Where Do We Go from Here? A Bibliometric Analysis Identifying Implications for Future Research in Circular Economy and Supply Chain Management

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ABSTRACT

The Circular Economy (CE) relies heavily on Supply Chain Management (SCM) as it involves managing the entire value chain and coordinating flows. Despite significant contributions, research on SCM for CE remains fragmented, which hinders a comprehensive exploration. This study presents a bibliometric analysis of 281 publications to examine the intersection between CE and SCM. The main research topics are identified and future directions are suggested. The findings contribute to the literature on CE and SCM by providing a comprehensive overview of the current state of knowledge and the barriers. Valuable implications for future research directions are also provided. Additionally, the implications can guide practitioners, institutions, and policymakers in shaping their SCM strategies and contributing to the ongoing transition to a CE.

KEYWORDS: circular economy · Supply chain management · bibliometric analysis · literature review · vosviewer

1. INTRODUCTION

Supply Chain Management (SCM) focuses on the management of relationships between various actors and stakeholders for delivering customer value at lower costs to the entire supply chain [7]. Supply chains are comprised of intricate networks of interconnected processes enabling firms to procure, manufacture, and deliver products and services to consumers [7, 8, 84, 85]. As the global economy consumed over 100 billion tonnes of materials after 2019 by designing supply chains based on the linear economic model of “take, use, dispose” or “take-make-waste” [86], SCM plays a central role for academia and practice in the implementation of circular economy [CE; 9, 10, 11, 12, 13, also 14].

CE is predominantly considered a crucial approach that facilitates fewer resources use, waste reduction, and, most importantly, the mitigation of greenhouse gas emissions contributing to the climate crisis [1; e.g., 5, 6]. In this context, scholars increasingly realize the indispensable need for comprehensive research on CE [2, 3]. [2] provide a comprehensive literature review from the late 2000s and early 2010s, aiming to capture the main features and perspectives of the transition towards an interplay of environmental and economic systems. [3] provides an overview of research efforts related to the circular economy in order to understand the contexts and perspectives in which CE has been explored to date and, as a next step, to develop a framework for a CE implementation strategy for the manufacturing industry. The study by [4] provides an analysis of the drivers, barriers and practices that influence the implementation of CE in the context of supply chains through a systematic review of the literature from 2000 to 2016. Moreover, [87] and [88] deliver a comprehensive review of SCM for CE, with the former emphasizing core SCM processes and the latter exploring green SCM across different levels of CE implementation. Consequently, these studies specifically highlight distinct facets of SCM for CE.

Although there have been substantial contributions, research on SCM for CE is fragmented [87, 90] and, therefore, limits a comprehensive exploration. The fragmentation might be attributed to the prevailing focus among scholars on CE and sustainability as standalone topic [e.g., 15] or the prevalent reliance on subjective selection and content analysis methods, grounded in predetermined coding schemes [16, 17, see e.g., 4]. In this context, we argue that a bibliometric

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analysis offers the potential to provide a holistic overview [83; e.g., 16, 19, 20, 79] of the intersection between SCM and CE. This analysis helps to identify core research themes, emerging trends, and gaps in the literature, which can be used to develop a structured roadmap for future research directions. Moreover, such an analysis can illuminate the impact of various research contributions, facilitating a deeper understanding of the field’s evolution and guiding scholars towards areas that promise substantial academic and practical contributions.

To address the issue of fragmentation, this study examines the intersection between CE and SCM in a holistic manner. Through a comprehensive bibliometric analysis [16, 19, 20, 79] of the existing literature, we seek to uncover the current state of research at this intersection and identify key areas where further research could significantly advance our understanding and application of CE through SCM. Accordingly, our research questions are formulated as follows:

RQ1. How is SCM currently addressed within the context of CE in the existing literature, and what are the main topics identified?

RQ2. What are the implications for future research at the intersection of CE and SCM?

To answer the RQs, we employed a bibliometric analysis [16, 19, 20, 79]. Relevant publications for the analysis are taken from journals with an ABS ranking between one and four [21]. This bibliometric analysis allows us to analyze the interplay between different research topics. By examining keywords, abstracts, and methodologies used in the selected articles, we identify prominent areas of investigation and suggest opportunities for further research. Therefore, a bibliometric analysis is particularly well suited for the purpose of this study and helps to suggest directions or opportunities for further knowledge development [22]. The findings of our study contribute to the literature on CE and SCM by providing a thorough overview of the current state of knowledge as well as the barriers based on 281 publications. They also provide valuable implications for future research directions. Additionally, the implications can guide practitioners in shaping their SCM strategies and contributing to the ongoing transition to a CE.

2. THEORETICAL BACKGROUND

SCM fundamentally focuses on the systematic and strategic coordination of flows - be it materials, goods, or services - from suppliers to customers [7, 8, 23, 24]. A hallmark of SCM is its dedication to aligning these flows with customer needs, a strategy designed to deliver unparalleled customer value. Furthermore, SCM adopts a holistic perspective, engaging the entire supply chain and integrating both upstream and downstream relationships. This coordination and integration, encompassing all traditional business functions within and among companies in the supply chain, are directed towards optimizing costs and enhancing the long-term performance of both the individual entities and the supply chain collectively. Given its holistic approach, the management of supply chains emerges as an important unit of analysis for CE [94].

CE is increasingly gaining importance [25]. It represents a transformative approach towards sustainable business practices and SCM, offering a promising pathway to reconcile economic growth with environmental sustainability [4]. Unlike the conventional linear economy model, which follows a ‘take-make-use-destroy’ sequence, the CE approach emphasizes the restorative and regenerative use of resources, aiming to minimize waste and optimize resource efficiency [4]. A crucial component of CE is the consideration of the whole supply chain. That is, the collaboration of actors within and across industrial sectors to extract value from waste, thereby aspiring towards zero waste generation [9].

The successful implementation of CE requires significant awareness, efforts, and participation [4]. CE challenges the neoclassical economic framework, even threatening some of its key pillars. Transitioning to a functional CE model requires overcoming significant institutional, financial, and technological barriers [92, 93]. For instance, CE proposes a rethinking of the limited and exhaustible nature of natural resources, striving for an economic model regulated according to the laws of nature [2]. CE necessitates the reengineering of numerous facets of production and consumption. On the production side, this entails investments in durable product design and processes that facilitate maintenance, repair, reuse, remanufacturing, refurbishing, and recycling [87, 91]. Moreover, the integration of Industry 4.0 technologies represents a promising opportunity, offering potential for optimization of resource use and waste reduction [19]. However, [87] provide five principles that can assist researchers and managers in rethinking value creation activities for CE implementation. These principles include closing loops, slowing loops, intensifying loops, narrowing loops, and dematerializing loops.

3. RESEARCH METHODOLOGY

In our methodology, we embarked on a comprehensive bibliometric analysis of the extant literature. The initial step involved performing a literature review to identify relevant studies (stage 1) [18]. Subsequent to this, we delved into a bibliometric analysis following [16; e.g., 19, 20, 79], with a particular focus on co-occurrence keyword analysis, to discern prevalent themes within
the identified body of work. Figure 1 delineates the logical progression of our research methodology [16; 83].

**Table 1 Inclusion and exclusion criteria**

<table>
<thead>
<tr>
<th>No.</th>
<th>Inclusion criteria</th>
<th>Exclusion criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Publication period from 2012 to 2022</td>
<td>Published before 2012</td>
</tr>
<tr>
<td>2</td>
<td>Document type article</td>
<td>Conference publication, proceeding paper, book chapter, book review, meeting abstract, letter</td>
</tr>
<tr>
<td>3</td>
<td>Publication language English</td>
<td>Publication language other than English</td>
</tr>
<tr>
<td>4</td>
<td>Journal listed in ABS journal ranking [21] (1 to 4*)</td>
<td>Journal not listed in ABS journal ranking [21]</td>
</tr>
<tr>
<td>5</td>
<td>Title or abstract had to exhibit a connection to CE</td>
<td>Title or abstract does not demonstrate relevance to CE</td>
</tr>
</tbody>
</table>

We conducted a bibliometric analysis (stage 2) following [16; e.g., 19, 20, 79], with a particular focus on co-occurrence keyword analysis. A bibliometric analysis (stage 2) is a widely used and versatile method in scientific and engineering disciplines. It allows for the assessment of the current state of research due to its flexibility and capacity to handle large bibliometric data sets [26; 27; 83]. This analysis type provides comprehensive information about a research area, and its visualization feature makes the presented information easier to understand [28]. Moreover, bibliometric analysis can swiftly process hundreds of articles, analyzing the relationships between articles, citations, co-citations, and keywords [28]. Consequently, it can assist in identifying research clusters [26]. In other words, a bibliometric analysis can ascertain main research areas within a specific scientific field, their interconnections or relations, and how these research areas have developed over time [29].

**For the bibliometric analysis** (stage 2) following [16; e.g., 19, 20, 79], we conducted a co-occurrence keyword analysis of the 281 publications using VOSviewer software [32]. Essentially, a co-occurrence analysis probes into the connections and similarities between keywords [16; 37; 32]. Thus, by considering keywords, their frequency of co-occurrences, and the Euclidean distance, VOSviewer clusters related keywords [16]. Hence, a co-occurrence analysis aids in objectively and algorithmically identifying and summarizing keywords into different clusters [e.g., 19; 16; 79; 80]. The result
of this analysis offers a comprehensive overview of research clusters, helping to identify main research topics in the field of CE and SCM, and elaborating implications for future research [e.g., 79]. We employed VOSviewer as our software tool of choice, attributing this selection to its definitive capabilities in visualizing bibliometric networks [16; 32]. Specifically, VOSviewer is distinguished by its proficiency in managing large datasets.

To conduct a co-occurrence analysis (stage 2) following [e.g., 16, 19, 20, 79], we considered the 281 publications identified. The SCOPUS database assigns various keywords to the individual publications. The keywords were also transferred to the reference software Citavi during the export of the dataset from SCOPUS. This made the keywords available in Citavi along with their corresponding publication. When working with keywords, the occurrence attribute indicates the number of documents in which a keyword appears [81]. In VOSviewer, we have configured the settings such that a keyword must appear at least six times to be included in the analysis [e.g., 79]. 68 keywords reached this threshold in our study. Figure 3 displays the final outcome of the co-occurrence analysis, which is a network consisting of six clusters based on the 68 keywords. Prior to defining this setting for our analysis, we executed a series of trials, varying the thresholds for minimum occurrences [e.g., 79]. The trials revealed that there was minimal variation in the number of clusters and the frequency of their associated keywords. Consequently, we posited that this setting effectively captured the principal clusters and keywords.

4. DESCRIPTIVE STATISTICS

The dataset of 281 studies indicates that the majority of the publications are from the journal Business Strategy and the Environment, accounting for about 15% of all included studies. Table 2 presents the top five journals with the highest number of publications, their corresponding count of their publications, their individual share, and the cumulative share. This table reveals that most articles in our dataset were published in the Business Strategy and the Environment, International Journal of Production Economics, International Journal of Production Research, Production Planning & Control, and Journal of Enterprise Information Management. An overview of all journals and articles included in this study can be found in the Appendix.

<table>
<thead>
<tr>
<th>Journal</th>
<th>Number of publications</th>
<th>Share</th>
<th>Cumulative share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Strategy and the Environment</td>
<td>42</td>
<td>14.95%</td>
<td>14.95%</td>
</tr>
<tr>
<td>International Journal of Production Economics</td>
<td>23</td>
<td>8.19%</td>
<td>23.14%</td>
</tr>
<tr>
<td>International Journal of Production Research</td>
<td>23</td>
<td>8.19%</td>
<td>31.33%</td>
</tr>
<tr>
<td>Production Planning &amp; Control</td>
<td>22</td>
<td>7.83%</td>
<td>39.16%</td>
</tr>
<tr>
<td>Journal of Enterprise Information Management</td>
<td>18</td>
<td>6.41%</td>
<td>45.57%</td>
</tr>
</tbody>
</table>

Moreover, the selected 281 studies were only published between 2015 and 2022. Figure 2 illustrates that just one study was published in each of the two years 2015 and 2016. In the subsequent years, the number of studies increased from six in 2017 to a range between 22 and 32 in 2018, 2019, and 2020. Conversely, the number of results escalated to 71 studies in 2021 and 124 in 2022. The swift increase between 2020 and 2022 underscores the current relevance of the CE in the field of SCM.
5. RESULTS

Figure 3 shows the result of our co-occurrence analysis. Based on the co-occurrence analysis with article keywords, we identified six clusters (main topics; RQ1) from Figure 3: Cluster 1 red (Intra-firm and Inter-firm Challenges in Implementing CE), Cluster 2 green (Institutional Support and Closed-loop Supply Chains), Cluster 3 blue (Environmental Impact), Cluster 4 yellow (Industry 4.0 Technologies and Smart Circular Supply Chains), Cluster 5 purple (Food Supply Chains), and Cluster 6 orange (Capabilities and Innovation). The following sections provide a characterization of these clusters [e.g., 16, 19, 20, 79]. To ensure a manageable characterization within the scope of the article and to verify cluster names, we identified the associated articles in our Citavi reference file using the top three keywords specific to each cluster.
5.1. Cluster 1 (red): Intra-firm and Inter-firm Challenges in Implementing CE

Through the analysis of this cluster, a research focus has emerged on the challenges in implementing sustainability and CE concepts within SCM. [38] detail the transformation process of a traditional paper towel manufacturer towards a business model informed by CE. They propose that this transformation can be successful by aiming to reduce the consumption of natural resources, reuse paper waste, and foster sustainable innovations. Further supporting this, [39] and [40] point to the development of innovations within SCM as a potential driver for implementing CE.

In addition, [38] identify managing complex relationships with supply chain partners as a key success factor. This viewpoint is echoed in the studies by [10], [39], [27], [41], and [40], all emphasizing the importance of considering the entire partner network when implementing circular economy concepts. This underscores the point that managing the supply chain network is one of the principal challenges in transitioning to a circular economy.

Within this context, both [41] and [40] highlight the lack of awareness among supply chain partners and stakeholders about the necessary framework for implementing circular economy concepts. To overcome this hurdle, they suggest not only the training of stakeholders but also the implementation of rules as potential solutions to raise awareness [40]. The influence of policymakers in this implementation process is further underscored by [38, 27, 41]. To mitigate the challenge of insufficient information sharing in networks and the complexity of relationships, [10] put forth the utilization of big data analytics for data-driven decision-making as a potential driver.

5.2. Cluster 2 (green): Institutional Support and Closed-loop Supply Chains

Upon analysis of this cluster, a research focus emerged on institutional support and closed-loop supply chains in the transition towards sustainability. [42] underscore the role of policymakers, arguing they can make significant contributions to the implementation of sustainable practices through political support and legal regulations. Their study focuses on developing a framework for implementing sustainability on a B2C e-commerce platform. The pursuit of sustainable policies and practices in this area not only enhances the environmental and social performance of companies but also fosters the development of sustainability competencies, which may yield competitive advantages [42].

The papers by [43] and [44] both present mathematical models for CE implementation, especially closed-loop supply chains. [43] concentrate on the evolution from linear business models to circular economy concepts, specifically addressing integrated decision-making in the context of reverse logistics. Optimal strategies in this framework consider the analytical view of the interdependencies between sourcing, sorting, and planning processes. [44], on the other hand, focus on a closed-loop supply chain network of reusable citrus crates. Their model provides insights into the quantity and locations of distribution, collection, and recycling centers, enabling effective use of transportation capacity to reduce both transportation costs and emissions.

5.3 Cluster 3 (blue): Environmental Impact

By analyzing this cluster, a research focus emerged on environmental impact, specifically waste and resource management. [45] show that management control and technological capabilities are crucial key capabilities in managing circular supply chains. Furthermore, they highlight the growing importance of technological components to facilitate supply chain coordination and synergies. However, technological developments and the dynamic environment can also pose challenges to organizations [46]. [46] also underscore the lack of a shared vision and the absence of regulatory provisions for cross-sectoral collaboration in circular SCM have been identified as challenges. These can be addressed primarily through strategic action by managers and policymakers.

[47] conceptualize waste as a resource, arguing that the long-term focus should extend beyond mere conceptualization and towards prevention of waste and reverse flows. This viewpoint aligns with the publication by [45], who emphasize maximizing resource use and minimizing waste along the entire supply chain. Similarly, [48] found that manufacturing and purchasing teams primarily focus on design-related aspects of products and processes to minimize resource use. Conversely, the marketing team primarily focuses on customer interaction and management of collection and recycling systems.

5.4. Cluster 4 (yellow): Industry 4.0 Technologies and Smart Circular Supply Chains

By analyzing this cluster, a research focus emerged on industry 4.0 and smart circular supply chains. [49] and [50] point out that Industry 4.0 technologies such as big data analytics and cloud technologies are widely used in a CE context due to their positive impact on resource and information management, production efficiency, coordination, and collaboration among all supply chain stakeholders. In conjunction with these digital technologies, the most promising CE approaches are identified in the areas of 3Rs, waste management, and material and energy efficiency [50]. This is also reflected in the study by [51], who identify knowledge of circular supply chains and Industry 4.0 as an important success factor for implementing circular approaches. Furthermore, regulations are identified as key supporters for the successful implementation of smart and sustainable circular supply chains [52; 49]. This emphasizes that institutions and policy makers have
a crucial role to play in the implementation of circular supply chains for CE. In addition to this support, top management commitment is seen as playing an important role in achieving sustainability goals [52]. Moreover, [51] also identify top management commitment as critical for Industry 4.0-integrated circular supply chains.

Moreover, [52] and [49] analyze enablers of smart circular supply chains. In the study by [52], SDG 16 (peace, justice, and strong institutions), SDG 9 (industry, innovation, and infrastructure), and SDG 15 (living on land) are assigned the highest importance for the identified drivers. In contrast, [49] identify SDG 12 (sustainable consumption and production) and SDG 17 (partnerships to achieve the goals) as relevant enablers. In this context, coordination and collaboration among supply chain partners are highlighted [51; 49]. This is because the pursuit of sustainability goals is a complex process that requires extensive collaboration among all partners in the circular supply chain [52].

5.5 Cluster 5 (purple): Food Supply Chains

By analyzing this cluster, a research focus emerged on food supply chains. [53] explore the applicability of strategic planning tools for food safety. [54] develop a circular network model with the aim of reducing food waste. [55] also develop a model with the goal of minimizing food waste in the specific context of slaughterhouses. [56] point out that data-based technologies can make an important contribution to reverse logistics in the context of the circular economy in food supply chains. Similarly, [57] identify digital technologies as opportunities to improve visibility, tracking, and location throughout the food supply chain. In addition, [58] emphasize digital technologies alongside partnerships, industry symbiosis, and government regulation as drivers of sustainability in the reverse logistics context. Furthermore, [59] provide an agenda to combat food waste based on digital technologies. The authors show that the focus in the use of technologies should not only be on the reuse of waste, but also on the reduction and prevention of waste. [60] examine the impact of disruptions, such as the COVID-19 pandemic, on food waste reduction. Their study investigates how certain consumer characteristics related to food waste change in the context of lockdowns and shows that uncertainty has a negative impact on waste reduction by inducing excessive purchasing behavior.

5.6 Cluster 6 (orange): Capabilities and Innovation

By analyzing this cluster, a research focus related to capabilities, collaboration, and innovation emerged. [61] conclude that dynamic capabilities can help to adopt circular economy and develop sustainable competitive advantage. In addition, knowledge of Industry 4.0 can contribute to the development of dynamic capabilities. [62] consider dynamic capabilities in conjunction with the concept of open innovation to develop a cross-firm framework for implementing CE. Despite the conflict between protecting individual competitive advantage and achieving network competitive advantage, dynamic capabilities support the network in rapidly adapting to a dynamic environment, and the concept of open innovation reinforces systems thinking.

6. DISCUSSION

To address RQ 2, we analyze the clusters identified and derive implications for future research. The clusters establish a conceptual framework for formulating research propositions at the nexus of SCM and CE, thereby contributing to scientific literature. Our contribution illuminates this intersection, proposing potential avenues for subsequent studies.

6.1 Cluster 1: Intra-firm and Inter-firm Challenges in Implementing CE

The findings show that barriers emanate from supply chain operations and value creation activities. The cost of collecting used products [41], limitations imposed by asset-light business models [40], the absence of a common vision and a successful business model with a value creation architecture for implementing CE [46; 4], the lack of zero-waste shops [58], and high investment costs [41; 4] all pose considerable obstacles. Design challenges, such as the definition of waste as a resource [39], the absence of a circular design principle [57], and difficulties in secure product return [4; 2] are also of great significance. Finding the right customers for recycled products presents another obstacle [61], as does the challenge of designing reusable and recyclable products [41]. Additionally, the low usage of reusable transport methods [58], complications arising from property issues and the return of other companies’ products [4; 2], the limited availability of reusable products [4], and a broad supplier base [25] further complicate CE implementation. These hurdles underline the need for a comprehensive shift in supply chain operations towards the consideration of the entire supply chain network or ecosystem.
Future research should take a holistic approach and examine the entire supply chain network or ecosystem [74], rather than focusing on specific focal actors or supply chain operations [75]. This would support a shift towards the collaborative efforts of all stakeholders within the network or ecosystem [e.g., 82] during CE implementation. Therefore, a holistic approach that examines the entire supply chain network or ecosystem is helpful for a comprehensive understanding and successful CE implementation. Related research could consider the ecosystem concept or stakeholder theory for this purpose. Stakeholder theory essentially deals with the influence of actors from the environment [77]. The application of stakeholder theory might be a good fit because the pursuit of sustainability goals is a complex process that requires extensive collaboration among all stakeholders in a circular supply chain [52; also 10; 46; 14; 78]. In addition, future research could also take a dynamic perspective and investigate whether there are certain patterns or schemes (maturity models) that describe a transition for implementing CE in supply chain networks or ecosystems. Possible patterns or schemes could also differ from industry to industry. We therefore suggest the following implication:

Proposition 1: Future studies should strive to provide a holistic and dynamic understanding of the entire supply chain network or ecosystem during the implementation of CE.

Research indicates that CE implementation is hindered by duplication of responsibility for relevant supply chain activities [46], limited external cooperation with supply chain actors and stakeholders [61], and a lack of trust in collaboration [46]. If future research considers a holistic understanding of the entire supply chain network or ecosystem during the development and implementation of CE, the issue of coordination and collaboration will arise [76; 75]. That is, practitioners and researchers will face the question of which actor or stakeholder coordinates the development and implementation of CE in a supply chain network or ecosystem. Next, the question will arise as to how an actor or stakeholder coordinates the network or ecosystem and how collaboration between actors and stakeholders is managed. Therefore, we additionally argue the following implication for future research:

Proposition 2: Future research should aim to analyze coordination and collaboration issues in a supply chain network or ecosystem during the implementation of CE.

The necessity for implementing organizational change towards CE is evident due to inadequate internal cooperation between responsible entities, which is caused by internal bureaucracy and a lack of commitment from top management [46; 61; 4; 41; 57]. This suggests that leadership, organizational culture, and governance could significantly facilitate this change. Thus, we suggest the following research implication:

Proposition 3: Future research could explore the role of leadership and culture in facilitating the implementation of CE in a supply chain network or ecosystem.

6.2. Cluster 2: Institutional Support and Closed-loop Supply Chains

The lack of governmental regulations is a significant issue. This can limit the enforcement of sustainable practices and adherence to Circular Economy (CE) principles in supply chains [40; 46; 51; 4]. Furthermore, the absence of governmental support, policies, and incentive systems for supply chain actors and stakeholders hinders progress in this field [41; 57; 58; 4]. In this context, the lack of adaptable governance structures [46] for supply chains or ecosystems also presents a notable barrier to the implementation of CE. Additionally, the lack of system standardization for circular loops, combined with inadequate information exchange on relevant supply chain activities among actors and stakeholders, presents further obstacles [46; 57; 4].

Future research could focus on the role of institutions in shaping the supply chain environment for CE implementation. For example, [40], [46], [57], [4], [41], and [58] highlight the lack of government regulations and support as significant challenges to CE implementation. This suggests that policymakers can have a significant impact on the successful implementation of CE. However, research on the design of policies, regulations, and guidelines related to CE represents a complex endeavor as multiple actors and stakeholders from the supply chain network or ecosystem might participate in CE implementation. Therefore, future research should address the role of relevant institutions and policy makers as well as the design of policies, regulations, guidelines, and incentives related to CE beyond their effectiveness. In this context, we believe that related research should also consider national or industry specific requirements or conditions. However, we suggest the following research implication:

Proposition 4: Future research should explore not only the effectiveness but also the design of policies, regulations, guidelines, and incentives related to CE and SCM, taking into account national or industry-specific requirements or conditions.

6.3. Cluster 3: Environmental Impact

Given the scarcity of performance indicators capable of assessing the environmental impact and implementation success of CE, the development and analysis of such
metrics represent a significant research need [46; 4; 57]. These indicators or metrics, applicable across supply chains or at various levels, such as for carbon management [69; 70; 71], or supplier relationship management, could provide an efficient means of monitoring and managing CE adoption, execution, and efficiency [also 51; 50]. Therefore, developing and scrutinizing such indicators could represent a meaningful contribution to SCM and CE research. Thus, we propose the following implication:

**Proposition 5:** Future studies should focus on the development and validation of viable performance indicators and related measurement approaches for CE implementation in a supply chain network or ecosystem.

### 6.4. Cluster 4: Industry 4.0 technologies and Smart Circular Supply Chains

Technological challenges, such as the lack of IT standards and difficulties in measuring CE performance in supply chains [46; 57; 4], coupled with unreliable data exchange between systems and entities, are restricting CE implementation efforts [41; 46; 4]. Additionally, the underutilization of tracking & tracing systems [57; 4; 2] and technological constraints in tracking recycled materials [57] are considered significant barriers to CE implementation.

While digital technologies have been recognized as critical enablers of CE implementation, their specific applications and impacts within the CE framework remain underexplored. [46], [56], [57], [4], and [10] all identify these issues as significant barriers in implementing CE within SCM. [41] further emphasize the potential of big data analytics in enhancing data sharing and decision-making in CE [also 10]. [61] highlight that data sharing is essential for cross-functional collaboration among all supply chain partners. Therefore, the role of digital technologies in enabling and facilitating CE implementation should also be a research priority [19]. That is, a more in-depth examination of these technologies, how specific technologies work in the context of CE, their potential impact, guidelines for data ownership and exchange among supply chain actors, and standardization could provide valuable insights. Hence, we propose the following implication:

**Proposition 6:** Investigations should aim to elucidate the mechanisms and impacts of specific digital technologies within the CE and SCM context.

### 6.5. Cluster 5: Food Supply Chains

Adopting a broader perspective that encompasses multiple industries could be crucial when researching CE and SCM. Although the primary focus has been on the food and automotive industries, the potential benefits of CE extend far beyond these sectors [19]. Therefore, future CE research could prioritize the reduction of waste and inefficiency across the entire supply chain network or ecosystem of various sectors, not only those currently most explored. As a result, we propose the following implication:

**Proposition 7:** Future research should prioritize expanding CE to other industries and across multiple sectors.

### 6.6. Cluster 6: Capabilities and Innovation

The study of dynamic capabilities represents a burgeoning topic within the intersection of SCM and CE research [61; 64; 62; 63]. In particular, understanding the capabilities and structures required for successful CE implementation holds significant potential. Furthermore, the role of technologies in shaping these capabilities and internal resources needs further exploration. In the context of today’s disruptive environment [72; 73; also 13], this area of research is particularly important. Hence, we propose the following research implication:

**Proposition 8:** Future research should focus on identifying the key capabilities required for successful CE implementation, and the role of digital technologies therein.

Table 3 presents a summary of the identified propositions, highlighting potential research directions.
<table>
<thead>
<tr>
<th>Cluster</th>
<th>Proposition</th>
<th>Potential research direction (not limited to)</th>
</tr>
</thead>
</table>
| 1. Intra-firm and Inter-firm Challenges in Implementing CE | 1. Future studies should strive to provide a holistic and dynamic understanding of the entire supply chain network or ecosystem during the implementation of CE. | • What actors in the supply chain or ecosystem are necessary for implementing CE?  
• How do the roles of actors change during CE implementation?  
• How do supply chain networks or ecosystems emerge and evolve during CE implementation? |
| | 2. Future research should aim to analyze coordination and collaboration issues in a supply chain network or ecosystem during the implementation of CE. | • What mechanisms or practices enable actors to seamlessly collaborate for implementing CE?  
• How can participating actors be coordinated to ensure that all actors create and benefit from relevant value?  
• How can participating actors be incentivized to share relevant data for implementing CE? |
| | 3. Future research could explore the role of leadership and culture in facilitating the implementation of CE in a supply chain network or ecosystem. | • What cultural factors (e.g., cognitions, frames, knowledge paradigms, logics, values) facilitate or impede the implementation of CE?  
• How do executives of supply chain actors and other stakeholders motivate the investments necessary to implement CE?  
• How do executives of supply chain actors decide between incremental and more comprehensive changes when seeking CE implementation? |
| 2. Institutional Support and Closed-loop Supply Chains | 4. Future research should explore not only the effectiveness but also the design of policies, regulations, guidelines, and incentives related to CE and SCM, taking into account national or industry-specific requirements or conditions. | • What public policies facilitate or hinder the implementation of CE in supply chains or ecosystems?  
• What are the institutional guidelines and incentives that influence the implementation of CE in supply chain networks or ecosystems?  
• How are CE policies from different countries experienced and managed within a supply chain network or ecosystem? |
<table>
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<tr>
<th>Cluster</th>
<th>Proposition</th>
<th>Potential research direction (not limited to)</th>
</tr>
</thead>
</table>
| 3. Environmental Impact | 5. Future studies should focus on the development and validation of viable performance indicators and related measurement approaches for CE implementation in a supply chain network or ecosystem. | • How can companies, supply chain networks, and ecosystems measure and manage trade-offs that occur in CE implementation (e.g., raw material, water, carbon, energy)?  
• How can companies, supply chain networks, and ecosystems measure the impact of CE implementation on national economies, society, or nature?  
• How can economies of scale and economies of scope be used to facilitate the implementation of CE? |
| 4. Industry 4.0 technologies and Smart Circular Supply Chains | 6. Investigations should aim to elucidate the mechanisms and impacts of specific digital technologies within the CE and SCM context. | • How can digital platforms accelerate CE implementation? / How can digital platforms reconfigure supply chain networks or ecosystems for CE implementation?  
• How can federated data infrastructure facilitate CE implementation?  
• What data-driven services and contributions from actors in the supply chain network or ecosystem are necessary for implementing a CE? |
| 5. Food Supply Chains | 7. Future research should prioritise expanding CE to other industries and across multiple sectors. | • How can supply chain networks or ecosystems be designed to implement CE in the machinery and equipment industry?  
• How can supply chain networks or ecosystems be designed to implement CE in the chemicals industry under consideration of mining and raw material extraction?  
• How can supply chain networks or ecosystems be designed to implement CE in the healthcare industry? |
| 6. Capabilities and Innovation | 8. Future research should focus on identifying the key capabilities required for successful CE implementation, and the role of digital technologies therein. | • What different capabilities for inter-organizational relationships facilitate the implementation of CE?  
• What capabilities are required to facilitate resource integration for CE implementation?  
• What capabilities enable companies, supply chain networks, and ecosystems to adopt digital technologies for implementing CE? / How does the adoption of digital technologies change capabilities of actors in a supply chain network or ecosystem? |
7. CONCLUSION

In this study, we thoroughly explored the synergies between CE and SCM, addressing the noted fragmentation in SCM research related to CE [87, 90] which hampers a holistic understanding. To achieve this, we conducted a comprehensive bibliometric analysis [16, 18, 19, 20, 79] of the existing literature. We selected the SCOPUS database due to its comprehensiveness and compatibility with the VOSviewer software [16; 30; 31]. We conducted a co-occurrence keyword analysis on 281 relevant publications using VOSviewer software. This helped us identify core research topics and develop implications for future research.

Through the co-occurrence keyword analysis, we identified six main research topics (clusters) within the intersection between CE and SCM research: 1. Intra-firm and Inter-firm Challenges in Implementing CE, 2. Institutional Support and Closed-loop Supply Chains, 3. Environmental Impact, 4. Industry 4.0 technologies and Smart Circular Supply Chains, 5. Food Supply Chains, and 6. Capabilities and Innovation.

We used these main research topics to establish a conceptual framework for formulating propositions at the nexus of SCM and CE, contributing to the scientific literature. Specifically, eight directions were proposed. Firstly, future studies should take a holistic approach to understanding the entire supply chain network or ecosystem during CE implementation, emphasizing collaboration among supply chain actors and stakeholders (Proposition 1). Secondly, future research should investigate coordination and collaboration issues within the supply chain network or ecosystem (Proposition 2). Thirdly, further analysis is required to understand the role of leadership, culture, and governance in facilitating the transition towards a circular economy (Proposition 3). Fourthly, research should address the effectiveness and design of policies, regulations, guidelines, and incentives related to CE and SCM, considering national or industry-specific contexts (Proposition 4). Fifthly, research should focus towards developing performance indicators for CE implementation in supply chains (Proposition 5). Sixthly, further studies should uncover the mechanisms and impacts of specific digital technologies within CE and SCM (Proposition 6). Seventhly, future research should examine the expansion of CE across multiple sectors (Proposition 6). Eighthly, investigations should identify key capabilities required for successful CE implementation (Proposition 8).

This study’s findings also bear important implications for practitioners, institutions, and policymakers. Initially, the findings offer a comprehensive overview of the main topics and related findings academic community is currently addressing. Furthermore, our study outlines critical issues for future research that could be considered in CE implementation projects. Lastly, we underscore the pivotal role of institutions and policymakers in fostering the successful implementation of CE through the enactment of effective regulatory frameworks.

However, it is important to acknowledge the limitations of our study. Specifically, our literature search was restricted to specific keywords in the title, abstract, and author keywords, which may have resulted in relevant articles that focus on our unit of analysis being overlooked. Additionally, we only used one database (Scopus) for our study. The identification of main research topics relies on the keywords authors selected for their articles through a co-occurrence keyword analysis. Our study primarily focuses on examining the intersection between CE and SCM in a holistic manner, maintaining a medium to high level of abstraction.

REFERENCES


APPENDIX

Annals of Operations Research

Asia Pacific Journal of Management
**Benchmarking**


**Business Strategy and the Environment**


Computers and Industrial Engineering


Decision Support Systems


Ecological Economics


Energy Economics


Energy Policy


European Journal of Operational Research


European Management Review


European Planning Studies


Expert Systems with Applications


IEEE Transactions on Engineering Management


Industrial Management and Data Systems


**Industrial Marketing Management**


Information and Management


International Journal of Entrepreneurial Behaviour and Research


International Journal of Information Management


International Journal of Innovation Management

International Journal of Logistics Management


International Journal of Logistics Research and Applications


International Journal of Operations and Production Management


International Journal of Production Economics


**International Journal of Production Research**


Journal of Enterprise Information Management


Journal of Manufacturing Systems


Journal of Manufacturing Technology Management


Journal of Purchasing and Supply Management


Journal of Retailing

Journal of Strategic Marketing

Journal of the Operational Research Society
Management Decision


Marine Policy


Maritime Economics and Logistics


Omega


Production Planning and Control


Scandinavian Journal of Hospitality and Tourism

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