

Review

Sustainable Supply Chain Management in a Circular Economy: A Bibliometric Review

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Abstract: Since the mid-2010s, the circular economy has emerged as a key conceptual lever in corporate efforts to achieve greater environmental sustainability. Corporations have increasingly drawn upon the circular economy perspective in efforts to rethink sustainable supply chain management practices. This new corporate approach to sustainable supply chain management is evident in an emerging literature that has yet to be fully documented. In this systematic review of research, bibliometric methods were applied to a database of 709 Scopus-indexed documents. Author co-citation analysis identified four schools of thought comprising the intellectual structure of this literature: Sustainable Production and Environmental Management, Sustainable Supply Chain Management, Reverse Supply Chain Management, and Circular Economy. Synthesis of these themes suggests that the adoption of a circular economy perspective is transforming sustainable supply chain management in two important ways. First, this perspective reorients supply chain management away from a narrow focus on efficiency and waste reduction and towards a new paradigm of redesign, reuse, and product transformation. Second, adoption of the circular economy highlights and leverages reverse cycles in the supply chain. Thus, circular economy business models enable supply chain management to enhance corporate contributions to sustainable production and consumption. Drawing upon this framing of supply chain management within a circular economy, the review proposes a new framework for accelerating corporate sustainability.

Keywords: bibliometric review; circular economy; sustainable supply chain; supply chain; corporate sustainability



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1. Introduction

A recent meta-analytic review of sustainability management research identified supply chain management as the most influential corporate management strategy used to address economic, social, environmental, and economic sustainability [1,2]. Sustainable supply chain management relies on co-operation among diverse actors in the supply chain working together to achieve effective management of materials, data, and financial resource flows [3]. Both research and practice in sustainable supply chain management have made impressive gains over the past 25 years [4]. This has resulted in the development of a well-documented knowledge base concerning both the nature and effects of different supply chain management models and strategies (e.g., [5–8]).

In recent years, however, growing acceptance of the “circular economy” concept has begun to transform conceptualizations of “sustainable supply chain management” [9]. The circular economy concept posits connections between the four economic roles that the environment plays in corporate sustainability: providing amenity value, serving as a resource base, functioning as a source of economic activities, and acting as a life-support system [10].

Geissdoerfer and colleagues (2017) [11] defined the circular economy as, “a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops. Through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling” (p. 759).

Integration of a circular economy perspective implies a need for sustainable supply chain management (S-SCM) to place greater emphasis on product transformation and reverse loops in the supply chain [11]. With an aim for waste and pollution elimination, material circularity, and natural regeneration under the circular economy concept, Industry 4.0 technologies have been studied as the enablers for sustainable operations and sustainable supply chain management [12–14]. The adoption of advanced technologies such as additive manufacturing, big data, artificial intelligence, and blockchain for supply chain reconfiguration enhance flexibility in responding to demand, as well as facilitating planning and forecasting, and optimization [15–17]. Thus, we assert that conjoint application of these sustainability concepts offers potential for up-scaling corporate contributions to environmental sustainability [7,9,14].

Indeed, this conceptual reframing of sustainable supply chain management through a circular economy lens has been a catalyst for the emergence of a new literature. To date, two published reviews of research have examined the links between S-SCM and circular economy [7,18]. These integrative reviews were, however, based on relatively small document databases (i.e., <80), and focused on identifying critical factors that impact supply chain management in a circular economy context. The current review was designed to build on these reviews by employing a bibliometric review method for the purpose of analyzing the evolving conceptual landscape of published research on this topic. More specifically, this review assesses the conceptual and practical value added by analyzing sustainable supply chain management within the context of a circular economy. The research questions (RQs) guiding the review were as follows.

1. How does the distribution of documents across time, geographies, and subject areas offer insights into the production of knowledge on sustainable supply chain management in a circular economy?
2. What do the top-cited documents reveal about key topics, conceptual themes, and interdisciplinary collaboration in the literature on sustainable supply chain management in a circular economy?
3. What is the intellectual structure of the published knowledge base on sustainable supply chain management in a circular economy?

The review examined 709 Scopus-indexed documents on sustainable supply chain management in a circular economy. Descriptive statistics, document citation analysis, and author co-citation analysis were used to analyze bibliographic data associated with the document database. These analyses were designed first to document the literature and second to analyze its intellectual or conceptual structure.

This review seeks to contribute to both research and practice concerning supply chain management in a circular economy, with particular attention to the COVID-19 era. The review presents the theoretical background on supply chain management and circular economy in Section 2, research methods used in the review in Section 3, results related to the research questions in Section 4, interpretation of the findings in Section 5, and conclusions in Section 6.

2. Theoretical Background

Over the last three decades, supply chain management has become a key management discipline within the broader literature on managing for sustainability [1–3]. Sustainable supply chain management (S-SCM) addresses external pressures and incentives set by different stakeholder groups (e.g., government regulators, environmental and social movements, community members, and consumers) with respect to the production and consumption activities of companies and societies [3]. In this review, we adopted Seuring and Müller’s (2008) definition of sustainable supply chain management as, “the management

of material, information, and capital flows as well as co-operation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, into account" (p. 1700).

The pressing need for sustainable consumption and production requires systems change with actions from all sectors—governments, financial institutions, and businesses—and geographies [19]. The circular economy concept has recently gained increased priority from policymakers, as evidenced by the European Circular Economy Action Plan and the Circular Economy Promotion Law of the People's Republic of China [20,21]. Moreover, since 2017, the conjoint application of supply chain management and the circular economy has gained interest from scholars in several disciplines [22].

Endorsement of the 2030 Agenda for Sustainable Development by the United Nations in 2015, with 17 Sustainable Development Goals (UN SDGs) at its center, has driven the exponential growth in S-SCM publications [3,5,6,23]. From a business perspective, S-SCM and circular economy practices such as recycling have been identified as key strategies for achieving corporate sustainability [24–28]. By developing standards governing relationships with suppliers and service providers within the supply chain, firms are able to have a positive impact on a wide range of environmental and social issues including gas emissions, water management, waste management and reduction, skill enhancement, and workplace safety [29–33]. Furthermore, enabled by reverse logistics, circular economy practices such as reuse and end-of-life recovery can be employed to facilitate responsible consumption [34–36].

The increasing adoption of a sustainability perspective towards supply chain management has involved the integration of various environmental management concepts [37]. In this review, we examine four related conceptualizations of supply chain management that have evolved over the past 15 years: green, sustainable, closed loop, and circular supply chain management for analysis and comparison (see Table 1).

Each of these conceptualizations of supply chain management has distinctive features when considered from the perspective of a circular economy (see Table 2). For example, the integration of forward and reverse supply chains is the focus of green supply chain management [38]. Both closed-loop and circular supply chain management emphasize value creation and maximization through product recovery and waste reduction [39,40]. Sustainable supply chain management is distinguished from the other conceptualizations through its explicit incorporation of stakeholder theory [3]. Among the four approaches, only sustainable supply chain management and circular supply chain management explicitly aim to impact all three elements of the triple bottom line.

Nimsai et al.'s (2020) review of research found exponential growth in publications on S-SCM since 2010 [23]. However, the Nimsai et al. (2020) review was concluded prior to the onset of the COVID-19 pandemic which challenged organizations to rethink their management strategies not only during the pandemic, but also in the post-pandemic era [41,42]. Thus, the global pandemic can be viewed as a new demarcation in the evolution of corporate sustainability strategies. This suggests the relevance of examining changes in sustainable supply strategies during this period of global economic disruption and highlights the need for identifying innovative approaches to existing management practices.

A review of research conducted by Türkeli and colleagues [43] found that the circular economy concept has been associated with related concepts such as industrial ecology [44], green and bio-economies [45], and sustainability [11]. The reverse supply chain, which emphasizes recovery of after-use products is at the interconnection of the circular economy and supply chain management concepts [9,46,47]. Value recovery at the end-of-product life can be performed by either original producers or other parties for the purposes of reuse, refurbishment, and recycling. This conceptual integration of supply chain management with the circular economy concept frames the review of research conducted in this article.

Table 1. Four definitions of supply chain management.

Author(s)	Definitions
Srivastava, 2007 [38]	<i>Green Supply Chain Management:</i> “Integrating environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life” (p. 54).
Seuring and Müller, 2008 [3]	<i>Sustainable Supply Chain Management:</i> “The management of material, information and capital flows as well as cooperation among companies along the supply chain while integrating goals from all three dimensions of sustainable development, i.e., economic, environmental and social, which are derived from customer and stakeholder requirements” (p. 1700).
Guide Jr and Van Wassenhove, 2009 [40]	<i>Closed-loop Supply Chain Management:</i> “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” (p. 10).
Batista, Bourlakis, Smart and Maull, 2018 [39]	<i>Circular Supply Chain Management:</i> “The coordinated forward and reverse supply chains via purposeful business ecosystem integration for value creation from products/services, by-products and useful waste flows through prolonged life cycles that improve the economic, social and environmental sustainability of organizations” (p. 446).

Table 2. Comparison of four conceptions of supply chain management in circular economy context.

Concept	Distinctive Features	Expected Outcomes
<i>Green Supply Chain Management</i>	Integration of forward and reverse supply chain	Environmental focus
<i>Sustainable Supply Chain Management</i>	Customer and stakeholder engagement	Holistic triple bottom line
<i>Closed-loop Supply Chain Management</i>	Value creation maximization throughout product life cycle	Environmental and economic focus
<i>Circular Supply Chain Management</i>	Value creation through business ecosystem	Holistic triple bottom line

3. Research Method

In this review, bibliometric methods were employed to quantify and synthesize bibliographic data extracted from research documents on sustainable supply chain management in a circular economy. A strength of bibliometric reviews lies in their ability to synthesize patterns in knowledge production across a large body of documents [48]. Although previous bibliometric reviews have been published on sustainable supply chain management [4,23,49] and the circular economy [11,50], this method has not yet been applied to the conjoint literature on these complementary concepts.

3.1. Identification of Sources

Scopus was chosen as the document source rather than the Web of Science, based on its wider coverage of social science and management literature [48,51]. This research focused on peer-reviewed journal articles due to their more rigorous vetting of document quality.

The conceptual scope of the review was defined as “sustainable supply chain management in a circular economy” without regard to date of publication, sector, industry, or geography.

The preferred reporting items for systematic reviews and meta-analyses, or PRISMA [52], was used to guide the document search and selection process. An open-ended Scopus search was initiated in October 2021 by using the keywords “supply chain” and “circular economy” within article titles, abstracts, and keywords. The Scopus search resulted in an initial document list comprising 982 articles published from 2006 to October 2021 (see Figure 1). Application of Scopus filters limited documents to journal articles and reviews published in English, resulting in the exclusion of 245 documents. The authors then screened out additional articles that were either identified as duplicates or irrelevant. At the end of the selection process, the review database included 709 journal articles and reviews.

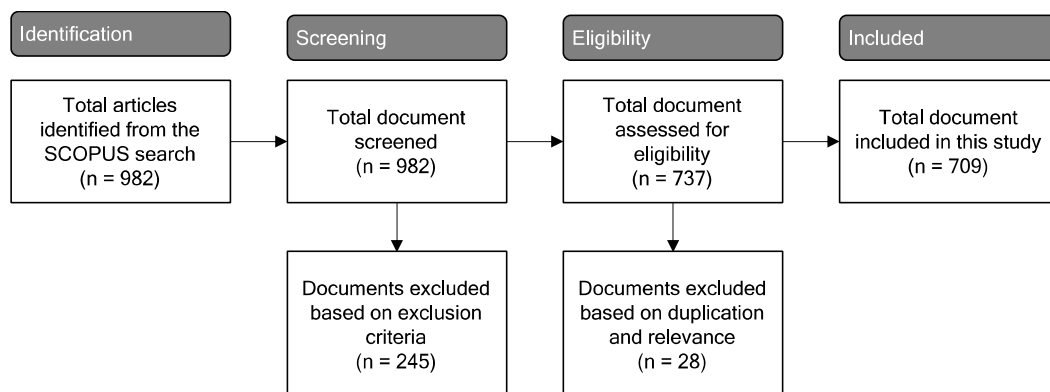


Figure 1. PRISMA diagram detailing the search and selection process.

3.2. Data Analysis

Metadata associated with the list of 709 documents were exported from Scopus to an Excel file for data analyses performed in Excel, Tableau, and VOSviewer [53]. Disambiguation of the meta-data was carried out to ensure accuracy in the bibliometric analyses [48]. For example, an author’s name could be expressed as Jones, P. and Jones, P.R. in different articles. VOSviewer and Excel were used in tandem to create a thesaurus file that replaced multiple forms of an author’s name with a single form (i.e., Jones, P. replaced by Jones, P.R.). A similar process was used to “disambiguate” document titles and keywords.

The first research question was analyzed using descriptive statistics. Scopus analytical tools were used to document the growth trajectory and the subject area distribution of the knowledge base. Tableau software was used to visually illustrate the geographical distribution of authors who published the 709 documents.

Document citation analysis and author co-citation analysis, performed with VOSviewer software version 1.6.8 [53], were used to address the second and third research questions. Document citation analysis was used to identify the most influential journal articles among the 709 documents in our Scopus-indexed database. Though not without limitations, citation analysis is the most widely used method of measuring scholarly impact [48]. In this review, citation analysis was used to determine the number of times each journal article had been cited by all other Scopus documents. Thus, we refer to this frequency metric as “Scopus citations”.

Co-citation analysis is a complementary form of bibliometric analysis that was used to analyze the intellectual structure of the literature on S-SCM in a circular economy. Using VOSviewer, co-citation analysis was conducted in a three-step process [53]. In the first step, VOSviewer identified the frequency with which different authors had been cited in the reference lists of the 709 review documents [54]. Zupic and Čater (2015) noted that, “co-citation connects documents, authors, or journals according to the way the writers use them. This is a rigorous grouping principle repeatedly performed by subject-matter experts

who cited publications they deem valuable and/or interesting” (p. 431). Author co-citation analysis was applied in order to gain insight into the theoretical foundations of scholarship on S-SCM in a circular economy [48].

In the second step, VOSviewer tracked the frequency with which “pairs of authors had been cited” in the reference lists of the review documents. Each time that a pair of authors (e.g., Seuring and Sarkis) was found in the same reference list, VOSviewer assigned a “co-citation link” to them. Authors who are repeatedly cited together by other scholars are assumed to share an intellectual similarity [54]. Thus, VOS actually stands for “visualization of similarities”.

In the third step, VOSviewer built an author co-citation matrix comprising data describing the links between pairs of authors [53,54]. Using this co-citation matrix, VOSviewer is able to generate a social network map, referred to in bibliometric analysis as a “science map” [53]. This review employed the author co-citation map (ACA) to visualize associations among authors in the literature on S-SCM in a circular economy. ACA maps are widely used to identify the “intellectual structure” of a discipline or line of inquiry [1,4,23,48].

4. Results

The presentation of results is organized in response to three research questions.

4.1. Growth Trend, Subject Areas, and Geographical Distribution of the Literature

The first documents that explicitly linked S-SCM and circular economy were published in 2006 [55,56]. However, 2018 marked the beginning of exponential growth in articles that address the conjoint topics (see Figure 2). One of the drivers explaining this pivot point is the adoption of sustainable development goals as part of the 2030 Agenda for Sustainable Development by United Nations member states in 2015 [19]. This agenda prioritized the circular economy and supply chain management as crucial means of achieving the 17 sustainable development goals.

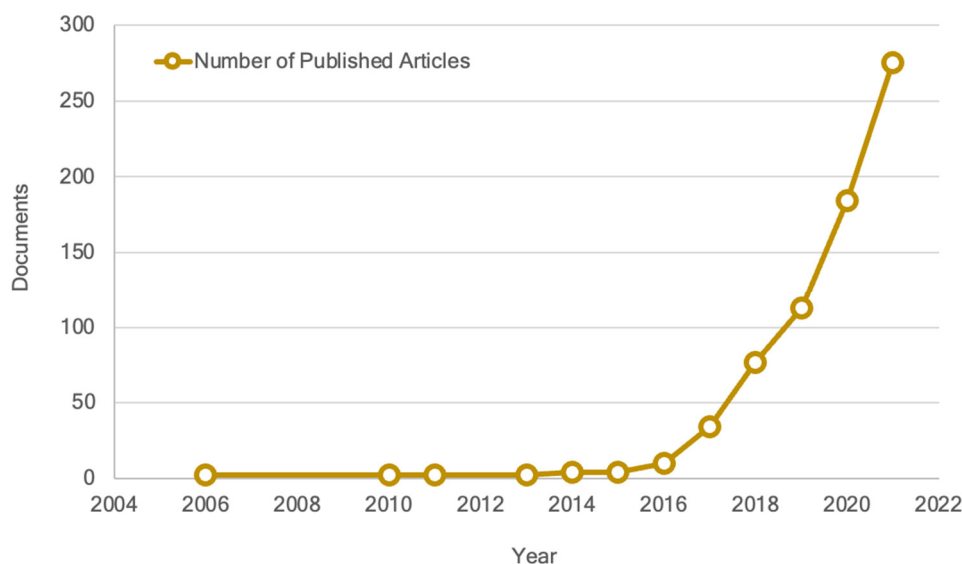


Figure 2. Growth trajectory of articles on sustainable supply chain management in a circular economy through October 2021 ($n = 709$).

Analysis of the subject domains encompassed in the 709 articles revealed a highly interdisciplinary knowledge base focusing on the dual concepts driving this review (see Figure 3). Notably, scholarship from environmental sciences, business, management and accounting, engineering, and energy accounts for more than two-thirds (68%) of the literature. This suggests potential for significant innovation through the cross-fertilization of theoretical perspectives and interdisciplinary solutions.

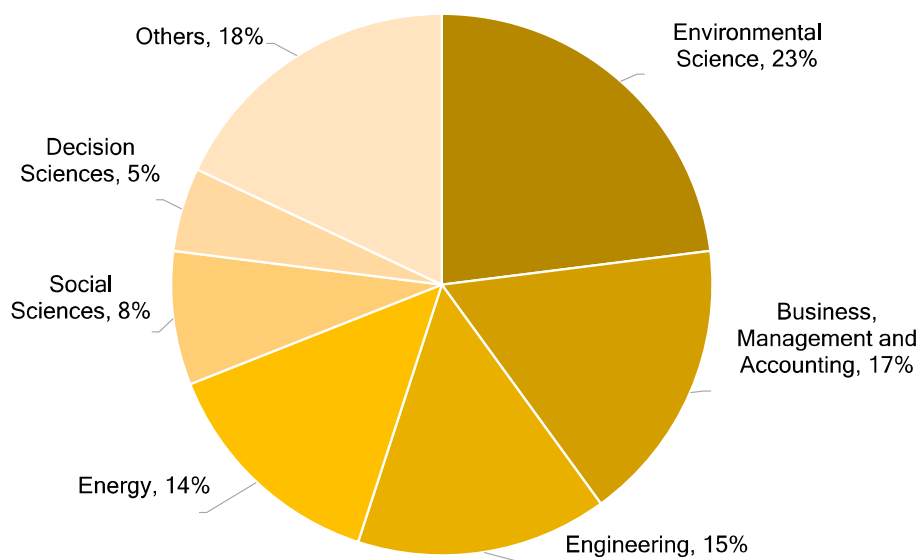


Figure 3. Subject area distribution of the literature on sustainable supply chain management in a circular economy ($n = 709$). Note. Subject areas (18) contributing less than 5% were grouped into “others”.

The heat map in Figure 4 highlights concentrations of scholarship originating in particular countries/regions as well as the global reach of this literature. Scholars from the United Kingdom, Italy, United States, India, and China have made the largest contributions to this literature. More broadly, scholars from Europe and Asia have been particularly active contributors to this knowledge base. Indeed, the aggregated literature published by all European Union countries and the United Kingdom comprises slightly more than 50% of the database. This interest among European scholars may be explained by the European Commission’s 2015 endorsement of circular economy-related actions as a priority mode of response to sustainability challenges [57]. Increasing interest from scholars in China is similarly policy-related, driven by the enforcement of China’s Circular Economy Promotion Law which was established in 2009 [58].

4.2. High Impact Documents on Sustainable Supply Chain Management in a Circular Economy

The most highly cited documents in this knowledge base have focused on the conceptual integration of the core concepts (e.g., [50,59]), as well as on identifying relevant drivers, barriers, business models, practices, and strategies (e.g., [7,60]). We noted a pattern of interdisciplinary collaboration among the authors of 13 of the top-cited articles. This collaboration was evident in articles that drew upon management and production engineering [13], economics and marketing [22], and corporate sustainability, business, economics, and industrial design engineering [60]. Moreover, there has been a high level of collaboration not only among scholars from different geographic areas but also between developed and developing countries (e.g., [13,59–62]).

The top-cited articles evidence a balance towards empirical studies (11 articles), when compared with conceptual (4) and review (4) articles. This suggests room for more conceptual development and reviews of research in this literature. For example, Winkler (2011) [63] introduced the sustainable supply chain network (SSCN) concept by moving from isolated applications of waste management in the production process to a closed-loop production system in which interacting companies work together to create a network for collecting and conditioning waste to be reused as resources. Winkler (2011) [63] emphasized that companies within an SSCN should involve those outside the same industry who can benefit from waste and use it as materials, as well as those providing know-how, technologies, and services in collecting, conditioning, or exchanging waste material. As the proposed network is built within the circular economy context, the supply chain network is extended

to the end-of-life stage when products are recovered effectively from customers for reuse, remanufacture, or recycling [63].

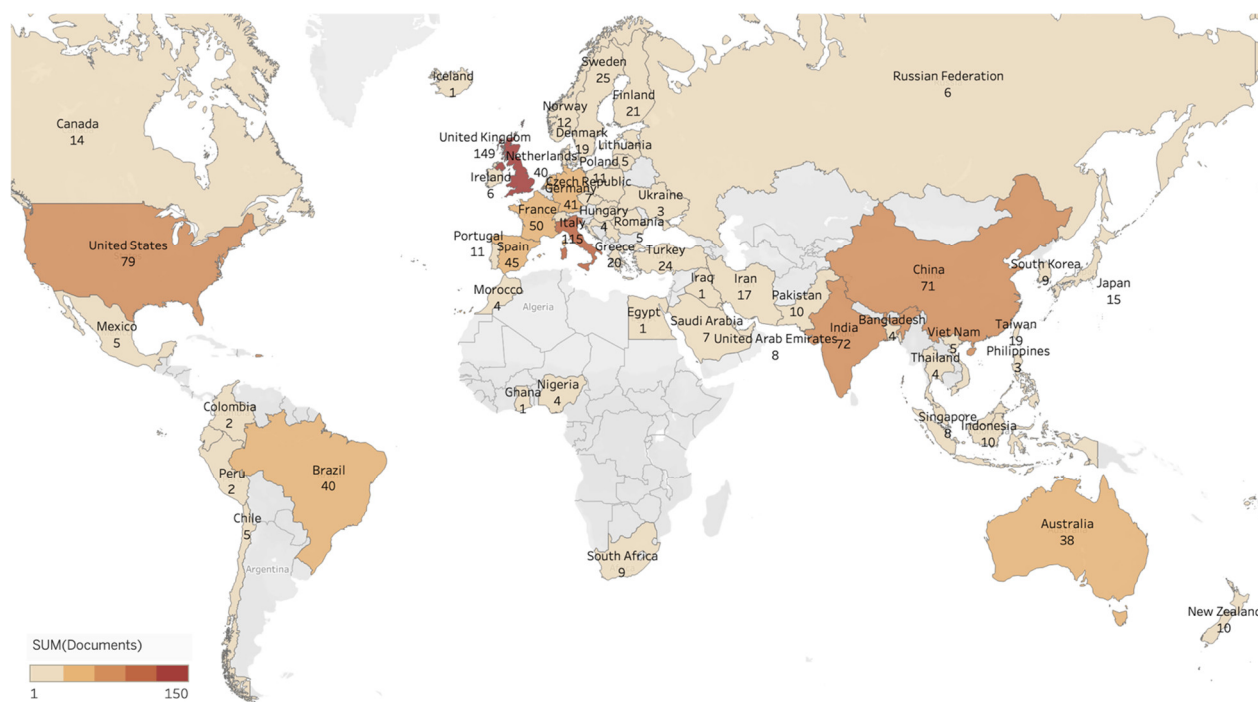


Figure 4. Geographical distribution of the literature on sustainable supply chain management in a circular economy, 2006–2021 ($n = 709$).

The review conducted by Lüdeke-Freund et al., (2019) [60] consolidated key ideas emerging from the literature. They proposed that a supply chain with reverse loops represents the backbone of the circular economy, and identified 26 business models that derive from the integrated concepts (see also [14,59]). These include, for example, a product-service system, take-back management, and waste handling and management [64,65].

Govindan and Hasanagic (2018) [7] identified 34 practices carried out by enterprises after adopting a circular economy perspective on supply chain management. For example, they highlighted the increased eco-efficiency in production that results from integrating 6R—reduction, reuse, recycling, recovery, redesign and remanufacture—into the production process [21,46,62,65]. They also identified efficiencies gained through corporate collaboration within industrial parks [66], as evidenced in China, Japan, India, the European Union, and the United States. This strategy leverages resource exchange in the form of by-products, materials, and energy [46], as well as the potential of shared recycling [21].

The review conducted by Kalmykova and colleagues (2018) [67] identified 45 circular economy strategies that can be applied by different actors in the value chain. These include material sourcing, design, manufacturing, distribution and sales, consumption and use, collection and disposal, recycling and recovery, remanufacturing, and circular inputs. Their analysis further highlighted the role played by community stakeholders with respect to sustainable consumption and usage [67].

These business models, practices, and strategies share similarities in terms of their enablers. However, these business models require clear performance measurement metrics in order to achieve desired systemic effects on the triple bottom line of corporate outputs. Notably, the literature suggests a current imbalance with social sustainability impact receiving less attention.

The empirical studies contained in the list of top-cited articles address production and consumption in a wide range of industries including aluminum, chemical, leather, building, construction, food, furniture, fashion, and electronics (see Table 3). Notably, however, only

a single study focused on consumers [68]. Wang and Hazen (2016) examined the effect of remanufactured product knowledge on consumers' perceptions and their purchase intent in China. They found that quality knowledge had the strongest effect on perception and purchase intention when compared with cost and green attributions.

On the production side, empirical evidence captured by case studies and interviews underpins the integration of supply chain and circular economy concepts. For instance, Genovese et al. (2017) [9] provided evidence on emissions reduction through supply chain carbon mapping. Through four case studies, Geissdoerfer et al. (2018) [59] identified opportunities to reduce negative environmental and social impact through proactive multiple stakeholder management. These included supply chain network development for product recovery at the end of product life, use of recycled material mix to reduce the raw material import dependency, and alternate modes of transportation in order to reduce traffic-related pollution.

In addition, advanced technologies were studied as key enablers for sustainable production and supply chain management. For example, Pan et al. (2015) [8] reviewed waste-to-energy technologies and proposed strategies to implement waste-to-energy supply chains in a circular economy context. These included policy formation, economic schemes, performance evaluation measures, programs for social acceptance, and investment mobilization. Lopes de Sousa Jabbour et al. (2018) [13], Nascimento et al. (2019) [14], and Despeisse et al. (2017) [12] examined the applications of Industry 4.0 technologies such as additive manufacturing to manufacture products with 3D printers and treatment of waste for use as raw material.

4.3. Intellectual Structure of the Literature

The intellectual structure, or theoretical pillars of the literature, was analyzed through author co-citation mapping (see Figure 5). The size of an author node on the co-citation map suggests the frequency with which a scholar was cited in the reference lists of the review documents [48]. The proximity of nodes reflects the relative degree of intellectual affinity of the corresponding authors [48]; authors located close together (e.g., Van Wassenhove and Guide) are, therefore, considered to be closely affiliated. The lines connecting author nodes represent co-citation "links" between the two scholars; the density of the lines reflects their co-citation frequency [53]. The colored clusters represent "schools of thought" consisting of authors whose publications tend to share a common lineage [53,54].

The author co-citation map in Figure 5 visualizes four schools of thought, which we have labeled Sustainable Supply Chain Management, Circular Economy, Sustainable Production and Environmental Management, and Reverse Supply Chain Management. The coherence of the clusters highlights the clarity of the literature's conceptual structure. Though the smallest of the four schools of thought, the central location and numerous links to other schools suggests that Sustainable Supply Chain Management is the conceptual anchor of this literature. Based on his influence across all four schools, Joseph Sarkis is the key "boundary-spanning" scholar in this literature. His contributions span a wide range of conceptual foci including sustainable operations, environmental management, green supply chain management strategic decision frameworks, and performance measurement methodologies [69–71]. Sarkis's collaborations with Zhu and Geng in China cover a wide range of research including system pressures, operational practices, measurement models, and S-SCM in a circular economy in the Chinese context [72–74].

Sarkis' most recent contributions include a performance measurement framework for resilient supply chains, analysis of social sustainability impact from technologies under a circular economy approach, and assessment of corporate sustainability standards in tier-based supply chains [75,76]. Recent studies published by Seuring focus on social sustainability, uncertainty management, resilience, collaboration, and supply chain management in a circular economy [77–79].

Table 3. Top-cited documents in the Scopus-indexed literature on sustainable supply chain management in a circular economy ($n = 709$).

Rank	Document	Type	Scopus Citations
1	Genovese et al. (2017). Sustainable supply chain management and the transition towards a circular economy: Evidence and some applications.	Emp	407
2	Kalmykova et al. (2018). Circular economy—From review of theories and practices to development of implementation tools.	Rev	350
3	Pan et al. (2015). Strategies on implementation of waste-to-energy (WTE) supply chain for circular economy system.	Con	264
4	Lopes de Sousa Jabbour et al. (2018). Industry 4.0 and the circular economy: A proposed research agenda and original roadmap for sustainable operations.	Con	258
5	Geissdoerfer et al. (2018). Business models and supply chains for the circular economy.	Emp	241
6	Govindan and Hasanagic (2018). A systematic review on drivers, barriers, and practices towards circular economy: A supply chain perspective.	Rev	239
7	Zhu et al. (2010). Circular economy practices among Chinese manufacturers varying in environmental-oriented supply chain cooperation and the performance implications.	Emp	225
8	Homrich et al. (2018). The circular economy umbrella: Trends and gaps on integrating pathways.	Rev	190
9	Park et al. (2010). Creating integrated business and environmental value within the context of China's circular economy and ecological modernization.	Emp	186
10	Lüdeke-Freund et al. (2019). A review and typology of circular economy business model patterns.	Rev	179

Table 3. Cont.

Rank	Document	Type	Scopus Citations
11	Nascimento et al. (2019). Exploring Industry 4.0 technologies to enable circular economy practices in a manufacturing context: A business model proposal.	Emp	161
12	Despeisse et al. (2017). Unlocking value for a circular economy through 3D printing: A research agenda.	Con	155
13	Wang and Hazen (2016). Consumer product knowledge and intention to purchase remanufactured products.	Emp	141
14	Hong et al. (2018). Sustainable supply chain management practices, supply chain dynamic capabilities, and enterprise performance.	Emp	138
15	Moktadir et al. (2018). Drivers to sustainable manufacturing practices and circular economy: A perspective of leather industries in Bangladesh.	Emp	130
16	Nasir et al. (2017). Comparing linear and circular supply chains: A case study from the construction industry.	Emp	124
17	Zeng et al. (2017). Institutional pressures, sustainable supply chain management, and circular economy capability: Empirical evidence from Chinese eco-industrial park firms.	Emp	121
18	Islam and Huda (2018). Reverse logistics and closed-loop supply chain of Waste Electrical and Electronic Equipment (WEEE)/E-waste: A comprehensive literature review.	Rev	119
19	Winkler (2011). Closed-loop production systems-A sustainable supply chain approach.	Con	119
20	Leising et al. (2018). Circular Economy in the building sector: Three cases and a collaboration tool.	Emp	116

Con = conceptual; Emp = empirical; Rev = review.

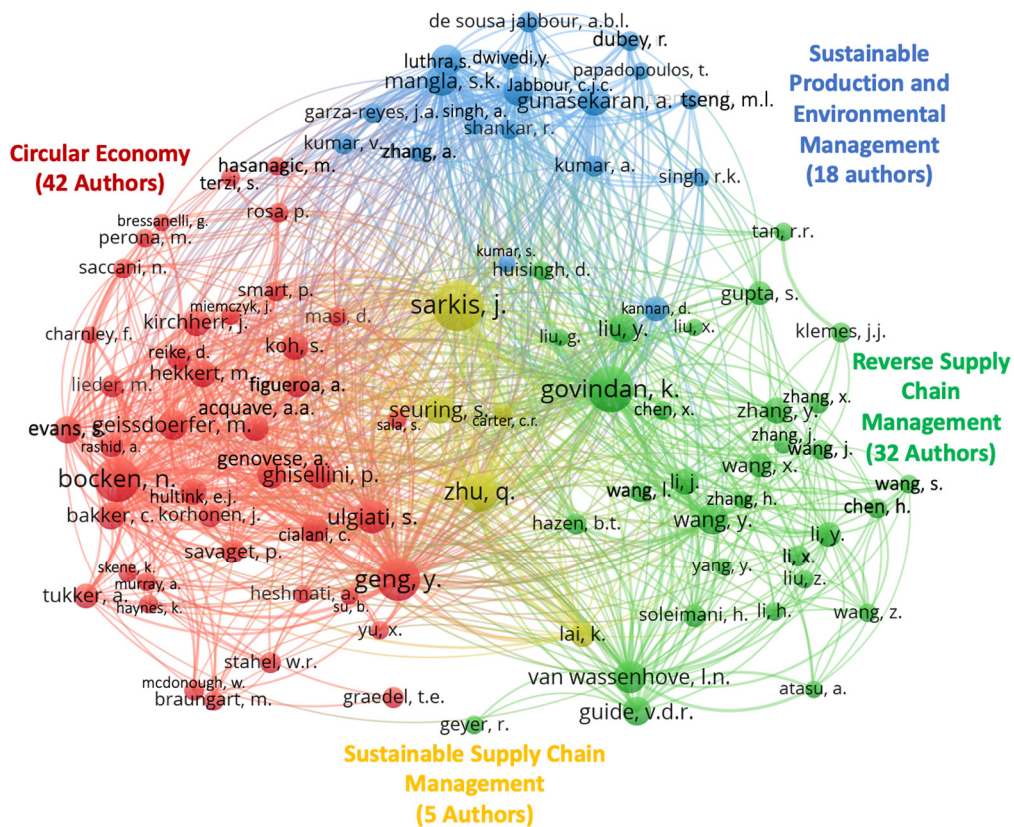


Figure 5. Author co-citation map of the literature on sustainable supply chain management in a circular economy, with a threshold of 80 co-citations (97 authors).

The Circular Economy school, comprising 42 authors, is the largest of the four clusters. Key scholars in this cluster (e.g., Bocken, Geng, Ulgiati, Geissdoerfer, Ghisellini, Genovese) represent diverse fields including engineering, environmental science, science and technology, business and management, and sustainable development. Their published works focus on conceptualizing the circular economy, identifying drivers and constraints, developing new business models, and developing applications as a vehicle for sustainability transition [9,11,46,80,81]. Their research highlights the importance of measurement when seeking to bring about systems change in circular economy practices [11,46,80].

The collaboration between Ulgiati and Ghisellini yielded an extensive review of the circular economy at micro, meso, and macro levels of implementation. The Ghisellini et al. (2016) [46] review identified need for more research on measurement indicators for circular economy application. Ulgiati's research in the EU identified opportunities and challenges concerning the transition into a circular economy [82,83]. Bocken, Geissdoerfer and Evans emphasized conceptualizing circular economy through product design and business models with empirical studies focusing on the passage of the model from linearity to circularity [25,59,80,84,85].

The Sustainable Production and Environmental Management school comprises 18 authors, with key scholars including Mangla, Luthra, Jabbour, Gunasekaran and Kannan. Their research has focused on sustainable production, green manufacturing, production planning, optimization, and sustainable operations as well as environmental management. Recent publications have applied the circular economy concept explicitly to the production process [86–89].

Mangla and Luthra evaluated barriers and challenges of the circular supply chain, building frameworks for supplier selection, and providing practical implications based on studies in India [90,91]. Jabbour and colleagues proposed a framework that integrates the circular economy concept and human resource management from a change management perspective [92]. Jabbour and Gunasekaran focused on the adoption of advanced digital

technologies (Industry 4.0) as a means of integrating the circular economy with production and supply chain management. These technologies have included big data, cloud manufacturing, internet of things, additive manufacturing, and blockchain [13,93,94].

The last cluster, Reverse Supply Chain Management, consists of 32 authors, led by Govindan, Van Wassenhove, Wang, Liu, and Guide. These authors span engineering, social sciences, business, and management. Their research has concentrated on reverse supply chain management, circular supply chains, waste management, and integrated reverse loop practices including reuse, remanufacturing, recycling, and product-service systems [34,95,96]. Notably, authors in this school have also focused on the consumption side of supply chain management.

Govindan has examined reverse supply chain management from the perspectives of network development, decision making models, forecasting, provider selection criteria, and performance measurement metrics [34,97,98]. Van Wassenhove and Wang's research has sought to assess reverse-loop circular economy practices including return, leasing, renting, sharing, and remanufacturing [68,95,99]. Research within this school has also examined consumer knowledge, perceptions, preferences, adoption criteria, and purchase intention toward products and services under the circular economy concept [68,99–101].

5. Discussion

This bibliometric review of research on sustainable supply chain management (S-SCM) in a circular economy builds upon prior reviews by explicitly linking the related but conceptually distinct concepts of S-SCM and circular economy. The main contribution of the review is to provide insights into how the conceptualization of S-SCM is enriched through integration with the circular economy.

This bibliometric review confirmed that S-SCM in a circular economy is an emergent field of study. Moreover, we believe that stakeholder pressure for achieving the UN SDGs will continue to generate interest in this interdisciplinary field of research, policy, and practice [19,102–104]. This conclusion is supported by the current growth trajectory of the literature (see Figure 2), as well as by the policy-driven contributions to this literature by scholars from the European Union, United Kingdom, and China [57,58]. Indeed, the literature already evidences unusually strong collaboration among scholars from different geographies.

Analysis of the top-cited documents in this literature highlighted the means through which the concept of the circular economy has transformed sustainable supply chain management strategies. This transformation is enabled by six reverse cycles of the circular economy: (1) repair and maintenance, (2) reuse and redistribution, (3) refurbishment and remanufacturing, (4) recycling, (5) cascading and repurposing, and (6) resource extraction [46,60]. Furthermore, these documents suggest that reframing supply chain management from a circular economy perspective has the potential to yield benefits at several levels.

At the macro level, countries can expect to achieve more rapid progress towards sustainable development goals related to resource security, emissions reduction, and landfill usage when supply chain management adopts circular economy principles [46]. At the meso level, industry collaboration can reduce resource scarcity and price volatility [13,22,64,66], lower harmful emissions [9,105], and increase support from communities through green operations and supply chain collaboration [46,60,66]. Collaboration creates the possibility for achieving the critical mass in operations that makes sustainable supply chain management economically viable for individual firms. At the micro level, adopting circular economy principles enables companies to position themselves with the right to operate in global markets, build brand reputation, create new revenue streams, and reduce business risks resulting from inventory and supply shortages [18,46,60,62].

The top-cited studies also point towards the potential that Industry 4.0 technologies hold for leveraging circular economy principles in supply chain management. Technologies such as additive manufacturing, big data, artificial intelligence, blockchain, and cloud

computing can be used to enhance resource recovery, reduce virgin material exploitation, and lower carbon emissions [12–14]. These technologies enable firms to gain greater precision in supply-demand forecasting, secure sustainable resources through circularity, and create new revenue streams from innovative products and services derived from circular economy strategies. Therefore, sustainable supply chain management enabled by advanced technologies has the potential to accelerate the transformation from linear to circular economy, and progress toward sustainable consumption and production [106,107].

Moreover, the examination of the highly cited documents indicated that the business models, strategies, and practices associated with managing supply chains in a circular economy may require a shift in the use of performance metrics. More specifically, the nature of the circular economy is such that performance measurement metrics will be needed for each actor engaging in this multi-level, systemic process. At the micro-level, relevant metrics are reflected in environmental, social, and governance (ESG) goals that organizations develop and report. However, more attention needs to be given to the aggregation of corporate metrics at the meso-level in the form of industry indexes and benchmarks, and in articulating linkage to the UN SDGs at the macro-level.

The author co-citation map revealed four schools of thought comprising the intellectual structure of the knowledge base on S-SCM in a circular economy. The first school, Sustainable Supply Chain Management, conceptualizes supply chain management for sustainable development [3,70]. Notably, this school's location in the center of the map highlights its role as the conceptual anchor of this literature. The Circular Economy, the second school, has focused on process reconfiguration, product redesign, and new business models that are grounded in a regenerative conceptualization of sustainable consumption and production [9,11,81]. The third school, Sustainable Production and Environmental Management examines how government and corporate policies and practices reorient operations and manufacturing to reduce harmful environmental effects while supporting economic growth [87–89]. The last school, Reverse Supply Chain Management, highlights the role that “reverse loops” associated with a circular economy can play in extending our understanding of sustainable supply chain management [7,68,108].

The map reframes sustainable supply chain management by connecting corporate practices to both production and consumption [47,99,100,109]. Nascimento et al. (2019) [14] asserted that supply networks must be circular in order to achieve sustainable production. Winkler (2011) [63] emphasized the need for all actors along the supply chain to co-operatively implement circular economy practices from production to consumption. The vital interdependency among circular economy, sustainable operations, and sustainable consumption is visualized on the map where sustainable supply chain management is located in the center linking the three concepts (see Figures 4 and 5).

On the production side, studies revolve around the integration of circular economy and sustainable production and operations. The goal is to create self-sustaining production systems minimizing virgin material exploitation through waste recovery, reuse, and transformation [22,90,93]. In a circular economy, supply chain management practices recover waste which can be transformed into raw material for use in newly designed materials, products, and supply chains [94,110]. Such systems are enabled by cascading, repurposing, and extraction processes that are, in turn, driven by renewable energy [9,11,46].

Studies have also uncovered circular-economy-related supply chain practices that support sustainable consumption. These include infrastructure enabling maintenance and repair, redistribution and reuse, remanufacturing and refurbishment, and recycling services, education to change consumer attitudes and behaviors, and incentives in the form of competitive pricing achieved [68,96,99,100,108]. Both self-sustaining production systems and infrastructure that increases consumer awareness, involvement, and responsibility also offer possibilities for moving toward more sustainable consumption.

Over the last 30 years, studies of sustainable supply chain management have tended to adopt an isolated view towards forward and reverse flows [3–5] However, as Lüdeke-Freund et al. (2019) [60] emphasized, the circular economy implementation posits the

reverse loop supply chain as its backbone. All 26 business models captured by Lüdeke-Freund et al. (2019), 34 circular economy practices identified by Govindan and Hasanagic (2018) [7], and 45 circular economy strategies proposed by Kalmykova et al. (2018) ride along the 6R reverse loops of the supply chain [46]. Adoption of a circular economy perspective emphasizes the long-lasting design and reduction concept which involves upstream collaboration with suppliers and forward flow providers.

6. Conclusions

The interplay among the four schools of thought identified in this review highlights the value gained by considering supply chain management in tandem with the circular economy. Over the past 30 years, scholars and practitioners in sustainable production, operations, and supply chain management increasingly integrated environmental management principles in order to reduce harmful effects on the environment. Yet, predominant conceptualizations of S-SCM continued to operate on a take–make–dispose linear economy model. This paradigm does not address the loss of valuable materials in landfills, resource scarcity, and over-consumption. The circular economy concept challenges production and supply chain management to adopt a “systems view” of sustainability solutions. When a circular economy perspective is adopted, managers begin to think in terms of product design, as well as processes for reduction, reuse, recycling, recovery, redesign and remanufacture. Putting these reverse loop processes into practice, however, requires more proactive engagement and collaboration among a broad set of stakeholders. In this closing section of the paper, we highlight limitations of the review, and discuss implications of the findings.

6.1. Limitation of the Findings

Two limitations deserve attention. First, as discussed earlier, bibliometric reviews are designed to analyze knowledge base attributes in lieu of examining specific findings from a body of literature. Therefore, despite the fact that this review did discuss theoretical trends in this emerging literature, this was based primarily on inferences drawn from co-citation analyses of bibliographic data associated with the Scopus-indexed database of documents. Future reviews may draw upon our findings in order to guide closer examination of findings using more fine-grained review methods.

Second, to enable closer reading of selected documents, the authors chose to exclude articles published in languages other than English. We do wish to note, however, that China, Brazil, and Italy were identified as particularly active in producing research on this topic. Reviews of the local language literatures in these countries could provide a useful complement to our own research.

6.2. Implications and a Proposed Model toward Sustainable Futures

The first implication from this review lies in the conceptual sphere. Drawing upon our findings, we have adapted Rebs, Brandenburg and Seuring’s (2019) [111] model of sustainable supply chain management in a circular economy model (see Figure 6). The original model included three key elements: circular supply chain, stakeholder engagement, and triple bottom line benefits.

Our proposed model (see Figure 6) expands the original Rebs et al. (2019) [111] model to adopt a strategic perspective drawn from Suriyankietkaew and Petison’s (2020) [42] review of the literature on strategic management for sustainability. The integrated model incorporates macro-level environmental constituencies and pressures (e.g., global SDG movement, changing market demands, institutional policies) that can be viewed as drivers of change in sustainability policies and practices (i.e., balance, resilience, sustainable development) toward sustainable futures. The proposed framework may become a sustainable business model that provides pragmatic guidance toward corporate sustainability.

Based on the enduring barriers identified in transitioning to a circular economy from supply chain management perspective [7,8,82], we identify several implications for policy-makers. First, the most urgent tasks are the issuance of circularity policies, empowerment

of enforcement bodies, and development of stronger, relevant performance management metrics. The launch of top-down initiatives in the forms of subsidies and tax benefits can reduce the burden of capital investment on eco-innovation for product/service redesign, production, and supply chain reconfiguration with reverse loops, and the deployment of advanced technologies.

Second, along with these initiatives, a platform is needed that supports collaboration among different actors within and outside supply chains, enhances information sharing, and enables clearer benchmarking of progress and results. The launch of consumer education programs is needed to overcome attitudinal and behavioral barriers to the use of eco-products. As Ghisellini and Ulgiati (2020) [82] pointed out, recycling remains by far the dominant practice among the “6Rs”. Within corporate supply chain management, this highlights both the urgency and potential of diversifying circular economy practices. This suggests a need to reprioritize financing, and build infrastructure that supports reduction, reuse, recovery, remanufacture and redesign practices.

Third, for practitioners, the proposed framework provides guidelines for evaluation of environmental impact, assessment of demand, and development of innovative strategies. Practitioners should seek to increase alignment between headquarters’ ESG goals and local ESG initiatives, particularly in multinational companies. The review provides evidence that can support managers in building a business case to secure budget for leveraging reverse loop practices in the supply chain.

Findings from this review also suggest several directions for future research. First, future research can test and further refine the proposed framework. With the impact of COVID-19 pandemic, different countries and industries have their own challenges and priorities. It is imperative to validate the environment and consider different theories such as stakeholder theory and complexity theory.

Second, this review found a geographical imbalance in the global literature, with limited research from developing countries. Yet, developing societies are critical actors in global trade and supply chains. Thus, future studies should place greater emphasis on how developing nations are incorporating circular economy principles to refine supply chain management practices.

Third, collaboration among actors within and outside supply chain has been highlighted as a crucial factor driving systems change [6,22,25,60]. Future research should look more in depth into the duties and obligations of various supply chain participants. The complexity of global supply chain networks, different stages in implementing circular economy policies and growth agenda might cause the deviation when defining roles and responsibilities.

Finally, future studies are needed that examine the use of performance measurement metrics employed at micro, meso, and macro levels of sustainable supply chain management in a circular economy context. For example, research could investigate how environmental, social, and governance (ESG) goals align with actions and how they are measured in relation to United Nations Sustainable Development Goals (UN SDGs). Factors such as business structures, sizes, and geographies should be taken into consideration. For example, multinational corporations might centralize performance measurement activities and report at the corporate level without the breakdown by geography. This research could also examine how this would impact the way each country reports progress toward UN SDGs.

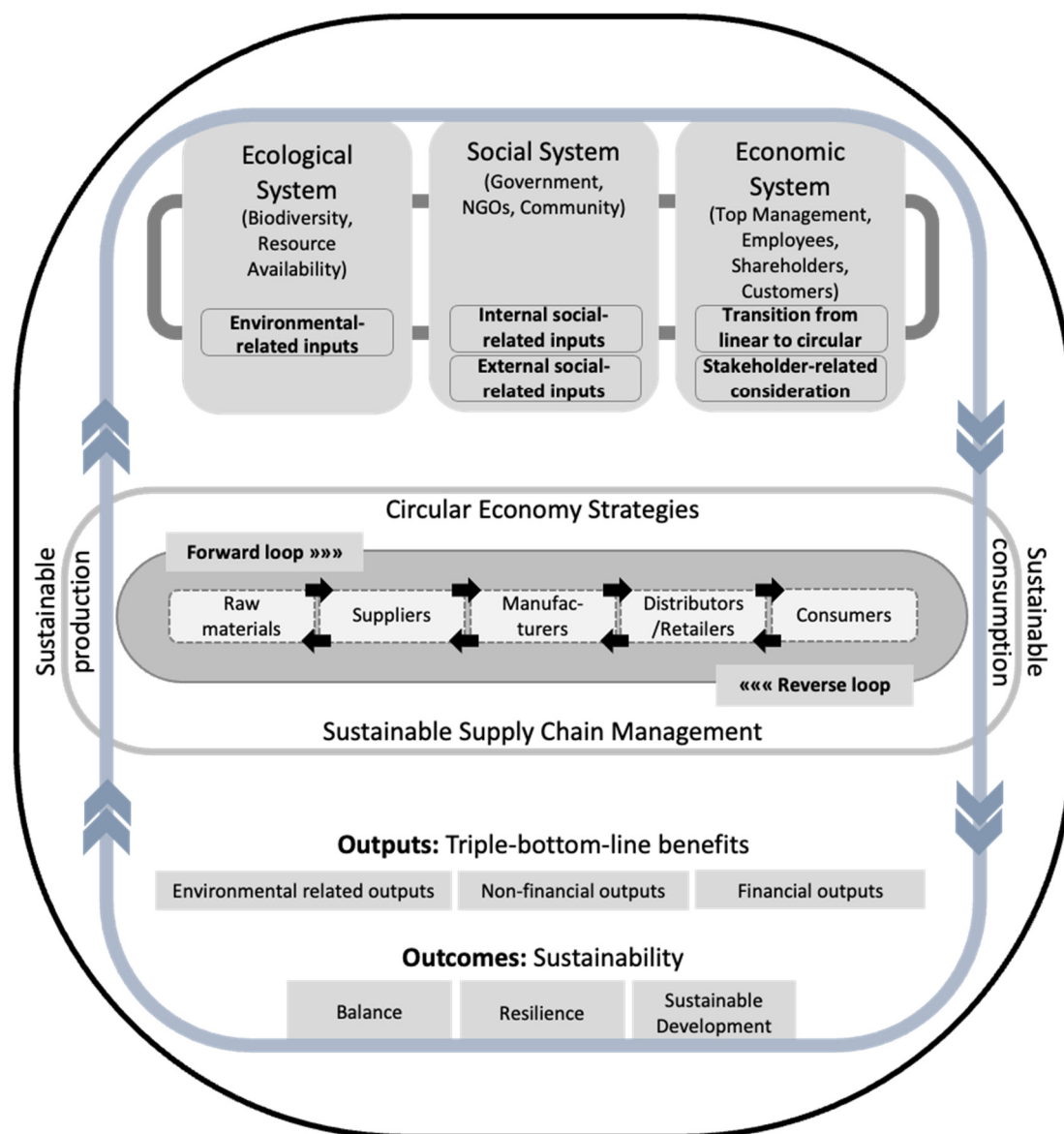


Figure 6. Proposed framework for sustainable supply chain in circular economy in the COVID-19 era (Source: adapted from Rebs et al., 2019 [111], p. 1276 and Suriyankietkaew and Petison, 2020 [42], p. 18).

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