significant challenges (Frei et al., 2020; Shang et al., 2020) in inventory management and control (Zolfagharinia et al., 2014), production planning (Niknejad & Petrovic, 2014), and vehicle routing (Qiu et al., 2018). Stock and Mulki (2009) emphasize the use of customer education programs that focus on training customers in the proper operation and use of the product in a bid to avoid unnecessary returns, which can be as high as 50% of the total returns in certain sectors such as consumer electronics. Alternative solutions, such as revenue sharing contracts among reverse supply chain members (Govindan & Popiuc, 2014) and trade-in pricing framework (Zhu et al., 2016), have also been proposed in the existing literature.

3.2.3.3. Legislations and policies. The issues and challenges related to resource scarcity and climate change have induced governments around the world to introduce various legislative, regulatory, policy, and strategic measures to improve social and environmental sustainability. Among them, the Circular Economy Directive (European Commission, 2020) of the European Union (EU) represents the most recent and the most comprehensive package, which not only encourages material circularity through recycling and remanufacturing operations but also prioritizes product reuse as the preferred activity for material recovery (Mazahir et al., 2019; Van Wassenhove, 2019). In general, the take-back laws require firms to take responsibility for the collection/disposal costs of their products (Webster & Mitra, 2007). The EU Waste Electrical and Electronic Equipment (WEEE) Directive legislates the creation of take-back systems where consumers can return their WEEE free of charge (Directive, 2012). The WEEE Directive holds the OEMs responsible for the collection, recovery, and disposal of end-of-life products (Mazahir et al., 2019). In many countries, the take-back law has been implemented in the form of Extended Producers Responsibility (EPR) regulation (Jacobs & Subramanian, 2012; Zuidwijk & Krikke, 2008). EPR is defined as an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle (OECD, 2021).

All these CE-related laws and regulations have stimulated the development of closed-loop supply chains (Georgiadis & Vlachos, 2004). Taking-back and selling remanufactured/refurbished products offer competitive advantages to manufacturers as their sales and profits increase substantially (Heese et al., 2005). However, effective implementation of take-back/EPR programs (Cai and Choi, 2021) at the firm and supply chain levels needs to consider certain strategic and operational decisions related to product recovery strategy (Zuidwijk & Krikke, 2008). At the strategic level, a manufacturer's product design decisions need to reflect life-cycle considerations while also maintaining their profitability (Subramanian et al., 2009; Zuidwijk & Krikke, 2008). Examples include product eco-design (Zuidwijk & Krikke, 2008; Xiao & Choi, 2020; Cai and Choi, 2021) and installed base management, i.e., product lease bundled with repair and maintenance services (Bhattacharya et al., 2019). In contrast, the operational level decision must consider the extent of disassembly and the type of recovery operation to be applied to the product and/or its components (Zuidwijk & Krikke, 2008). At the individual manufacturer's level, coordination between the manufacturer and customers through effective contracts is seen as a potential solution (Subramanian et al., 2009). Joint sharing of product recovery responsibility among supply chain parties can improve the overall supply chain profitability (i.e., economic and environmental benefits) as well as social welfare (Jacobs & Subramanian, 2012).

More recently, buyback and trade-in programs (Cao & Choi 2021; Dou & Choi 2021; Tang et al., 2020; Xiao et al., 2020; Xiao, 2017) have been introduced to take back used products from end-users (i.e., customers) for product and material recovery in response to take-back legislations (Cole et al., 2017). A buyback policy offers cash for a return, and a trade-in policy offers a discount to customers who seek to replace their old generation products with new ones (Cole et al., 2017; Shin et al., 2020; Mahmoudzadeh, 2020). Both buyback and trade-in programs provide firms with remanufacturing and refurbishing related benefits (Cole et al., 2017; Shin et al., 2020). Some products may also be sold in the second hand market (Guo et al., 2021). However, there is a potential cannibalization effect that occurs between new and remanufactured products which needs to be resolved by considering the optimal pricing, customers' maximum willingness to pay in the secondary market, and the production cost (Li et al., 2019).

Emissions trading regulations seek to reduce greenhouse gas emissions by imposing restrictions on emissions through the combination of government and market regulations (Yang et al., 2020). In 2005, the EU emissions trading system (EU ETS) was introduced as the world's first international emissions trading system. The EU ETS works on the "cap and trade" principle. A cap is set on the total amount of certain greenhouse gases that can be emitted by installations covered by the system. Within the cap, companies receive or buy emission allowances, which they can trade with one another as needed (European Commission, 2021).

Under stringent emissions regulations, it is vital for firms to pay attention to managing greenhouse gas emissions. Remanufacturing is highly regarded in the extant literature as an important means in the abatement of carbon emissions from the production process (Yang et al., 2020; Yenipazarli, 2016). Under the cap and trade regulation, the used products collection decision for remanufacturing (i.e., the collection by the manufacturer versus the retailer or the third party) will solely be made based on the party's unit carbon emission rather than the manufacturer's profit (Yang et al., 2020). We note that De and Giri (2020) propose models for reducing the total transportation cost with the consideration of carbon emissions in the closed-loop supply chain under the emissions regulation, such as cap and trade.

Lastly, subsidy policies either directly provide a financial incentive for the manufacturer to engage in product or material recovery such as remanufacturing or to induce customers to buy remanufactured products instead of new ones (Zhang et al., 2020). For example, in 2009, the Chinese government announced a subsidy scheme for home appliance replacements (Ma et al., 2013).

3.2.3.4. Remanufacturing SCM. Remanufacturing the returned products so that they perform as well as their new versions constitutes a higher form of recovery (Chen et al., 2015). In the past decades, remanufacturing has attracted substantial attention from researchers and practitioners (Yang et al., 2020). Extant literature reports remanufacturing closed-loop supply chains and independent third-party remanufacturing as the two major routes supporting remanufacturing operations (Martin et al., 2010). In remanufacturing closed-loop supply chains, a manufacturer (often an OEM) engages in remanufacturing itself or outsources to a third-party remanufacturer (Aras et al., 2006; Huang & Wang, 2017; Yang et al., 2020). In particular, when OEMs lack the remanufacturing motivation and/or capabilities, it creates opportunities for an independent third-party remanufacturer whose primary business is to remanufacture the end-of-use products of the major OEMs within a given industry (Chen & Chang, 2012). To deter competition from independent third-party remanufacturers, some OEMs adopt prohibitive pricing of the proprietary spare parts (Kleber, Neto, et al., 2020) or intentionally design the products to be non-remanufacturable (Shi et al., 2020).

Remanufacturing is generally regarded as a profitable business, which does, however, require some important considerations at the strategic level. First, remanufacturing should always benefit an integrated manufacturer once the remanufacturing cost is sufficiently low to overcome the negative cannibalization effect (Xiong et al., 2013). Second, the centralization of manufacturing and remanufacturing operations greatly influences manufacturing design decisions and profitability (Shi et al., 2020). Third, for non-integrated manufacturers or component suppliers, remanufacturing may constitute a lose-lose situation, making their profits lower than if remanufacturing was not implemented (Xiong et al., 2013). For OEMs, the potential cannibalization effect induced by remanufactured products on new product sales and uncertainties about the volume and quality of returned products remain the major challenges deterring the in-house remanufacturing capability development (Chen et al., 2015). In this regard, several attempts have been made to develop forecasting approaches that enable firms to make better and more accurate predictions; see Tsiliyannis (2018), Clottey et al. (2012), and Goltsos et al. (2019) for forecasting models for remanufacturing operations. Similarly, practice-oriented approaches such as seeding – selling new products as remanufactured at the start of a new product's life-cycle – have been reported in the extant literature, providing benefits to OEMs in terms of increased core recovery quantities, enabling the efficient remanufacturing earlier, and enhancing OEMs' ability to fulfill demands for remanufactured products throughout the product's life-cycle (Abbey et al., 2019).

3.2.3.5. Supply chain collaboration. The extant literature strongly advocates coordination and cooperation among supply chain members for material circularity. By cooperating, reverse supply chain members can collectively enhance their competitiveness and performance (Sheu & Gao, 2014). The need to coordinate manufacturing and remanufacturing operations simultaneously has been increasingly recognized by firms (Aras et al., 2006; Xiong et al., 2013). Effective coordination in closed-loop supply chains is seen to benefit all members (De Giovanni et al., 2016; Zheng et al., 2019). Examples of cooperation include technology licensing and the R&D joint venture mechanisms between OEMs and independent remanufacturers (Wu & Kao, 2018), and cooperation between manufacturers and reverse logistics service providers for waste recycling and resource-sharing activities (Sheu & Gao, 2014).

Problems may arise when members in closed-loop supply chains have non-aligned objectives (Souza, 2013), leading to competition among supply chain members for recovery operations and sales in the secondary market (Borenich et al., 2020; Kleber, Reimann, et al., 2020). De Giovanni (2018) suggests joint maximization to align the motivation of firms to close the material loops so as to achieve a triple bottom line.

3.2.3.6. Technologies and information. Value of information focuses on how information can be used to improve performance in supply chains where product returns and reuse cause a great deal of uncertainty with respect to demand, product return, product recovery (Ketzenberg et al., 2006), and capacity utilization (Ketzenberg, 2009). Hosoda et al. (2015) find that closed-loop supply chains with advance notice of product return not only reduce inventory variance but also can avoid the lead time paradox and the fundamental trade-off between the volume of return and dynamic supply chain performance. Huang and Wang (2017) compare manufacturer remanufacturing with supplier remanufacturing under four information-sharing scenarios, ranging from no information sharing to full information sharing. They find that information sharing benefits both the supplier and the manufacturer, while it is detrimental to the retailer due to the double marginalization effect.

A decision support system (DSS) aids firms and businesses in decision-making processes that involve determinations, judgments, and courses of action (Investopedia, 2020). The proper deployment of DSSs has shown improvements in productivity and competitiveness in reverse supply chains (Repoussis et al., 2009). Similarly, Koh et al. (2017) establish a circular framework for supply chain resource sustainability and provide a decision-support methodology for assessing resource sustainability against its foundational premises.

In recent years, internet-based platforms have enabled buyers and sellers to connect with each other conveniently. Examples include online material and waste exchanges such as MNExchange.org (Dhanorkar et al., 2015) and online matching platforms such as Craigslist, FreeCycle and Gumtree (Dhanorkar, 2019). Using such platforms, sellers of surplus materials can post items for sale (Cai et al., 2020), and buyers can contact sellers directly to obtain additional information before making a possible transaction (Dhanorkar et al., 2015). This not only promotes reuse behavior in general, it also helps in limiting reliance on recycling and other disposal alternatives (Dhanorkar, 2019).

3.2.3.7. Recycling SCM. Recycling probably has the longest history among all types of value recovery options. Recycling of common materials found in municipal solid waste (i.e., paper, plastic, metals, and glass) is considered as the most desirable (environmentally and/or financially) recovery option (Cui & Sošić, 2019). At present, recycling the material content of returns is a more prevalent form of value recovery than refurbishing and remanufacturing (Chen et al., 2015). It has been advocated as a strategic supply source (Raz & Souza, 2018). Scavenging (informal waste recycling activities), which is often regarded as detrimental to the formal waste recovery system, can be beneficial to economic, environmental, and social sustainability if it is legislated appropriately (Besiou et al., 2012). Esenduran et al. (2020) suggest that a recycler's preference over two certification standards, namely, "e-Stewards" and "Responsible Recycling", may change depending on competition in recovery channels and waste processing scale economies.

3.2.3.8. Industrial symbiosis. Compared to conventional supply chains where waste reduction efforts occur mainly at the firm and supply chain levels, industrial symbiosis emphasizes reuse, recycling, and reprocessing by-products and intermediates within the entire ecosystem of firms within and outside the original supply chain (Bansal & Mcknight, 2009). Although industrial symbiosis has a higher potential to advance supply chain sustainability and circularity to a larger scope, it receives little attention in the existing literature.

4. Research-practice gaps and future research directions

4.1. Research-practice gaps

Due to the nature of non-probability case sampling, it is not valid to apply statistical inference on the case analysis results for generalization. However, the case studies collection of the Ellen MacArthur Foundation does depict a big picture of the state-of-the-art CE implementations in practice. Our comparisons of the reviewed research and real-life practices reveal the following noticeable research-practice gaps.

Research-practice gap #1: An overwhelming majority (85%) of research studies published in the sampled journals are mathematical modeling works. Empirical and conceptual/theoretical works are seriously underrepresented. Furthermore, most modeling studies have no reference to specific industry/product contexts or real-life applications. There is an obvious disconnect between academic research and practice. Given that the pathways to circularity highly depend on a product's material composition and supply chain contexts, such omissions of contexts are likely to undermine the validity and relevance of the modeling results.

Research-practice gap #2: The closed-loop dimension of CSCM has been recognized and studied by academic researchers. The importance of industrial symbiosis in a CE has been acknowledged (Bansal & Mcknight, 2009), and the efficacy of using the open-loop circularity archetype has been reported in many real-life cases. However, supply chain researchers have not conducted much research on industrial symbiosis and its associated open-loop circularity archetype, which cover a much wider scope and have greater potential for improving circularity. Consequently, research on CSCM has rarely touched cross-sector collaboration, which is a key characteristic of industrial symbiosis in practice.

Research-practice gap #3: The review of practices shows the CE concept has been implemented in a very wide range of industry sectors. However, academic research has covered comparatively fewer industry sectors and are mainly focused on manufacturing, water supply, sewerage, waste management and remediation activities, and wholesale and retail trade and repair of motor vehicles and motorcycles. We need more studies on the primary industry sectors (for example, agriculture, fishing, forestry, and mining) and some service sectors (such as renting and leasing and financial and insurance services). In practice, these industry sectors are also important stakeholders in a CE. For instance, food waste in agriculture can be used for composting and/or producing biogas. In Nike, pineapple leaves are processed and used to produce sneakers[3]. Renting and leasing services enable a sharing economy, which is often practiced in synergy with a CE (Choi et al., 2020).

Research-practice gap #4: Most studies have concentrated on specific product sectors such as electronics/electrical, automotive and aviation, chemicals and biofuels, and personal, business and industrial equipment. There is no doubt that these products deserve attention because they are of high value and/or may cause great harm to the environment if not properly disposed of after use. Nevertheless, this cannot justify the negligence of other product sectors which are making great efforts toward a CE as shown in our case sample, including agri-food, textile and fashion, and wood and furniture. In connection with this negligence, there is little research on the management of regenerative cycles for biological materials, although their importance in comparison with the restorative cycles for technical materials in a CE is almost equal.

Research-practice gap #5: Academic research has mainly addressed the primary concerns about environmental and economic performance in a CE, but it has not dealt extensively with the implications of CE for social sustainability and supply chain resilience. Our sample of cases suggests that a considerable number of organizations implement the CE practice to create local employment opportunities and to increase diversity in the labor force. Another major incentive is to secure supply sources and to reduce risks from supply chain disruptions (Raz & Souza, 2018).

4.2. Future research directions

Supply chain research has made great strides in the field of resource circularity. In fact, research in the closed-loop SCM started about two decades ago, even before the CE concept became widely known. Nevertheless, the journey ahead to a CE is going to be a marathon, and further research efforts are required in the quest for supply chain circularity. Based on the research-practice gaps identified above and ongoing research needs, we call for supply chain research in the following directions.

1) **Empirically-driven research**: To narrow the research-practice gaps, we urge more empirical research and/or mathematical modeling work that is driven by real-life practice. Such research is more likely to generate insights and guidelines for industry practitioners and government agencies to further advance a CE operation. For example, case studies of circular business models and technological solutions and survey studies can shed light on the relationships between variables for theory building and testing.
2) **Context-specific studies**: Pathways to circularity are dependent on the technical attributes of products and their embedded materials, as well as the industrial and regional contexts in which the supply chains operate. Therefore, it is necessary to give due attention to contexts, which is absent in most modeling work in the extant literature. In particular, more research can be conducted in the context of primary and service industries. More attention also needs to be given to the product sectors that mainly use biological materials. Their value recovery operations involve a regenerative cycle, which has not gained much attention in the supply chain management field. We also note that most developing countries are lagging in their CE endeavors. Further research is needed to understand their challenges which can be quite different from those in the developed countries.
3) **Industrial Symbiosis**: Studies on closed-loop, remanufacturing, and reverse SCM dominate the extant literature on supply chain circularity. With an open-loop circularity archetype, industrial symbiosis has been proven in practice to be highly effective for achieving sustainable development goals, but it has received little attention from supply chain researchers. It deserves more attention as it offers greater scope and more opportunities for value recovery than what can be achieved in a product's original supply chain. Supply chain researchers should consider cross-disciplinary research with experts in industrial ecology for improving resource circularity.
4) **Product circularity metrics and assessment**: To understand and effectively manage the progress toward a CE, it is essential to develop appropriate circularity metrics at the product and supply chain levels. Such a task is extremely challenging due to a very wide range of products and materials being involved in highly complex and dynamic global supply chains. Supply chain researchers would benefit from multidisciplinary collaboration with researchers in environmental engineering and management, especially those specialized in life cycle assessment. This may ask for the adoption of multiple methods in conducting the related analyses (Choi et al., 2016). Researchers also need to co-operate with governments, practitioners, and technology providers to develop metrics and innovative solutions for product circularity assessment.
5) **Performance implications of CSCM**: The environmental benefits of CSCM have been widely acknowledged. In terms of economic performance, Zhu et al. (2010, 2011) suggest financial benefits, while Genovese et al. (2017) and Nasir et al. (2017) believe it may be economically challenging. More studies are required to draw a conclusion on the economic viability of CSCM. Furthermore, researchers need to conduct large-scale empirical investigations on the interplays between supply chain circularity, resilience, and social sustainability to validate the findings of some case studies.
6) **"Soft sides" of CSCM**: Much of the extant literature focuses on the "hard" aspects of CSCM, including supply chain design, processes, returns forecasting, and technological platforms. There is a need to dive deep into the "soft sides" of CSCM, including supply chain relationships, incentives, coordination, integration, collaboration, and co-opetition. For example, cross-sector collaboration plays a crucial role in industrial symbiosis, but it has been practically ignored by supply chain researchers. For future studies that focus on the "soft sides" of CSCM, it may be necessary to consider a variety of units of analysis, including a functional department, a

[3] https://vegoutmag.com/news/nike-debuts-sneakers-made-from-pineapple-leather/# (Accessed 16 July 2021)

firm, a buyer–supplier dyad, and a complete supply chain system. Depending on the unit of analysis, the concerned decision-making dynamics may vary. Therefore, different research and modeling approaches may be required.

7) **CSCM drivers, barriers, and enablers**: Extended producer reliability and take-back legislations have been key drivers to a CE in some developed countries. In response, many manufacturers and retailers have actively started to manage returns, which, in turn, have been studied by some researchers. However, more work is required to investigate the drivers to CSCM, especially in the context of developing countries which often have a weak legal infrastructure. It is equally, if not more, important to study barriers that have persisted in transitioning to CSCM (Farooque, Zhang, Thürer, et al., 2019). We also call for more empirical studies on enabling technologies and information systems, for example, blockchain-enabled CSCM (Wang et al., 2020). The case studies reviewed in Section 2, as summarized in Appendix A, report many innovations in practice on the usage of technologies to facilitate resource circularity through the secondary goods market, the sharing economy, and value recovery operations from wastes.
8) **CSCM and consumer behaviors**: Consumers play a crucial role in the transition to a CE because they determine the demand for circular products, the returns of after-use products, and waste source separation (Wang et al., 2021) for value recovery. There is a dire need to investigate how to increase consumers' acceptance of remanufactured products in CSCM. In addition, more studies are required for improving consumers' willingness to return after-use products or to give up product ownership in favor of a product-service system which is regarded as a more circular business model. Supply chain researchers should consider interdisciplinary collaboration with researchers in marketing and/or consumer psychology to tackle the challenges arising from the ever-changing consumer behaviors.

5. Conclusions

In recent years, the CE concept has become increasingly popular and has been embraced by policy makers and business leaders across the globe. The integration of circular thinking into the management of the supply chain, i.e., CSCM, advances the supply chain sustainability domain by offering a new and compelling perspective. CSCM extends the boundaries of closed-loop SCM to recover value from wastes not only in the immediate supply chains but also across different supply chains with partnering firms in the same industrial sector and/or other sectors. Given the promising vision offered by CE, this study reviews state-of-the-art research and practice in CSCM for understanding the current state and opportunities for future research.

This review paper makes several important contributions. First, to the best of our knowledge, no review work has attempted to compare state-of-the-art practices and research in CE. Therefore, this review is original and sheds light on this important topic from a unique perspective. Second, our review of practices offers insights on the CE implementation incentives, benefits, circularity archetypes, as well as implications for supply chain relationships and performance. Our literature review shows eight distinctive but interrelated research themes on CSCM: closed-loop SCM, reverse SCM, legislations and policies, remanufacturing SCM, supply chain collaboration, technology and information, recycling SCM, and industrial symbiosis. A disconnect between research and practice is identified through our comparative review. Third, a framework of multi-dimensional CSCM is developed based on a synthesis of knowledge in the reviewed case studies and academic publications. The framework establishes the relationships of multiple dimensions of CSCM. Last but not least, future research directions are discussed. They provide guidance for researchers on how to advance this active research domain further, especially in addressing the research-practice gaps.

This paper has its limitations. It only covers academic literature from eleven high-ranking journals in operations and supply chain management that we selected. The review of real-life CE implementation cases is limited to the case studies collected by the Ellen MacArthur Foundation. As the research domain of CE and CSCM is highly active, there will be a need to update this review after several years.

CRediT authorship contribution statement

Abraham Zhang: Conceptualization, Methodology, Project administration, Formal analysis, Writing – original draft, Writing – review & editing. **Jason X. Wang:** Formal analysis, Writing – original draft. **Muhammad Farooque:** Formal analysis, Writing – original draft. **Yulan Wang:** Methodology, Formal analysis, Writing – review & editing. **Tsan-Ming Choi:** Conceptualization, Methodology, Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

Table A1
List of sample cases in this study

Case Title	Case Company
Increasing clothing use through subscription	Circos
Closing the loop on single-use food packaging	Biopak
City and industry in collaboration to save clothes from landfill	New York City: The #WearNext Campaign
Bringing office furniture full circle	Ahrend
Redesigning medium-life bulky products from scratch	DSM-Niaga
Creating new value and saving city and business costs	Austin
An open access circular supply chain for fashion	Teemill
The online platform for scaling reuse	Trove
A Second Life: returns management, parts recovery and product repairs	CoreCentrics
Creating a reverse logistics ecosystem	HP Brazil & Sinctronics
Achieving reuse at scale in the fast moving consumer goods sector	Braiform
Conserving materials for the next mobility revolution	GEM China
Scaling up remanufacturing	Huadu Worldwide Transmission
Bike sharing with Chinese characteristics	Mobike
A wardrobe in the cloud	Ycloset
Valorising a costly waste stream	Palm Silage and Phoenix City
A more circular music experience	Gerrard Street
Borrow stuff you need. Lend stuff you don't.	Fat Lama
Customizable packaging platform for liquid concentrates	Replenish
Data-backed stories that drive change	Winnow
Closing the Nutrient Loop	Ostara
Effective water systems for urban circularity	Biopolus
Saving our seas, one factory at a time	Agriprotein
High yields, high above the city	Lufa Farms
Pre-consumer waste' - a GBP 1.9 billion opportunity awaits	eStoks
Unlocking the circular potential of the steel industry	ArcelorMittal
Full spectrum circularity in the apparel industry	AHLMA
Artisanal network turns corporate waste into quality goods	Rede Asta
Bio-based material for single-use food containers	Já fui Mandioca
Improving income levels of Indian farmers through better access to information	ITC (e-Choupa)
Bringing printing as a service to the home	HP
Synergistic food production space	The Plant
Finding rare earth elements above ground, not underground	Urban Mining Company
Air conditioning as a service reduces building carbon emissions	Kaer
Short-loop recycling of plastics in vehicle manufacturing	Renault
Financing the expansion of circular business models	JLG & DLL
A mobility revolution in Wales	Riversimple
Regenerative agriculture at scale	Balbo Group
Brewing beer from surplus bread	Toast Ale
The circular economy and the promise of glass in concrete	Google
How refurbishment can work, even when safety and performance matter the most	DLL Group
How tool sharing could become a public utility	Toronto Tool Library and Makerspace
Finding a fast fashion business model that lasts	Better World Fashion
Scotland: Increasing customer confidence in reused products	Zero Waste Scotland
Increasing diversity, building resilience	British Sugar plc
The final stop for quality furniture	Kaiyo
A new circular approach towards paper use in the digital era	REEP Technologies Ltd.
Remanufacturing of refuse vehicles	Refuse Vehicle Solutions
Denmark: Public procurement as a circular economy enabler	Danish Environmental Protection Agency
Effective industrial symbiosis	Kalundborg Symbiosis
Business-to-business asset sharing	FLOOW2
Cradle to Cradle design of carpets	Desso
Retailer shifts to remanufacturing	GameStop
Production of nylon yarn from waste materials	Aquafil
Techniques for rapid, non-destructive disassembly	Active Disassembly
Growing alternatives to petroleum-based packaging	Ecovative
Collection, refurbishment and resale of mobile phone handsets	Mazuma Mobile
Unlocking value from used cooking oils	Brocklesby
Remanufacturing in the automotive industry	Autocraft Drivetrain Solutions
Pioneering a lease model for organic cotton jeans	MUD Jeans
Using Product Passports to improve the recovery and reuse of shipping steel	Maersk Line
United Kingdom: Bringing industry together to tackle food packaging waste	Waste & Resources Action Programme
Selling light as a service	Philips & Turntoo
Design and business model considerations for heavy machinery remanufacturing	Caterpillar
Increasing post-consumer plastic content in packaging	Coca-Cola Enterprises
Circular economy options in office furnishing	Rype Office
A model offering multiple benefits for multiple electronic products	Bundles
Establishing a reverse supply chain for electronics	Re-Tek

References

Abbey, J.D., Geismar, H.N., Souza, G.C., 2019. Improving remanufacturing core recovery and profitability through seeding. Production and Operations Management 28 (3), 610–627. https://doi.org/10.1111/poms.2019.28.issue-310.1111/poms.12937.

Akçalı, E., Çetinkaya, S., Üster, H., 2009. Network design for reverse and closed-loop supply chains: An annotated bibliography of models and solution approaches. Networks 53 (3), 231–248 https://doi.org/https://doi.org/10.1002/net.20267.

Alumur, S.A., Nickel, S., Saldanha-da-Gama, F., Verter, V., 2012. Multi-period reverse logistics network design. Eur. J. Oper. Res. 220 (1), 67–78 https://doi.org/https://doi.org/10.1016/j.ejor.2011.12.045.

Aras, N., Verter, V., Boyaci, T., 2006. Coordination and priority decisions in hybrid manufacturing/remanufacturing systems. Production and Operations Management 15 (4), 528–543. https://doi.org/10.1111/j.1937-5956.2006.tb00161.x.

Ashayeri, J., Ma, N., Sotirov, R., 2015. The redesign of a warranty distribution network with recovery processes. Transportation Research Part E: Logistics and Transportation Review 77, 184–197 https://doi.org/https://doi.org/10.1016/j.tre.2015.02.017.

Atasu, A., Toktay, L.B., Van Wassenhove, L.N., 2013. How collection cost structure drives a manufacturer's reverse channel choice. Production and Operations Management 22 (5), 1089–1102. https://doi.org/10.1111/j.1937-5956.2012.01426.x.

Aydinliyim, T., Murthy, N.N., 2016. Managing engineering design for competitive sourcing in closed-loop supply chains. Decision Sciences 47 (2), 257–297. https://doi.org/10.1111/deci.12164.

Bansal, P., Mcknight, B., 2009. Looking forward, pushing back and peering sideways: Analyzing the sustainability of industrial symbiosis. Journal of Supply Chain Management 45 (4), 26–37. https://doi.org/10.1111/j.1745-493X.2009.03174.x.

Besiou, M., Georgiadis, P., Van Wassenhove, L.N., 2012. Official recycling and scavengers: Symbiotic or conflicting? European Journal of Operational Research 218 (2), 563–576 https://doi.org/https://doi.org/10.1016/j.ejor.2011.11.030.

Bhattacharya, S., Robotis, A., Van Wassenhove, L.N., 2019. Installed base management versus selling in monopolistic and competitive environments. Eur. J. Oper. Res. 273 (2), 596–607 https://doi.org/https://doi.org/10.1016/j.ejor.2018.08.038.

Borenich, A., Dickbauer, Y., Reimann, M., Souza, G.C., 2020. Should a manufacturer sell refurbished returns on the secondary market to incentivize retailers to reduce consumer returns? European Journal of Operational Research 282 (2), 569–579 https://doi.org/https://doi.org/10.1016/j.ejor.2019.09.049.

Braiform. (2017). Achieving re-use at scale in the fast moving consumer goods sector. Ellen MacArthur Foundation Case Studies. https://www.ellenmacarthurfoundation.org/case-studies/achieving-re-use-at-scale-in-the-fast-moving-consumer-goods-sector.

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 (23), 7395–7422. https://doi.org/10.1080/00207543.2018.1542176.

Cai, Y.J., Choi, T.M., 2021. Extended producer responsibility: a systematic review and innovative proposals for improving sustainability. IEEE Trans. Eng. Manage. 68 (1), 272–288. https://doi.org/10.1109/TEM.1710.1109/TEM.2019.2914341.

Cai, Y.J., Choi, T.M., Feng, L., Li, Y., 2021a. Producer's choice of design-for-environment under environmental taxation. Eur. J. Oper. Res. https://doi.org/10.1016/j.ejor.2021.04.048.

Cai, Y.J, Choi, T.M., Zhang, J., 2021b. Platform supported supply chain operations in the blockchain era: supply contracting and moral hazards. Decision Sciences 52 (4), 866–892. https://doi.org/10.1111/deci.v52.410.1111/deci.12475.

Cai, Y.J., Choi, T.M., Zhang, T., 2021c. Commercial used apparel collection operations in retail supply chains. Eur. J. Oper. Res. https://doi.org/10.1016/j.ejor.2021.05.021.

Cao, K.Y., Choi, T.M., 2021. Optimal trade-in-return policies: is it wise to be generous? Production and Operations Management accepted in 2021.

Chan, C.K., Zhou, Y., Wong, K.H., 2018. A dynamic equilibrium model of the oligopolistic closed-loop supply chain network under uncertain and time-dependent demands. Transportation Research Part E: Logistics and Transportation Review 118, 325–354 https://doi.org/https://doi.org/10.1016/j.tre.2018.07.008.

Chen, R., Roma, P., 2011. Group buying of competing retailers. Production and Operations Management 20 (2), 181–197. https://doi.org/10.1111/j.1937-5956.2010.01173.x.

Chen, W., Kucukyazici, B., Verter, V., Jesús Sáenz, M., 2015. Supply chain design for unlocking the value of remanufacturing under uncertainty. Eur. J. Oper. Res. 247 (3), 804–819 https://doi.org/https://doi.org/10.1016/j.ejor.2015.06.062.

Choi, T.M., Cheng, T.C.E., Zhao, X., 2016. Multi-methodological research in operations management. Production and Operations Management 25 (3), 379–389. https://doi.org/10.1111/poms.12534.

Choi, T.M., Taleizadeh, A.A., Yue, X., 2020. Game theory applications in production research in the sharing and circular economy era. Int. J. Prod. Res. 58 (1), 118–127. https://doi.org/10.1080/00207543.2019.1681137.

Choi, T.M., Wallace, S.W., Wang, Y., 2018. Big data analytics in operations management. Production and Operations Management 27 (10), 1868–1883. https://doi.org/10.1111/poms.12838.

Clottey, T., Benton Jr., W.C., Srivastava, R., 2012. Forecasting product returns for remanufacturing operations. Decision Sciences 43 (4), 589–614. https://doi.org/10.1111/j.1540-5915.2012.00362.x.

Enterprises, Coca-Cola, 2017. Increasing post-consumer plastic content in packaging. Ellen MacArthur Foundation Case Studies. https://www.ellenmacarthurfoundation.org/case-studies/increasing-post-consumer-plastic-content-in-packaging.

Cole, D., Mahapatra, S., Webster, S., 2017. A comparison of buyback and trade-in policies to acquire used products for remanufacturing. Journal of Business Logistics 38 (3), 217–232. https://doi.org/10.1111/jbl.2017.38.issue-310.1111/jbl.12159.

Cui, H., Sošić, G., 2019. Recycling common materials: Effectiveness, optimal decisions, and coordination mechanisms. European Journal of Operational Research 274 (3), 1055–1068 https://doi.org/https://doi.org/10.1016/j.ejor.2018.11.010.

De, M., Giri, B.C., 2020. Modelling a closed-loop supply chain with a heterogeneous fleet under carbon emission reduction policy. Transportation Research Part E: Logistics and Transportation Review 133, 101813 https://doi.org/https://doi.org/10.1016/j.tre.2019.11.007.

De Giovanni, P., 2018. A joint maximization incentive in closed-loop supply chains with competing retailers: The case of spent-battery recycling. Eur. J. Oper. Res. 268 (1), 128–147 https://doi.org/https://doi.org/10.1016/j.ejor.2018.01.003.

De Giovanni, P., Reddy, P.V., Zaccour, G., 2016. Incentive strategies for an optimal recovery program in a closed-loop supply chain. Eur. J. Oper. Res. 249 (2), 605–617 https://doi.org/https://doi.org/10.1016/j.ejor.2015.09.021.

De Giovanni, P., Zaccour, G., 2014. A two-period game of a closed-loop supply chain. Eur. J. Oper. Res. 232 (1), 22–40 https://doi.org/https://doi.org/10.1016/j.ejor.2013.06.032.

Dhanorkar, S., 2019. Environmental benefits of internet-enabled C2C closed-loop supply chains: A quasi-experimental study of craigslist. Manage. Sci. 65 (2), 660–680. https://doi.org/10.1287/mnsc.2017.2963.

Dhanorkar, S., Donohue, K., Linderman, K., 2015. Repurposing materials and waste through online exchanges: Overcoming the last hurdle. Production and Operations Management 24 (9), 1473–1493. https://doi.org/10.1111/poms.12345.

Directive. (2012). Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE) Text with EEA relevance. EUR-Lex.. https://eur-lex.europa.eu/eli/dir/2012/19/oj.

Dou, G., Choi, T.M., 2021. Will implementing trade-in and green technology together do more harm than good to the environment? Eur. J. Oper. Res. 295, 517–533.

e-Choupal. (2017). Improving income levels of Indian farmers through better access to information. Ellen MacArthur Foundation Case Studies. https://www.ellenmacarthurfoundation.org/case-studies/improving-income-levels-of-indian-farmers-through-better-access-to-information.

Ellen MacArthur Foundation. (2013). Towards the circular economy. https://www.ellenmacarthurfoundation.org/circular-economy/concept.

Ellen MacArthur Foundation. (2015). Towards a Circular Economy: Business rationale for an accelerated transition. https://www.ellenmacarthurfoundation.org/assets/downloads/publications/TCE_Ellen-MacArthur-Foundation_26-Nov-2015.pdf.

Esenduran, G., Lin, Y.T., Xiao, W., Jin, M., 2020. Choice of electronic waste recycling standard under recovery channel competition. Manufacturing & Service Operations Management 22 (3), 495–512. https://doi.org/10.1287/msom.2018.0750.

eStoks. (2017). 'Pre-consumer waste'—A GBP 1.9 billion opportunity awaits. Ellen MacArthur Foundation Case Studies. https://www.ellenmacarthurfoundation.org/case-studies/pre-consumer-waste-a-gbp-1-9-billion-opportunity-awaits.

European Commission. (2020). Communication from the commission to the European parliament, the council, the European economic and social committee and the committee of the regions. A new Circular Economy Action Plan. For a cleaner and more competitive Europe. EUR-Lex. https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN.

European Commission, 2021. EU Emissions Trading System (EU ETS). European Commission. https://ec.europa.eu/clima/policies/ets_en.

Farooque, M., Zhang, A., Liu, Y., 2019. Barriers to circular food supply chains in China. Supply Chain Management: An International Journal 24 (5), 677–696 https://doi.org/https://doi.org/10.1108/SCM-10-2018-0345.

Farooque, M., Zhang, A., Thürer, M., Qu, T., Huisingh, D., 2019. Circular supply chain management: A definition and structured literature review. J. Cleaner Prod. 228, 882–900 https://doi.org/https://doi.org/10.1016/j.jclepro.2019.04.303.

Fleischmann, M., Beullens, P., Bloemhof-Ruwaard, J.M., Van Wassenhove, L.N., 2001. The impact of product recovery on logistics network design. Production and Operations Management 10 (2), 156–173. https://doi.org/10.1111/j.1937-5956.2001.tb00076.x.

FLOOW2. (2017). Business-to-business asset sharing. Ellen MacArthur Foundation Case Studies. https://www.ellenmacarthurfoundation.org/case-studies/business-to-business-asset-sharing.

Frei, R., Jack, L., & Brown, S. (2020). Product returns: A growing problem for business, society and environment. International Journal of Operations & Production Management, 40(10), 1613-1621. https://doi.org/10.1108/IJOPM-02-2020-0083.

Fu, L., Meng, F., 2020. A human disease transmission inspired dynamic model for closed-loop supply chain management. Transportation Research Part E: Logistics and Transportation Review 134, 101832 https://doi.org/https://doi.org/10.1016/j.tre.2019.101832.

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(Part B), 344-357. https://doi.org/https://doi.org/10.1016/j.omega.2015.05.015.

Georgiadis, P., Athanasiou, E., 2013. Flexible long-term capacity planning in closed-loop supply chains with remanufacturing. Eur. J. Oper. Res. 225 (1), 44–58 https://doi.org/https://doi.org/10.1016/j.ejor.2012.09.021.

Georgiadis, P., Vlachos, D., 2004. The effect of environmental parameters on product recovery. Eur. J. Oper. Res. 157 (2), 449–464 https://doi.org/https://doi.org/10.1016/S0377-2217(03)00203-0.

Goltsos, T.E., Syntetos, A.A., van der Laan, E., 2019. Forecasting for remanufacturing: The effects of serialization. J. Oper. Manage. 65 (5), 447–467. https://doi.org/10.1002/joom.v65.510.1002/joom.1031.

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 (1–2), 278–311. https://doi.org/10.1080/00207543.2017.1402141.

Govindan, K., Popiuc, M.N., 2014. Reverse supply chain coordination by revenue sharing contract: A case for the personal computers industry. Eur. J. Oper. Res. 233 (2), 326–336 https://doi.org/https://doi.org/10.1016/j.ejor.2013.03.023.

Guide, V.D.R., Souza, G.C., Van Wassenhove, L.N., Blackburn, J.D., 2006. Time value of commercial product returns. Manage. Sci. 52 (8), 1200–1214 http://www.jstor.org.ezproxy.aut.ac.nz/stable/20110594.

Guide, V.D.R., Van Wassenhove, L.N., 2003. Business aspects of closed-loop supply chains, Vol. 12. Carnegie Mellon University Press.

Guide, V.D.R., Van Wassenhove, L.N., 2006. Closed-loop supply chains: An introduction to the feature issue (Part 1). Production and Operations Management 15 (3), 345–350 https://doi.org/https://doi.org/10.1111/j.1937-5956.2006.tb00249.x.

Guide, V.D.R., Van Wassenhove, L.N., 2009. The evolution of closed-loop supply chain research. Oper. Res. 57 (1), 10–18 http://www.jstor.org.ezproxy.aut.ac.nz/stable/25614727.

Guo, S., Choi, T.M., Zhang, J., 2021. Second-hand-clothing imports in least-developed-countries: Impacts on local clothing manufacturing and remedial measures. IEEE Trans. Eng. Manage. https://doi.org/10.1109/TEM.2021.3061528.

He, Q., Wang, N., Yang, Z., He, Z., Jiang, B., 2019. Competitive collection under channel inconvenience in closed-loop supply chain. Eur. J. Oper. Res. 275 (1), 155–166. https://doi.org/10.1016/j.ejor.2018.11.034.

Heese, H.S., Cattani, K., Ferrer, G., Gilland, W., Roth, A.V., 2005. Competitive advantage through take-back of used products. Eur. J. Oper. Res. 164 (1), 143–157 https://doi.org/https://doi.org/10.1016/j.ejor.2003.11.008.

Hong, X., Govindan, K., Xu, L., Du, P., 2017. Quantity and collection decisions in a closed-loop supply chain with technology licensing. Eur. J. Oper. Res. 256 (3), 820–829 https://doi.org/https://doi.org/10.1016/j.ejor.2016.06.051.

Hosoda, T., Disney, S.M., Gavirneni, S., 2015. The impact of information sharing, random yield, correlation, and lead times in closed loop supply chains. Eur. J. Oper. Res. 246 (3), 827–836 https://doi.org/https://doi.org/10.1016/j.ejor.2015.05.036.

HP Brazil & Sinctronics, 2017. Creating a reverse logistics ecosystem. Ellen MacArthur Foundation Case Studies. https://www.ellenmacarthurfoundation.org/case-studies/creating-a-reverse-logistics-ecosystem.

Huang, Y., Wang, Z., 2017. Values of information sharing: A comparison of supplier-remanufacturing and manufacturer-remanufacturing scenarios. Transportation Research Part E: Logistics and Transportation Review 106, 20–44 https://doi.org/https://doi.org/10.1016/j.tre.2017.07.015.

Huynh, C.H., So, K.C., Gurnani, H., 2016. Managing a closed-loop supply system with random returns and a cyclic delivery schedule. Eur. J. Oper. Res. 255 (3), 787–796 https://doi.org/https://doi.org/10.1016/j.ejor.2016.05.035.

Investopedia. (2020). Decision Support System—DSS. Investopedia. https://www.investopedia.com/terms/d/decision-support-system.asp.

Já Fui Mandioca, 2017. Bio-based material for single-use food containers. Ellen MacArthur Foundation Case Studies. https://www.ellenmacarthurfoundation.org/case-studies/business.

Jacobs, B.W., Subramanian, R., 2012. Sharing responsibility for product recovery across the supply chain. Production and Operations Management 21 (1), 85–100. https://doi.org/10.1111/j.1937-5956.2011.01246.x.

Jeihoonian, M., Kazemi Zanjani, M., Gendreau, M., 2016. Accelerating Benders decomposition for closed-loop supply chain network design: Case of used durable products with different quality levels. Eur. J. Oper. Res. 251 (3), 830–845 https://doi.org/https://doi.org/10.1016/j.ejor.2015.12.052.

Symbiosis, K., 2017. Effective industrial symbiosis. Ellen MacArthur Foundation Case Studies. https://www.ellenmacarthurfoundation.org/case-studies/effective-industrial-symbiosis.

Ketzenberg, M., 2009. The value of information in a capacitated closed loop supply chain. Eur. J. Oper. Res. 198 (2), 491–503 https://doi.org/https://doi.org/10.1016/j.ejor.2008.09.028.

Ketzenberg, M.E., van der Laan, E., Teunter, R.H., 2006. Value of information in closed loop supply chains. Production and Operations Management 15 (3), 393–406. https://doi.org/10.1111/j.1937-5956.2006.tb00253.x.

Keyvanshokooh, E., Ryan, S.M., Kabir, E., 2016. Hybrid robust and stochastic optimization for closed-loop supply chain network design using accelerated Benders decomposition. Eur. J. Oper. Res. 249 (1), 76–92 https://doi.org/https://doi.org/10.1016/j.ejor.2015.08.028.

Kleber, R., Neto, J.Q.F., Reimann, M., 2020a. Proprietary parts as a secondary market strategy. Eur. J. Oper. Res. 283 (3), 929–941 https://doi.org/https://doi.org/10.1016/j.ejor.2019.11.062.

Kleber, R., Reimann, M., Souza, G.C., Zhang, W., 2020b. Two-sided competition with vertical differentiation in both acquisition and sales in remanufacturing. Eur. J. Oper. Res. 284 (2), 572–587 https://doi.org/https://doi.org/10.1016/j.ejor.2020.01.012.

Koh, S.C.L., Gunasekaran, A., Morris, J., Obayi, R., Ebrahimi, S.M., 2017. Conceptualizing a circular framework of supply chain resource sustainability. International Journal of Operations & Production Management 37 (10), 1520–1540. https://doi.org/10.1108/IJOPM-02-2016-0078.

Krikke, H., le Blanc, I., van de Velde, S., 2004. Product modularity and the design of closed-loop supply chains. California Management Review 46 (2), 23–39. https://doi.org/10.2307/41166208.

Kristianto, Y., Helo, P., 2014. Product architecture modularity implications for operations economy of green supply chains. Transportation Research Part E: Logistics and Transportation Review 70, 128–145 https://doi.org/https://doi.org/10.1016/j.tre.2014.06.019.

Lahane, S., Kant, R., Shankar, R., 2020. Circular supply chain management: A state-of-art review and future opportunities. J. Cleaner Prod. 258, 120859. https://doi.org/10.1016/j.jclepro.2020.120859.

Lee, D.-H., Dong, M., 2008. A heuristic approach to logistics network design for end-of-lease computer products recovery. Transportation Research Part E: Logistics and Transportation Review 44 (3), 455–474 https://doi.org/https://doi.org/10.1016/j.tre.2006.11.003.

Li, G., Li, L., Choi, T.M., Sethi, S.P., 2020. Green supply chain management in Chinese firms: innovative measures and the moderator role of quick response technology. J. Oper. Manage. 66 (7–8), 958–988. https://doi.org/10.1002/joom.1061.

Li, Y., Feng, L., Govindan, K., Xu, F., 2019. Effects of a secondary market on original equipment manufactures' pricing, trade-in remanufacturing, and entry decisions. Eur. J. Oper. Res. 279 (3), 751–766 https://doi.org/https://doi.org/10.1016/j.ejor.2019.03.039.

Liu, W., Wei, W., Choi, T.M., Yan, X., 2021. Impacts of leadership on corporate social responsibility management in multi-tier supply chains. Eur. J. Oper. Res. https://doi.org/10.1016/j.ejor.2021.06.042.

Lombardi, D.R., Laybourn, P., 2012. Redefining industrial symbiosis. J. Ind. Ecol. 16, 28–37. https://doi.org/10.1111/j.1530-9290.2011.00444.x.

de Sousa, L., Jabbour, A.B., Jabbour, C.J.C., Godinho Filho, M., Roubaud, D., 2018. Industry 4.0 and the circular economy: A proposed research agenda and original roadmap for sustainable operations. Ann. Oper. Res. 270 (1–2), 273–286. https://doi.org/10.1007/s10479-018-2772-8.

Ma, W.-M., Zhao, Z., Ke, H., 2013. Dual-channel closed-loop supply chain with government consumption-subsidy. Eur. J. Oper. Res. 226 (2), 221–227 https://doi.org/https://doi.org/10.1016/j.ejor.2012.10.033.

Mahmoudzadeh, M., 2020. On the non-equivalence of trade-ins and upgrades in the presence of framing effect: Experimental evidence and implications for theory. Production and Operations Management 29 (2), 330–352. https://doi.org/10.1111/poms.v29.210.1111/poms.13104.

Martin, P., Guide, V.D.R., Craighead, C.W., 2010. Supply chain sourcing in remanufacturing operations: An empirical investigation of remake versus buy. Decision Sciences 41 (2), 301–324. https://doi.org/10.1111/j.1540-5915.2010.00264.x.

Masi, D., Kumar, V., Garza-Reyes, J.A., Godsell, J., 2018. Towards a more circular economy: Exploring the awareness, practices, and barriers from a focal firm perspective. Production Planning & Control 29 (6), 539–550. https://doi.org/10.1080/09537287.2018.1449246.

Mazahir, S., Verter, V., Boyaci, T., Van Wassenhove, L.N., 2019. Did Europe move in the right direction on e-waste legislation? Production and Operations Management 28 (1), 121–139. https://doi.org/10.1111/poms.2019.28.issue-110.1111/poms.12894.

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., 2019. Content analysis and thematic analysis. In: Brough, P. (Ed.), Research methods for applied psychologists: Design, analysis and reporting. Routledge, pp. 211–223.

Niknejad, A., Petrovic, D., 2014. Optimisation of integrated reverse logistics networks with different product recovery routes. Eur. J. Oper. Res. 238 (1), 143–154 https://doi.org/https://doi.org/10.1016/j.ejor.2014.03.034.

Organisation for Economic Cooperation and Development (OECD). (2021). Extended producer responsibility. http://www.oecd.org/environment/waste/extended-producer-responsibility.htm.

Özceylan, E., Paksoy, T., Bektaş, T., 2014. Modeling and optimizing the integrated problem of closed-loop supply chain network design and disassembly line balancing. Transportation Research Part E: Logistics and Transportation Review 61, 142–164 https://doi.org/https://doi.org/10.1016/j.tre.2013.11.001.

Ponte, B., Naim, M.M., Syntetos, A.A., 2019. The value of regulating returns for enhancing the dynamic behaviour of hybrid manufacturing-remanufacturing systems. Eur. J. Oper. Res. 278 (2), 629–645 https://doi.org/https://doi.org/10.1016/j.ejor.2019.04.019.

Prahinski, C., Kocabasoglu, C., 2006. Empirical research opportunities in reverse supply chains. Omega 34 (6), 519–532 https://doi.org/https://doi.org/10.1016/j.omega.2005.01.003.

Qin, Z., Ji, X., 2010. Logistics network design for product recovery in fuzzy environment. Eur. J. Oper. Res. 202 (2), 479–490 https://doi.org/https://doi.org/10.1016/j.ejor.2009.05.036.

Qiu, Y., Ni, M., Wang, L., Li, Q., Fang, X., Pardalos, P.M., 2018. Production routing problems with reverse logistics and remanufacturing. Transportation Research Part E: Logistics and Transportation Review 111, 87–100 https://doi.org/https://doi.org/10.1016/j.tre.2018.01.009.

Ramani, V., De Giovanni, P., 2017. A two-period model of product cannibalization in an atypical Closed-loop Supply Chain with endogenous returns: The case of DellReconnect. Eur. J. Oper. Res. 262 (3), 1009–1027 https://doi.org/https://doi.org/10.1016/j.ejor.2017.03.080.

Raz, G., Souza, G.C., 2018. Recycling as a strategic supply source. Production and Operations Management 27 (5), 902–916. https://doi.org/10.1111/poms.2018.27.issue-510.1111/poms.12851.

Asta, R., 2017. Artisanal network turns corporate waste into quality goods. Ellen MacArthur Foundation Case Studies. https://www.ellenmacarthurfoundation.org/case-studies/waste-recovery-network-turning-corporate-waste-into-handmade-goods.

REEP Technologies Ltd, 2017. A new circular approach towards paper use in the digital era. Ellen MacArthur Foundation Case Studies. https://www.ellenmacarthurfoundation.org/case-studies/reep.

Repoussis, P.P., Paraskevopoulos, D.C., Zobolas, G., Tarantilis, C.D., Ioannou, G., 2009. A web-based decision support system for waste lube oils collection and recycling. Eur. J. Oper. Res. 195 (3), 676–700 https://doi.org/https://doi.org/10.1016/j.ejor.2007.11.004.

Salema, M.I.G., Barbosa-Povoa, A.P., Novais, A.Q., 2010. Simultaneous design and planning of supply chains with reverse flows: A generic modelling framework. Eur. J. Oper. Res. 203 (2), 336–349 https://doi.org/https://doi.org/10.1016/j.ejor.2009.08.002.

Saunders, M., Lewis, P., Thornhill, A., 2019. Research methods for business students, (8th ed.). Pearson.

Savaskan, R.C., Bhattacharya, S., Van Wassenhove, L.N., 2004. Closed-loop supply chain models with product remanufacturing. Manage. Sci. 50 (2), 239–252 http://www.jstor.org.ezproxy.aut.ac.nz/stable/30046061.

Savaskan, R.C., Van Wassenhove, L.N., 2006. Reverse channel design: The case of competing retailers. Manage. Sci. 52 (1), 1–14 http://www.jstor.org.ezproxy.aut.ac.nz/stable/20110479.

Schweiger, K., Sahamie, R., 2013. A hybrid Tabu Search approach for the design of a paper recycling network. Transp. Res.Part E: Logistics and Transportation Review 50, 98–119 https://doi.org/https://doi.org/10.1016/j.tre.2012.10.006.

Seuring, S., Gold, S., 2012. Conducting content-analysis based literature reviews in supply chain management. Supply Chain Management: An International Journal 17 (5), 544–555. https://doi.org/10.1108/13598541211258609.

Seuring, S., Müller, M., 2008. From a literature review to a conceptual framework for sustainable supply chain management. J. Cleaner Prod. 16 (15), 1699–1710 https://doi.org/https://doi.org/10.1016/j.jclepro.2008.04.020.

Shang, G., McKie, E.C., Ferguson, M.E., Galbreth, M.R., 2020. Using transactions data to improve consumer returns forecasting. J. Oper. Manage. 66 (3), 326–348. https://doi.org/10.1002/joom.v66.310.1002/joom.1071.

Sheu, J.-B., Gao, X.-Q., 2014. Alliance or no alliance—Bargaining power in competing reverse supply chains. Eur. J. Oper. Res. 233 (2), 313–325 https://doi.org/https://doi.org/10.1016/j.ejor.2013.09.021.

Shi, T., Chhajed, D., Wan, Z., Liu, Y., 2020. Distribution channel choice and divisional conflict in remanufacturing operations. Production and Operations Management 29 (7), 1702–1719. https://doi.org/10.1111/poms.v29.710.1111/poms.13185.

Shin, Y., Lee, S., Moon, I., 2020. Robust multiperiod inventory model considering trade-in program and refurbishment service: Implications to emerging markets. Transportation Research Part E: Logistics and Transportation Review 138, 101932 https://doi.org/https://doi.org/10.1016/j.tre.2020.101932.

Souza, G.C., 2013. Closed-loop supply chains: A critical review, and future research. Decision Sciences 44 (1), 7–38 https://doi.org/https://doi.org/10.1111/j.1540-5915.2012.00394.x.

Srivastava, S.K., 2007. Green supply-chain management: A state-of-the-art literature review. International Journal of Management Reviews 9 (1), 53–80 https://doi.org/https://doi.org/10.1111/j.1468-2370.2007.00202.x.

Stewart, R., Niero, M., 2018. Circular economy in corporate sustainability strategies: A review of corporate sustainability reports in the fast-moving consumer goods sector. Business Strategy and the Environment 27 (7), 1005–1022. https://doi.org/10.1002/bse.v27.710.1002/bse.2048.

Stock, J.R., Mulki, J.P., 2009. Product returns processing: An examination of practices of manufacturers, wholesalers/distributors, and retailers. Journal of Business Logistics 30 (1), 33–62. https://doi.org/10.1002/j.2158-1592.2009.tb00098.x.

Subramanian, R., Gupta, S., Talbot, B., 2009. Product design and supply chain coordination under extended producer responsibility. Production and Operations Management 18 (3), 259–277. https://doi.org/10.1111/j.1937-5956.2009.01018.x.

Tang, F., Ma, Z.J., Dai, Y., Choi, T.M., 2020. Upstream or downstream: who should provide trade-in services in dyadic supply chains? Decision Sciences. https://doi.org/10.1111/deci.12476.

Tao, Y., Wu, J., Lai, X., Wang, F., 2020. Network planning and operation of sustainable closed-loop supply chains in emerging markets: Retail market configurations and carbon policies. Transportation Research Part E: Logistics and Transportation Review 144, 102131. https://doi.org/10.1016/j.tre.2020.102131.

Tranfield, D., Denyer, D., 2004. Linking theory to practice: A grand challenge for management research in the 21st century? Organization Management Journal 1 (1), 10–14. https://doi.org/10.1057/omj.2004.4.

Tsiliyannis, C.A., 2018. Markov chain modeling and forecasting of product returns in remanufacturing based on stock mean-age. Eur. J. Oper. Res. 271 (2), 474–489. https://doi.org/10.1016/j.ejor.2018.05.026.

Vahdani, B., Tavakkoli-Moghaddam, R., Modarres, M., Baboli, A., 2012. Reliable design of a forward/reverse logistics network under uncertainty: A robust-M/M/c queuing model. Transportation Research Part E: Logistics and Transportation Review 48 (6), 1152–1168 https://doi.org/https://doi.org/10.1016/j.tre.2012.06.002.

Van Wassenhove, L.N., 2019. Sustainable innovation: Pushing the boundaries of traditional operations management. Production and Operations Management 28 (12), 2930–2945. https://doi.org/10.1111/poms.v28.1210.1111/poms.13114.

Vanga, R., Venkateswaran, J., 2020. Fleet sizing of reusable articles under uncertain demand and turnaround times. Eur. J. Oper. Res. 285 (2), 566–582. https://doi.org/10.1016/j.ejor.2020.02.004.

Wang, B., Farooque, M., Zhong, R.Y., Zhang, A., Liu, Y., 2021. Internet of things (IoT)-enabled accountability in source separation of household waste for a circular economy in China. J. Cleaner Prod. 300, 126773. https://doi.org/10.1016/j.jclepro.2021.126773.

Wang, B., Luo, W., Zhang, A., Tian, Z., Li, Z., 2020a. Blockchain-enabled circular supply chain management: A system architecture for fast fashion. Comput. Ind. 123, 103324. https://doi.org/10.1016/j.compind.2020.103324.

Wang, X., Chen, X., Durugbo, C., Cai, Z., 2020b. Manage risk of sustainable product–service systems: A case-based operations research approach. Ann. Oper. Res. 291 (1), 897–920. https://doi.org/10.1007/s10479-018-3051-4.

Webster, S., Mitra, S., 2007. Competitive strategy in remanufacturing and the impact of take-back laws. J. Oper. Manage. 25 (6), 1123–1140. https://doi.org/10.1016/j.jom.2007.01.014.

Weetman, C. (2017). A Circular Economy handbook for business and supply chains: Repair, remake, redesign, rethink (Vol. 1). https://www.koganpage.com/product/supply-chains-for-a-circular-economy-9780749476755# (Kogan Page).

WRAP, 2017. *Waste & Resources Action Programme: United Kingdom: Bringing industry together to tackle food packaging waste*. Ellen MacArthur Foundation Case. Studies. https://www.ellenmacarthurfoundation.org/case-studies/united-kingdom.

Wu, C.-H., Kao, Y.-J., 2018. Cooperation regarding technology development in a closed-loop supply chain. Eur. J. Oper. Res. 267 (2), 523–539 https://doi.org/https://doi.org/10.1016/j.ejor.2017.11.068.

Wu, X., Zhou, Y., 2017. The optimal reverse channel choice under supply chain competition. Eur. J. Oper. Res. 259 (1), 63–66 https://doi.org/https://doi.org/10.1016/j.ejor.2016.09.027.

Xiao, L., Wang, X.-J., Chin, K.-S., 2020. Trade-in strategies in retail channel and dual-channel closed-loop supply chain with remanufacturing. Transportation Research Part E: Logistics and Transportation Review 136, 101898 https://doi.org/https://doi.org/10.1016/j.tre.2020.101898.

Xiao, T., Choi, T.M., 2020. Quality, greenness, and product line choices for a manufacturer with environmental responsibility behaviors. IEEE Trans. Eng. Manage. https://doi.org/10.1109/TEM.2019.2950440.

Xiao, Y., 2017. Choosing the right exchange-old-for-new programs for durable goods with a rollover. Eur. J. Oper. Res. 259 (2), 512–526. https://doi.org/10.1016/j.ejor.2016.11.002.

Xiong, Y., Zhou, Y., Li, G., Chan, H.-K., Xiong, Z., 2013. Don't forget your supplier when remanufacturing. Eur. J. Oper. Res. 230 (1), 15–25 https://doi.org/https://doi.org/10.1016/j.ejor.2013.03.034.

Yang, G.-F., Wang, Z.-P., Li, X.-Q., 2009. The optimization of the closed-loop supply chain network. Transportation Research Part E: Logistics and Transportation Review 45 (1), 16–28 https://doi.org/https://doi.org/10.1016/j.tre.2008.02.007.

Yang, L., Hu, Y., Huang, L., 2020. Collecting mode selection in a remanufacturing supply chain under cap-and-trade regulation. Eur. J. Oper. Res. 287 (2), 480–496 https://doi.org/https://doi.org/10.1016/j.ejor.2020.04.006.

Yenipazarli, A., 2016. Managing new and remanufactured products to mitigate environmental damage under emissions regulation. Eur. J. Oper. Res. 249 (1), 117–130 https://doi.org/https://doi.org/10.1016/j.ejor.2015.08.020.

Zhang, A., Luo, H., Huang, G.Q., 2013. A bi-objective model for supply chain design of dispersed manufacturing in China. Int. J. Prod. Econ. 146 (1), 48–58. https://doi.org/10.1016/j.ijpe.2012.12.008.

Zhang, Y., Hong, Z., Chen, Z., Glock, C.H., 2020. Tax or subsidy? Design and selection of regulatory policies for remanufacturing. Eur. J. Oper. Res. 287 (3), 885–900 https://doi.org/https://doi.org/10.1016/j.ejor.2020.05.023.

Zheng, X.-X., Li, D.-F., Liu, Z., Jia, F., Sheu, J.-B., 2019. Coordinating a closed-loop supply chain with fairness concerns through variable-weighted Shapley values. Transportation Research Part E: Logistics and Transportation Review 126, 227–253 https://doi.org/https://doi.org/10.1016/j.tre.2019.04.006.

Zhu, Q., Geng, Y., Lai, K.-h., 2010. Circular economy practices among Chinese manufacturers varying in environmental-oriented supply chain cooperation and the performance implications. J. Environ. Manage. 91 (6), 1324–1331.

Zhu, Q., Geng, Y., Lai, K.-H., 2011. Environmental supply chain cooperation and its effect on the circular economy practice-performance relationship among Chinese manufacturers. J. Ind. Ecol. 15 (3), 405–419. https://doi.org/10.1111/j.1530-9290.2011.00329.x.

Zhu, X., Wang, M., Chen, G., Chen, X., 2016. The effect of implementing trade-in strategy on duopoly competition. Eur. J. Oper. Res. 248 (3), 856–868 https://doi.org/https://doi.org/10.1016/j.ejor.2015.07.053.

Zikopoulos, C., Tagaras, G., 2007. Impact of uncertainty in the quality of returns on the profitability of a single-period refurbishing operation. Eur. J. Oper. Res. 182 (1), 205–225 https://doi.org/https://doi.org/10.1016/j.ejor.2006.10.025.

Zolfagharinia, H., Hafezi, M., Farahani, R.Z., Fahimnia, B., 2014. A hybrid two-stock inventory control model for a reverse supply chain. Transportation Research Part E: Logistics and Transportation Review 67, 141–161 https://doi.org/https://doi.org/10.1016/j.tre.2014.04.010.

Zuidwijk, R., Krikke, H., 2008. Strategic response to EEE returns: Product eco-design or new recovery processes? Eur. J. Oper. Res. 191 (3), 1206–1222 https://doi.org/https://doi.org/10.1016/j.ejor.2007.08.004.