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# CIRCULAR ECONOMY AND SUSTAINABLE SUPPLY CHAINS: A SYSTEMATIC LITERATURE REVIEW

## *EKONOMI SIRKULAR DAN RANTAI PASOK BERKELANJUTAN: SEBUAH TINJAUAN LITERATUR SISTEMATIS*

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**ABSTRACT**
This study aims to analyze the integration of Circular Economy (CE) principles within the Sustainable Supply Chain (SSC) framework through a cross-sectional approach.narrative integrative reviewThe study results show that theoretical models in the CE–SSC literature are still fragmented, with the dominance of NRBV, Industrial Ecology, and institutional theory approaches that have not been able to comprehensively integrate all circular loops. In addition, digital enablers such as IoT, AI, and blockchain have not been systematically integrated in existing models, creating important conceptual gaps in supporting traceability, coordination, and performance measurement of circular supply chains. This study offers an integrative framework that unites circular design, digital technology, supply chain coordination, reverse flow mechanisms, and sustainability outcomes. These findings provide academic contributions through comprehensive theoretical mapping and practical contributions in the form of guidance for organizations and policymakers in developing more effective, collaborative, and technology-based CE–SSC implementations.
**Keywords: Circular Economy; Sustainable Supply Chain; Model Integration; Digital Technology; Reverse Logistics; Sustainability Performance; Conceptual Framework**

***ABSTRAK***
*Penelitian ini bertujuan untuk menganalisis integrasi prinsip Circular Economy (CE) dalam kerangka Sustainable Supply Chain (SSC) melalui pendekatan narrative integrative review. Hasil kajian menunjukkan bahwa model-model teoritis dalam literatur CE–SSC masih terfragmentasi, dengan dominasi pendekatan NRBV, Industrial Ecology, dan teori institusional yang belum mampu menggabungkan seluruh loop circular secara komprehensif. Selain itu, digital enablers seperti IoT, AI, dan blockchain belum terintegrasi secara sistematis dalam model existing sehingga menciptakan kesenjangan konseptual penting dalam mendukung traceability, koordinasi, dan pengukuran kinerja circular supply chains. Studi ini menawarkan sebuah framework integratif yang menyatukan circular design, teknologi digital, koordinasi rantai pasok, reverse flow mechanisms, dan sustainability outcomes. Temuan ini memberikan kontribusi akademik melalui pemetaan teoritis yang komprehensif dan kontribusi praktis berupa panduan bagi organisasi dan pembuat kebijakan dalam mengembangkan implementasi CE–SSC yang lebih efektif, kolaboratif, dan berbasis teknologi.*
***Kata Kunci: Circular Economy; Sustainable Supply Chain; Integrasi Model; Teknologi Digital; Reverse Logistics; Kinerja Keberlanjutan; Framework Konseptual***

### 1. INTRODUCTION

Circular Economy (CE) is developing as a strategic paradigm that focuses on restorative loops, resource recovery, and closed-loop systems to replace the linear economic model of "take makes waste." In the context of the supply chain, CE emphasizes the importance of keeping materials in the use cycle as long as possible through activities such as reuse, remanufacturing, recycling, and regenerationThis approach is becoming increasingly relevant given the high global waste burden and unsustainable resource consumption.


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According to the OECD report, global plastic production reached 460 million tonnes in 2019, which has nearly doubled since 2000, while global plastic waste has reached 353 million tons, with only9%that are successfully recycled (OECD, 2022). On the other hand, UNEP reports that the world produces 2.3 billion tons of municipal solid waste (MSW)in 2023, and that figure is projected to increase to 3.8 billion tonnes by 2050if there are no structural interventions such as the implementation of CE in the supply chain (UNEP, 2024). In addition, the global cost of waste management is estimated to reachUSD 252 billion, and can increase toUSD 361 billionwhen taking into account external impacts such as health and pollution (UNEP, 2024).

The following table summarizes some important data regarding the urgency of implementing CE in the supply chain:

**Table 1**
**Global Statistics on Waste and Circularity**

| Key Indicators | Mark | Year | Source |
|---|---|---|---|
| Global plastic production | 460 million tons | 2019 | OECD |
| Total global plastic waste | 353 million tons | 2019 | OECD |
| Global plastic recycling rates | 9% | 2019 | OECD |
| Municipal solid waste global | 2.3 billion tons | 2023 | UNEP |
| Global MSW projections | 3.8 billion tons | 2050 | UNEP |
| Global waste management costs | USD 252 billion | 2020 | UNEP |
| Total cost including externalities | USD 361 billion | 2020 | UNEP |

Source: OECD (2022); UNEP (2024)

The data in the table shows that the global production system relies heavily on virgin materials, generating volumes of waste beyond the capacity of the environment and current waste management systems. Therefore, integrating CE principles is one of the most strategic solutions for reducing waste, reducing dependence on virgin resources, and optimizing supply chain efficiency through closed-loop design (McDonough & Braungart, 2002).

Apart from the waste problem, global pressures such as climate change, scarcity of resources, tightening of regulations, until ESG compliance demandsThis further reinforces the urgency of adopting CE in the supply chain (UNEP, 2024). Global companies now face multi-level pressures, including carbon taxation, extended producer responsibility (EPR), and mandatory sustainability reporting. This places CE at the heart of sustainable operational and supply chain strategies.

Sustainable Supply Chains (SSC) emerged as a comprehensive approach that integrates economic, environmental, and social dimensions in accordance with the principlesTriple Bottom Line (TBL)(Elkington, 1997). The evolution of the concept shows a shift from green supply chain management (GSCM)which focuses on reducing environmental impact, towards sustainable SCM, until now it has developed into circular SCMwhich not only reduces impact but also redesigns systems to generate sustainable value.

In this development, CE is positioned as an important mechanism in encouraging sustainability transitioning the supply chain. CE enables companies to maximize value materials, extend product life, and create regenerative systems that reduce reliance on new resources. Furthermore, integrating CE into SSC also supports increased efficiency, resilience, and operational risk reduction within the global supplier network.

Although CE and SSC have shown significant progress, their integration still faces various conceptual and theoretical challenges. First, the CE model is still fragmented between the domains environmental science which emphasizes the material cycle and industrial ecology which focuses on industrial metabolism (Graedel & Allenby, 2010). This fragmentation results in a lack of paradigm unity, making it difficult to produce a systematically integrated CE - SSC framework.

Second, the traditional SSC model still relies on linear architecture and has not fully integrated circular loops such as take, make, use, return, recover, regenerate. This is reflected in the lack of models that holistically cover the entire CE loop at various levels of the supply chain.

Third, there are significant multi-level coordination constraints at the national level.intra-firm, inter-firm, and network level, especially in the implementation of circular flows. This coordination requires integration between product design, reverse logistics management, collaboration with suppliers, and governance arrangements within the broader supply chain network (Sarkis, 2020). These gaps indicate the need for in-depth exploration of the theoretical models currently used in the CE - SSC literature and the identification of conceptual gaps which has not yet been handled systematically.

Despite the continued growth of research on the Circular Economy (CE) and Sustainable Supply Chains (SSC), the current literature shows that a comprehensive theoretical synthesis capable of systematically integrating the two concepts is still lacking. Most studies focus on specific aspects or loops within CE such as recycling, remanufacturing, or reverse logistics but have not yet linked them to a broader SSC framework encompassing multi-level coordination between actors within the supply chain network. This situation has led to fragmented knowledge, where the contributions of each theoretical model stand alone without producing a complete understanding of how circularity principles can be effectively integrated into a sustainability-oriented supply chain system. Furthermore, previous studies tend to position CE and SSC as two parallel entities, rather than as two complementary systems in managing the flow of materials, resources, and environmental impacts simultaneously.

The limitations in this literature are further highlighted by the inconsistent use of theoretical frameworks across existing studies. Some studies rely on the Resource-Based View (RBV) and Natural Resource Based View (NRBV) approaches to explain how firms gain competitive advantage through circularity practices. Meanwhile, others employ Institutional Theory to emphasize the role of external pressures, regulations, and industry norms, and Industrial Ecology to understand the ecological relationships and material flows within circular systems. However, none of the studies has successfully integrated these five perspectives into a unified conceptual framework. This divergence in approaches reflects the lack of a well-established theoretical foundation to explain the integrative mechanisms of CE–SSC, thus hindering the development of advanced theory and the consistent application of practices in the field.

In addition to theoretical diversity, there is also a lack of integration of key dimensions that are increasingly important in contemporary CE - SSC development, such as performance measurement, digital enablers, and behavioral aspects and organizational dynamics. While digital technologies such as the Internet of Things, blockchain, and artificial intelligence have the potential to be key drivers of circular transitions, their use in CE–SSC theoretical models remains very limited. Similarly, performance indicators encompassing economic, environmental, and social dimensions have not been comprehensively integrated into existing models. Without an adequate performance measurement system, it is difficult for companies and stakeholders to assess the effectiveness of circularity implementation in supply chain sustainability. Furthermore, aspects of individual behavior within organizations, adaptability, and coordination mechanisms between actors rarely receive attention in CE–SSC conceptual

models, even though these elements play a crucial role in the success of circular transformation.

This gap indicates that, to date, there is no conceptual model capable of simultaneously encompassing all the important dimensions of CE and SSC from circular design, multi-loop material flows, supporting technologies, governance and collaboration, to measurable sustainability outcomes. The absence of this integrated model complicates the mapping of research directions and hinders the development of theories that can strengthen the academic foundation for future CE–SSC integration. Therefore, studies are needed that specifically analyze, compare, and critique the theoretical models that have been developed to identify the extent to which such integration has occurred and which aspects have been overlooked by researchers.

Based on these needs, this study aims to identify the dominant theories and models used in the literature to explain the integration of Circular Economy principles into the Sustainable Supply Chain framework. This study also attempts to analyze how these theories are applied, combined, or even show contradictions in interpreting the relationship between circularity and supply chain sustainability. Furthermore, this study aims to uncover various conceptual gaps that have not been adequately addressed in previous research, both at the theoretical, methodological, and practical application levels. Through a critical analysis of existing models, this study is expected to provide new directions for the development of a more holistic, integrative, and relevant CE–SSC conceptual model to meet the operational challenges and needs of organizations in realizing a sustainable supply chain.

To achieve these objectives, this research is guided by the main questions:**"How do existing theoretical models integrate Circular Economy principles within Sustainable Supply Chain frameworks, and what conceptual gaps remain unaddressed?"**This question serves as a basis for exploring the extent to which theoretical integration has been carried out, identifying components that are still fragmented, and determining gaps that need to be addressed to strengthen the scientific foundation for the development of CE–SSC as an increasingly strategic field of study in modern supply chain management.

## 2. METHODS

### 2.1. Review Approach

This research uses narrative review with integrative approaches, the primary strategy for reviewing the literature related to the integration of Circular Economy (CE) principles into the Sustainable Supply Chain (SSC) framework. An integrative approach was chosen because the study's objective was not simply to count the frequency of findings (as in a meta-analysis), but rather to map, categorize, and synthesize the various theoretical models, conceptual concepts, and lines of thought development that underlie the CE–SSC field. A narrative review allows for a combination of deductive (reviewing the literature based on established theoretical frameworks, e.g., RBV/NRBV, Institutional Theory, Industrial Ecology) and inductive (identifying emerging themes from empirical and conceptual data) methods, making it suitable for exploring theoretical fragmentation and identifying conceptual gaps that are the focus of this research. To enhance transparency and reproducibility, the literature selection and analysis process was systematically documented covering the search strategy, inclusion/exclusion criteria, screening stages, and data extraction and mapping procedures and supplemented with a literature flow diagram (e.g., an adaptation of PRISMA) that reflects the number and reasons for exclusion of articles at each stage.

### 2.2. Search Strategy

A literature search was conducted on leading electronic databases relevant to the fields of supply chain, operations, and sustainability:Scopus, Web of Science, ScienceDirect, Emerald, Wiley Online Library, And Taylor & Francis OnlineThis database was selected to ensure cross

disciplinary coverage (supply chain management, industrial engineering, environmental studies, and information technology) and high quality peer-reviewed journals. The search included English-language literature with publication windows.2010–2025, because this period reflects the accelerated development of CE discourse and supply chain digitalization.

To increase the sensitivity and specificity of the search, a combination of keywords and Boolean operators is used. Examples of search strings that can be applied to Scopus / Web of Science (format adapted for each platform) are as follows:(“circular economy” OR “circularity” OR “circular supply chain”) AND (“sustainable supply chain” OR “sustainable supply chains” OR “sustainable supply chain management” OR “SSC”) AND (“conceptual model” OR “conceptual framework” OR “theoretical model” OR “framework” OR “closed-loop supply chain” OR “industrial ecology”).

In addition to the primary search keywords, secondary searches were conducted through: (1) backward citation chasing of key articles; (2) forward citation tracking using the citation function in Scopus/Web of Science to capture studies citing the primary articles; and (3) identification of articles from reputable journals (top-tier journals) and special issues focusing on the circular economy and supply chain sustainability. All search results were downloaded and managed using a reference manager (e.g., EndNote, Mendeley, or Zotero) to eliminate duplication and facilitate the screening process.

**3. Inclusion and Exclusion Criteria**

The article screening process follows the inclusion/exclusion criteria formulated to ensure relevance to the research objectives:

**Inclusion Criteria:**

1. Peer reviewed journal articles that discuss theory, conceptual model, or framework, which links the principles of the Circular Economy with aspects of the supply chain or sustainability.
2. Conceptual studies, theoretical reviews, model discussions, and empirical articles that substantively present or test the CE - SSC model.
3. Publication period between 2010 - 2025.
4. Publication language: English(to ensure international literature coverage and readability by the global academic community).
5. Field discipline: supply chain management, operations management, industrial ecology, environmental management, and information systems when relevant to CE - SSC.

**Exclusion Criteria:**

1. Non-peer-reviewed articles (e.g. non-peer working papers, white papers, blog posts) except highly influential leading institutional reports (may be included as contextual literature but not for the main analysis).
2. Studies that only present descriptive case studies without theoretical reflection or contribution of conceptual models.
3. Publications outside the specified year range.
4. Articles in languages other than English.

After the initial search phase, the screening process was carried out in two stages: (1) screening titles and abstracts to exclude articles that were clearly irrelevant; and (2) checking the full text to ensure compliance with the inclusion criteria. All screening steps were recorded and the reasons for exclusion at the full-text stage were documented for transparency purposes (to be presented in a customized PRISMA flowchart).

## 3. RESULT

### 3.1. Overview of Theoretical Models Used in CE - SSC

The integration of the Circular Economy (CE) into Sustainable Supply Chains (SSC) is primarily framed through two significant theoretical constructs: the Natural Resource-Based View (NRBV) and Industrial Ecology. The NRBV underscores the competitive advantage that companies can derive from their environmental capabilities, promoting the creation of cleaner, low-emissions production systems. This perspective emphasizes resource efficiency and the capacity to leverage environmentally sound practices for competitive success in markets increasingly focused on sustainability (Ya et al., 2023; Su et al., 2022). In parallel, Industrial Ecology facilitates an understanding of material flows, advocating for approaches such as reuse, remanufacturing, and recycling - elements that are central to circular business models (Nasir et al., 2017; Genovese et al., 2017).

While these theories form the backbone of CE-SSC discussions, additional frameworks such as Institutional Theory, Transaction Cost Economics (TCE), and Actor-Network Theory (ANT) have been recognized for their sporadic use in addressing particular facets of this complex landscape. For instance, Institutional Theory elucidates the regulatory pressures that supply chains face in adopting sustainable practices, while TCE provides insights into the cost implications associated with coordination in these emerging models (Angelis, 2021; Nygaard, 2022). However, the theoretical landscape remains fragmented, with no single theory prevailing as a comprehensive framework for understanding the entirety of CE-SSC interactions. This fragmentation indicates a nascent stage of theoretical development, pointing toward the need for integrative approaches that encompass environmental, economic, social, digital, and governance dimensions (Anilkumar & Sridharan, 2019; Kocaoğlu & Bulut, 2024).

Moreover, research efforts continue to highlight the dynamic nature of CE transitions across various industries, such as textiles and construction. Case studies and empirical evidence reinforce the necessity of harnessing multiple theoretical perspectives simultaneously to foster a coherent understanding of how these transitions can be effectively managed (Raman et al., 2025; Farrukh & Sajjad, 2024). The transition from linear to circular models involves complex stakeholder engagement and necessitates innovative practices in green logistics and sustainable production strategies (Nikseresht et al., 2023; Cuong et al., 2025). Ultimately, a more holistic theoretical framework is essential to bridge the existing gaps and to guide future research towards the establishment of comprehensive models coherent with both CE and SSC paradigms.

### 2. Categories of CE–SSC Models

The categorization of Circular Economy (CE) and Sustainable Supply Chain (SSC) models reveals diverse frameworks based on different theoretical perspectives. Each category plays a significant role in understanding the dynamics and challenges within circular supply chains, alongside highlighting their respective advantages and weaknesses.

#### A. Resource-Oriented Models (RBV/NRBV)

Resource-Based View (RBV) and Natural Resource-Based View (NRBV) models predominantly emphasize sustainable resource management through clean production and eco-efficiency. This perspective allows firms to derive value through the effective utilization of resources and waste reduction strategies, adhering to the principles of a circular economy (Zhou et al., 2024). However, these models have been critiqued for their narrow focus on firm-level dynamics, which limits their ability to explore multi-tier supply chain coordination and collaboration. One study noted that while RBV underscores internal capabilities, it inadequately addresses interorganizational relationships necessary for cohesive CE strategies across supply chains (Huang et al., 2020). Nonetheless, integrating aspects of collaboration

from NRBV has shown potential for enhancing competitive advantages through partnerships in the supply chain context (Mishra et al., 2019).

**B. Industrial Ecology & Closed-Loop-Oriented Models**

Industrial Ecology-based models contribute to the discussion by providing frameworks for loop design, focusing on practices like reuse, remanufacturing, and recycling. These models create flow maps and guidelines for implementing circular loops (Jæger & Upadhyay, 2020). However, they tend to overlook social dimensions, especially regulatory influences and stakeholder collaboration, which are crucial for effectively managing complex supply chain networks (Hazen et al., 2020). Research emphasizes the necessity of involving multiple actors and regulatory environments to optimize the circularity of supply chain practices (Rusch et al., 2022). The engagement of stakeholders is essential for facilitating the interplay between governance frameworks and operational practices within these models (Farooque et al., 2022).

**C. Digital Enabled CE SSC Models**

Digital-enabled models leverage technologies such as blockchain, IoT, and big data analytics to enhance the circular economy implementation process. They significantly improve material flow visibility, verification of recovery processes, and tracking capabilities, which are critical for effective CE practices (Jain et al., 2020; Nandi et al., 2020). Despite their advantages, these models are often in nascent stages of development and lack integrative frameworks that combine digital technologies with governance and behavioral dynamics (Böhmecke-Schwafert et al., 2022). This gap presents a hurdle as digitalization serves as a key driver for the success of contemporary CE implementations, necessitating further research to bridge these aspects (Desing et al., 2020; Okorie et al., 2018).

**D. Governance & Institutional Models**

Models framed within governance and institutional perspectives underscore the importance of external regulatory pressures and collaborations in the transition to circular supply chain practices. They articulate how institutional factors can guide organizational behaviors towards CE adoption (Kayıkçı et al., 2022). However, a comprehensive integration of various CE loop components is often absent, which can limit fully understanding how regulations and collaborations function within complex circular networks (Schöggl et al., 2023). For example, existing studies indicate that while governance mechanisms are outlined, their operational interactions within supply chains require deeper exploration, especially regarding their influence on stakeholder dynamics and circularity practices (Touboulic & Walker, 2015).

In conclusion, the categorization of CE–SSC models presents a multifaceted landscape wherein each model type contributes unique insights into the implementation and operational dynamics of circular practices. However, significant challenges remain in addressing interorganizational collaborations, governance interactions, and the integration of digital technologies within these frameworks. Continued research is vital to elucidate these complexities and develop robust integrative models that comprehensively address the intricacies of circular supply chains.

**3. Mapping of CE Principles Within SSC Frameworks**

The concept of integrating Circular Economy (CE) principles within Sustainable Supply Chain (SSC) frameworks has gained considerable academic interest. Recent literature categorizes this integration into three primary levels: product, process, and network. At the product level, focus is primarily on restorative flows such as reuse, refurbishment, and remanufacture, which are critical to sustainable product design (Brito & Dekker, 2004), (Gharfalkar et al., 2016). Brito and Dekker highlight various recovery options which are foundational for understanding the potential product-level interventions within CE (Brito &

Dekker, 2004). Furthermore, Allwood et al. advocate for embracing these restorative practices in product design, emphasizing their role in significantly reducing carbon emissions (Allwood et al., 2010).

At the process level, the literature underscores the necessity for low-emission production processes, enhanced material efficiency, and the integration of technology to facilitate circular operations (Chaudhari et al., 2021), Bag et al., 2019). Gharfalkar et al. delineate the hierarchical distinction between repair, refurbishing, and remanufacturing, which is crucial for developing effective processes aimed at resource efficiency (Gharfalkar et al., 2016). Chaudhari et al. offer insights into the importance of data-driven approaches for analyzing the sustainability impacts of various production processes and propose a framework that could bridge existing knowledge gaps related to advanced recycling technologies (Chaudhari et al., 2021).

However, at the network level, the application of CE principles appears constrained. Many studies only highlight specific loops or relationships within the supply chain rather than a systemic integration (Kuhlmann et al., 2023). Kuhlmann et al. emphasize that the successful transition towards a circular value chain necessitates joint reflections across all levels of supply chain management (Kuhlmann et al., 2023). This observation is reinforced by research from Jæger and Upadhyay, who point out that systemic collaboration among stakeholders is critical for transitioning CE principles from theoretical frameworks to practical applications within supply chains (Jæger & Upadhyay, 2020).

The mapping illustrates a pronounced limitation in the holistic understanding of CE integration across supply chain networks. Several studies concentrate on isolated aspects of the CE loop, leading to a fragmented perspective that overlooks critical interdependencies (Alonso et al., 2021; , Opstal et al., 2024). Therefore, to realize the full potential of CE within SSC frameworks, it is imperative to adopt a more systemic approach that considers the interconnectedness of various actors and processes throughout the supply chain (Zhang et al., 2021; , Stahel, 2013).

## 4. Conceptual Gaps Identified

The analysis of theoretical models in Circular Economy-Supply Chain Management (CE-SSC) reveals conceptual gaps that hinder the advancement of a cohesive understanding of circular practices and their integration into supply chain management.

### Gap 1: Integration of CE Loops

A critical shortcoming in the literature is the absence of a unified model that encompasses all circular economy loops reuse, repair, remanufacturing, recycling, and refurbishing into a cohesive supply chain framework. Much of the existing research tends to focus on one or two specific loops. For instance, while some studies address recycling or remanufacturing in isolation, a comprehensive approach incorporating all aspects of circularity is often lacking (Foroozanfar et al., 2022; , Zhang et al., 2021). This fragmented exploration limits the establishment of a holistic framework that informs integrated strategies across various supply chain stages (Frank et al., 2025).

### Gap 2: Digital Enablers

The integration of critical digital technologies such as blockchain, Internet of Things (IoT), and artificial intelligence (AI) into theoretical CE-SSC models remains inadequate. These technologies significantly enhance the traceability and visibility of circular flows, which are critical for effective supply chain management (Chen, 2024; , Dwivedi et al., 2023). For example, blockchain technology has shown promise in reinforcing supply chain transparency; however, there are notable gaps in the literature regarding how digital tools can effectively support CE practices (Neri et al., 2024; , Elghaish et al., 2023).

**Gap 3: Collaboration and Governance**

Another identified gap is the insufficient explanation of how collaboration and governance operate at the circular network level, particularly within multi-tier supply chains. Effective collaboration is essential for circular practices, as it enables stakeholders to co-create value and manage take-back systems effectively (Gharaibeh et al., 2022). Current frameworks largely fail to address the complexity of multi-tier governance structures and their influence on circular supply chains (Dwivedi et al., 2023; .

**Gap 4: Performance Measurement**

There is a notable deficiency in frameworks designed for performance measurement in CE-SSC. Despite the recognized necessity for evaluation metrics to assess the effectiveness of circular implementations, existing models remain underdeveloped (Liu et al., 2021; , Bernardi et al., 2022). Comprehensive frameworks that encompass environmental, social, and economic metrics are required to aid organizations in understanding their performance relative to circular objectives (Zhu et al., 2010).

**Gap 5: Fragmented Theoretical Duality**

A significant fragmentation exists between environmental theory covering aspects like industrial ecology and supply chain theory, which encompasses operations and logistics (Hofstetter et al., 2021; , Mehmood et al., 2021). This disconnection hinders a holistic understanding of and application of circular principles in supply chains, as discussions in one domain often fail to inform practices or theories in the other (Nag et al., 2021).

**Gap 6: Context of Emerging Economies**

Lastly, there is a conspicuous lack of research focusing on the context of emerging economies in CE-SSC. These regions possess distinct institutional characteristics, infrastructure challenges, and levels of digital readiness that significantly influence the application of circular economy principles (Cezarino et al., 2019). The absence of scholarly attention on this front threatens the broader applicability of CE practices and models across different economic landscapes (Dwivedi et al., 2023; , Bernal et al., 2020).

In conclusion, the urgency for developing a more holistic, integrative, and contextual conceptual model is imperative to advance our understanding of CE-SSC in an increasingly digitalized world. Addressing these six conceptual gaps will enhance the resilience and sustainability of supply chains globally.

## 4. DISCUSSION

### 4.1. Interpretation of Model Fragmentation

The study results show that the models used in the Circular Economy Sustainable Supply Chain (CE SSC) literature still exhibit a significant level of fragmentation. This fragmentation is primarily due to the diversity of theoretical approaches used, ranging from NRBV, Industrial Ecology, Institutional Theory, to technology-based models that operate in a fragmented and non-complementary manner. Each theory stems from different epistemological assumptions: CE is more rooted in ecology-based thinking, which emphasizes material cycles and resource regeneration, while SSC relies on operations and logistics-based thinking which is oriented towards efficiency, coordination of goods flow, and operational performance.

These paradigm differences have resulted in disparate models, preventing a comprehensive explanation of the integration of restorative loops, digital flows, and governance. Furthermore, most models emphasize only one or two CE loops, such as recycling or remanufacturing, without designing a comprehensive multi-loop architecture. The limited

integration of digital enablers such as IoT, AI, and blockchain further deepens this fragmentation, given that these technologies are now key drivers of traceability and coordination in circular supply chains. Thus, fragmentation is not only a methodological issue but also a consequence of the lack of a theoretical foundation capable of unifying the multidisciplinary dimensions of CE–SSC.

**2. Implications for Supply Chain Theory**

The findings regarding theoretical fragmentation have important implications for the development of supply chain theory. The integration of Circular Economy (CE) principles directly challenges the linear assumption of "take, make, dispose" that has dominated supply chain literature for decades. Circularity demands a new perspective: modern supply chains are no longer one-way systems, but multi-loop and multi-directional networks involving simultaneous forward, reverse, and regenerative flows. Consequently, a conceptual framework is needed that can explain the interdependencies between tiers in reuse, repair, remanufacturing, and recycling activities. Furthermore, the role of digital technology is crucial in creating traceability, increasing transparency, and reducing information asymmetry in circular supply chains. The complexity of circular networks also demands more adaptive governance and collaboration mechanisms than traditional linear models. Furthermore, the transformation towards CE-SSC generates new dynamics in economic, social, and environmental aspects that must be understood as part of the circular network architecture. Thus, the integration of CE-SSC does not simply expand supply chain management theory but requires a paradigm shift that can capture the dynamic, interactive, and regenerative logic of circularity.

**3. Implications for Practice**

Practically, the findings of this study confirm that organizations face an urgent need to adopt a more integrative approach in designing and implementing the Circular Economy - Sustainable Supply Chain (CE - SSC). Circular transformation cannot be achieved in parts but requires readiness across four key dimensions. First, circularity design is a crucial foundation because without modular, easily dismantled, and material-recovery-friendly product and process designs, various circular loops such as reuse, remanufacturing, and recycling cannot function optimally. Second, operational coordination is needed to manage the complexity of reverse logistics, material recovery, and cross-tier collaboration, which remains a common weakness in many companies. Third, technology adoption including IoT, AI, blockchain, and digital twins plays a crucial role in increasing the visibility, readability, and efficiency of circular flows, yet implementation is still at an early stage in most organizations. Fourth, collaborative governance is needed to address the challenges of incentives, benefit sharing, and risk management among supply chain actors. These four dimensions demonstrate that companies need an integrated conceptual model to guide operational and strategic decision-making, so that CE - SSC implementation can be more effective, collaborative, and sustainable.

**4. Proposed Integrative Conceptual Framework**

Based on the literature synthesis and identification of conceptual gaps, this study proposesIntegrative CE-SSC Frameworkwhich consists of five main blocks as the foundation for developing a more holistic circular supply chain model. The first block,Circular Design, emphasizes the importance of modular, eco-design-based product and process design, designed to enable multiple-use loops so that reuse, remanufacturing, and recycling activities can run optimally. The second block,Digital Enablers, encompasses technologies such as IoT, AI, and blockchain, which are prerequisites for creating traceability, predictive analytics, and automated governance in circular networks. The third block,Supply Chain Coordination, describes the cross-tier coordination mechanisms, incentive alignment, and collaborative

governance structures needed to manage the complexity of circular networks. The fourth block,Reverse Flow Mechanisms, integrates reverse logistics, remanufacturing, recycling, reprocessing, and closed-loop logistics systems as the core of regenerative material movement. The fifth block,Sustainability Outcomes, provides an evaluation framework for measuring the economic, environmental, and social impacts of circularity implementation across supply networks. Overall, this framework addresses the existing theoretical gap by presenting a comprehensive architecture that connects the dimensions of design, operations, technology, governance, and performance, while providing a new conceptual foundation and implementation guidelines for organizations across sectors in developing CE - SSC in a more effective and integrated manner.

**5. Directions for Future Research**

Based on the literature synthesis and the developed integrative framework, several important research agendas need to be prioritized to strengthen the future development of CE–SSC. First,technology-based CE-SSC integrationThis requires deeper exploration into how IoT, AI, blockchain, and digital twins can be systematically applied to support circular loops and improve cross-tier coordination. This technology integration is not only operational but also strategic in creating traceability, predictive decision-making, and automating circular network governance. Second, research needs to be directed at development of the CE–SSC model in developing countries, taking into account the differences in institutional characteristics, digital readiness, and infrastructure limitations that distinguish emerging economies from developed countries. Third,behavioral dimensions in CE adoption is an area that is still neglected, even though factors such as organizational resistance, risk perception, adaptability, and sustainability leadership play a key role in determining the success of implementation. Fourth, there is an urgent need for comprehensive performance metrics to evaluate the effectiveness of circular supply chains from an economic, social, and environmental perspective. Fifth,multi-tier governance dalam circular networksThis is a crucial research agenda given the complexity of coordination, incentive sharing, collaborative contracts, and control mechanisms in circular networks, which are far more dynamic than linear supply chains. Overall, these agendas offer significant opportunities to strengthen the theoretical and implementative foundations of CE - SSC in the future.

**5. CONCLUSION**

This study provides an in-depth understanding of how existing theories and models integrate Circular Economy (CE) principles into the Sustainable Supply Chain (SSC) framework. Key findings indicate that the CE-SSC literature is still dominated by theoretical fragmentation, where individual approaches such as NRBV, Industrial Ecology, Institutional Theory, and technology-based models operate in a fragmented manner and have not yet succeeded in forming a comprehensive model that encompasses all circularity principles. Furthermore, digitalization emerges as a critical element that has not been systematically integrated into existing models, thus creating missing links between circular flows, supply chain coordination, and decision-making mechanisms.

Academically, this research contributes by providing the most comprehensive conceptual mapping of CE-SSC models, while identifying key conceptual gaps that hinder theory development. Furthermore, this research offers an integrative framework that combines circular design, digital enablers, supply chain coordination, reverse flow mechanisms, and sustainability outcomes, providing new theoretical contributions that can serve as the foundation for future CE-SSC model development.

From a practical perspective, the results of this study provide direction for policymakers and companies in designing more structured, technology-driven CE-SSC strategies. The proposed framework can be used as a guideline for optimizing the

implementation of circular practices, enhancing multi-tier coordination, and strengthening sustainability performance measurement capabilities across supply chain networks.

However, this study has limitations, mainly due to the approach/narrative review which is not as rigorous as meta-analytic methods and still potentially contains literature selection bias. Therefore, further research is needed to validate the proposed integrative model, expand empirical testing across various industry and country contexts, and develop a more holistic and applicable theoretical approach to CE-SSC integration.

These findings underscore the urgency of developing future research that is capable of integrating aspects of technology, organizational behavior, multi-tier governance, and performance metrics in building a circular supply chain system that is more resilient, sustainable, and adaptive to global challenges.

## 6. REFERENCES

Allwood, J., Cullen, J., & Milford, R. (2010). Options for achieving a 50% cut in industrial carbon emissions by 2050. Environmental Science & Technology, 44(6), 1888-1894. https://doi.org/10.1021/es902909k

Alonso, S., Forradellas, R., Morell, O., & Jorge-Vázquez, J. (2021). Digitalization, circular economy and environmental sustainability: the application of artificial intelligence in the efficient self-management of waste. Sustainability, 13(4), 2092. https://doi.org/10.3390/su13042092

Angelis, R. (2021). Circular economy business models: a repertoire of theoretical relationships and a research agenda. Circular Economy and Sustainability, 2(2), 433-446. https://doi.org/10.1007/s43615-021-00133-x

Anilkumar, E. and Sridharan, R. (2019). Sustainable supply chain management. International Journal of System Dynamics Applications, 8(3), 15-52. https://doi.org/10.4018/ijsda.2019070102

Bag, S., Gupta, S., & Foropon, C. (2019). Examining the role of dynamic remanufacturing capability on supply chain resilience in circular economy. Management Decision, 57(4), 863-885. https://doi.org/10.1108/md-07-2018-0724

Bernal, J., Castro, J., & Moreno-Mantilla, C. (2020). The sustainable supply chain: concepts, optimization and simulation models, and trends. Ingeniería, 25(3), 355-377. https://doi.org/10.14483/23448393.16926

Bernardi, P., Bertello, A., & Forliano, C. (2022). Circularity of food systems: a review and research agenda. British Food Journal, 125(3), 1094-1129. https://doi.org/10.1108/bfj-05-2021-0576

Böhmecke-Schwafert, M., Wehinger, M., & Teigland, R. (2022). Blockchain for the circular economy: theorizing blockchain's role in the transition to a circular economy through an empirical investigation. Business Strategy and the Environment, 31(8), 3786-3801. https://doi.org/10.1002/bse.3032

Brito, M. and Dekker, R. (2004). A framework for reverse logistics., 3-27. https://doi.org/10.1007/978-3-540-24803-3_1

Cezarino, L., Liboni, L., Stefanelli, N., Oliveira, B., & Stocco, L. (2019). Diving into emerging economies bottleneck: industry 4.0 and implications for circular economy. Management Decision, 59(8), 1841-1862. https://doi.org/10.1108/md-10-2018-1084

Chaudhari, U., Lin, Y., Thompson, V., Handler, R., Pearce, J., Caneba, G., … & Shonnard, D. (2021). Systems analysis approach to polyethylene terephthalate and olefin plastics supply chains in the circular economy: a review of data sets and models. Acs Sustainable Chemistry & Engineering, 9(22), 7403-7421. https://doi.org/10.1021/acssuschemeng.0c08622

Chen, R. (2024). Sustainable supply chain management as a strategic enterprise innovation. Advances in Economics Management and Political Sciences, 85(1), 24-29. https://doi.org/10.54254/2754-1169/85/20240831

Cuong, T., Minh, D., & Chinh, T. (2025). Does stakeholder pressure enhance sustainable performance? mediating role of corporate social responsibility, circular economy practices, and sustainable supply chain management. Wseas Transactions on Business and Economics, 22, 962-978. https://doi.org/10.37394/23207.2025.22.80

Desing, H., Brunner, D., Takacs, F., Nahrath, S., Frankenberger, K., & Hischier, R. (2020). A circular economy within the planetary boundaries: towards a resource-based, systemic approach. Resources Conservation and Recycling, 155, 104673. https://doi.org/10.1016/j.resconrec.2019.104673

Dwivedi, A., Chowdhury, P., Agrawal, D., Paul, S., & Shi, Y. (2023). Antecedents of digital supply chains for a circular economy: a sustainability perspective. Industrial Management & Data Systems, 123(6), 1690-1716. https://doi.org/10.1108/imds-05-2022-0273

Dwivedi, A., Chowdhury, P., Paul, S., & Agrawal, D. (2023). Sustaining circular economy practices in supply chains during a global disruption. The International Journal of Logistics Management, 34(3), 644-673. https://doi.org/10.1108/ijlm-04-2022-0154

Elghaish, F., Hosseini, M., Kocatürk, T., Arashpour, M., & Ledari, M. (2023). Digitalised circular construction supply chain: an integrated bim-blockchain solution. Automation in Construction, 148, 104746. https://doi.org/10.1016/j.autcon.2023.104746

Elkington, J. (1997). Cannibals with forks: The triple bottom line of 21st century business. Capstone Publishing.

Farooque, M., Zhang, A., Liu, Y., & Hartley, J. (2022). Circular supply chain management: performance outcomes and the role of eco-industrial parks in china. Transportation Research Part E Logistics and Transportation Review, 157, 102596. https://doi.org/10.1016/j.tre.2021.102596

Farrukh, A. and Sajjad, A. (2024). Drivers for and barriers to circular economy transition in the textile industry: a developing economy perspective. Sustainable Development, 32(6), 7309-7329. https://doi.org/10.1002/sd.3088

Foroozanfar, M., Imanipour, N., & Sajadi, S. (2022). Integrating circular economy strategies and business models: a systematic literature review. Journal of Entrepreneurship in Emerging Economies, 14(5), 678-700. https://doi.org/10.1108/jeee-10-2021-0411

Frank, A., Batista, L., Chaudhuri, A., Subramaniam, N., Subramanian, A., Dora, M., … & Ritala, P. (2025). Circular economy and digital technology-enabled innovation: advances, applications and prospects. R and D Management, 55(5), 1421-1430. https://doi.org/10.1111/radm.70003

Genovese, A., Acquaye, A., Figueroa, A., & Koh, S. (2017). Sustainable supply chain management and the transition towards a circular economy: evidence and some applications. Omega, 66, 344-357. https://doi.org/10.1016/j.omega.2015.05.015

Gharaibeh, L., Eriksson, K., Lantz, B., Matarneh, S., & Elghaish, F. (2022). Toward digital construction supply chain-based industry 4.0 solutions: scientometric-thematic analysis. Smart and Sustainable Built Environment, 13(1), 42-62. https://doi.org/10.1108/sasbe-12-2021-0224

Gharfalkar, M., Ali, Z., & Hillier, G. (2016). Clarifying the disagreements on various reuse options: repair, recondition, refurbish and remanufacture. Waste Management & Research the Journal for a Sustainable Circular Economy, 34(10), 995-1005. https://doi.org/10.1177/0734242x16628981

Graedel, T. E., & Allenby, B. R. (2010). Industrial ecology and sustainable engineering. Prentice Hall.

Hazen, B., Russo, I., Confente, I., & Pellathy, D. (2020). Supply chain management for circular economy: conceptual framework and research agenda. The International Journal of Logistics Management, 32(2), 510-537. https://doi.org/10.1108/ijlm-12-2019-0332

Hofstetter, J., Marchi, V., Sarkis, J., Govindan, K., Klassen, R., Ometto, A., … & Vázquez-Brust, D. (2021). From sustainable global value chains to circular economy different silos, different perspectives, but many opportunities to build bridges. Circular Economy and Sustainability, 1(1), 21-47. https://doi.org/10.1007/s43615-021-00015-2

Huang, M., Kang, M., & Chiang, J. (2020). Can a supplier benefit from investing in transaction-specific investments? a multilevel model of the value co-creation ecosystem perspective. Supply Chain Management an International Journal, 25(6), 773-787. https://doi.org/10.1108/scm-09-2019-0347

Jæger, B. and Upadhyay, A. (2020). Understanding barriers to circular economy: cases from the manufacturing industry. Journal of Enterprise Information Management, 33(4), 729-745. https://doi.org/10.1108/jeim-02-2019-0047

Jæger, B. and Upadhyay, A. (2020). Understanding barriers to circular economy: cases from the manufacturing industry. Journal of Enterprise Information Management, 33(4), 729-745. https://doi.org/10.1108/jeim-02-2019-0047

Jain, N., Panda, A., & Choudhary, P. (2020). Institutional pressures and circular economy performance: the role of environmental management system and organizational flexibility in oil and gas sector. Business Strategy and the Environment, 29(8), 3509-3525. https://doi.org/10.1002/bse.2593

Kayıkçı, Y., Kazançoğlu, Y., Gözaçan, N., Lafçı, Ç., & Batista, L. (2022). Assessing smart circular supply chain readiness and maturity level of small and medium-sized enterprises. Journal of Business Research, 149, 375-392. https://doi.org/10.1016/j.jbusres.2022.05.042

Kocaoğlu, B. and Bulut, M. (2024). Circular supply chain network design for e-commerce. Gazi University Journal of Science, 37(2), 840-852. https://doi.org/10.35378/gujs.1234548

Kuhlmann, M., Meuer, J., & Bening, C. (2023). Interorganizational sensemaking of the transition toward a circular value chain. Organization & Environment, 36(3), 411-441. https://doi.org/10.1177/10860266231162057

Liu, Y., Wood, L., Venkatesh, V., Zhang, A., & Farooque, M. (2021). Barriers to sustainable food consumption and production in china: a fuzzy dematel analysis from a circular economy perspective. Sustainable Production and Consumption, 28, 1114-1129. https://doi.org/10.1016/j.spc.2021.07.028

McDonough, W., & Braungart, M. (2002). Cradle to cradle: Remaking the way we make things. North Point Press.

Mehmood, A., Ahmed, S., Viza, E., Bogush, A., & Ayyub, R. (2021). Drivers and barriers towards circular economy in agri-food supply chain: a review. Business Strategy & Development, 4(4), 465-481. https://doi.org/10.1002/bsd2.171

Mishra, J., Chiwenga, K., & Ali, K. (2019). Collaboration as an enabler for circular economy: a case study of a developing country. Management Decision, 59(8), 1784-1800. https://doi.org/10.1108/md-10-2018-1111

Nag, U., Sharma, S., & Govindan, K. (2021). Investigating drivers of circular supply chain with product-service system in automotive firms of an emerging economy. Journal of Cleaner Production, 319, 128629. https://doi.org/10.1016/j.jclepro.2021.128629

Nandi, S., Sarkis, J., Hervani, A., & Helms, M. (2020). Do blockchain and circular economy practices improve post covid-19 supply chains? a resource-based and resource dependence perspective. Industrial Management & Data Systems, 121(2), 333-363. https://doi.org/10.1108/imds-09-2020-0560

Nasir, M., Genovese, A., Acquaye, A., Koh, S., & Yamoah, F. (2017). Comparing linear and circular supply chains: a case study from the construction industry. International

Journal of Production Economics, 183, 443-457. https://doi.org/10.1016/j.ijpe.2016.06.008

Neri, A., Cagno, E., Susur, E., Urueña, A., Nuur, C., Kumar, V., … & Sorrentino, C. (2024). The relationship between digital technologies and the circular economy: a systematic literature review and a research agenda. R and D Management, 55(3), 617-713. https://doi.org/10.1111/radm.12715

Nikseresht, A., Golmohammadi, D., & Zandieh, M. (2023). Sustainable green logistics and remanufacturing: a bibliometric analysis and future research directions. The International Journal of Logistics Management, 35(3), 755-803. https://doi.org/10.1108/ijlm-03-2023-0085

Nygaard, A. (2022). From linear to circular economy: a transaction cost approach to the ecological transformation of the firm. Circular Economy and Sustainability, 2(3), 1127-1142. https://doi.org/10.1007/s43615-022-00158-w

OECD. (2022). Plastic pollution is growing relentlessly as waste management and recycling fall short. OECD Publishing.

Okorie, O., Salonitis, K., Charnley, F., Moreno, M., Turner, C., & Tiwari, A. (2018). Digitisation and the circular economy: a review of current research and future trends. Energies, 11(11), 3009. https://doi.org/10.3390/en11113009

Opstal, W., Smeets, A., & Pals, E. (2024). Aligning incentives for implementing reversible bonding as a circular economy innovation. Business Strategy and the Environment, 33(8), 8017-8036. https://doi.org/10.1002/bse.3904

Raman, R., Das, P., Aggarwal, R., Buch, R., Palanisamy, B., Basant, T., … & Nedungadi, P. (2025). Circular economy transitions in textile, apparel, and fashion: ai-based topic modeling and sustainable development goals mapping. Sustainability, 17(12), 5342. https://doi.org/10.3390/su17125342

Rusch, M., Schöggl, J., & Baumgartner, R. (2022). Application of digital technologies for sustainable product management in a circular economy: a review. Business Strategy and the Environment, 32(3), 1159-1174. https://doi.org/10.1002/bse.3099

Sarkis, J. (2020). Supply chain sustainability: Learning from the COVID-19 pandemic. International Journal of Operations & Production Management.

Schöggl, J., Stumpf, L., & Baumgartner, R. (2023). The role of interorganizational collaboration and digital technologies in the implementation of circular economy practices empirical evidence from manufacturing firms. Business Strategy and the Environment, 33(3), 2225-2249. https://doi.org/10.1002/bse.3593

Stahel, W. (2013). Policy for material efficiency sustainable taxation as a departure from the throwaway society. Philosophical Transactions of the Royal Society a Mathematical Physical and Engineering Sciences, 371(1986), 20110567. https://doi.org/10.1098/rsta.2011.0567

Su, J., Hodges, N., Wu, H., & Iqbal, M. (2022). Exploring sustainable sourcing in the apparel industry: perspectives from bangladesh and china.. https://doi.org/10.31274/itaa.13578

Touboulic, A. and Walker, H. (2015). Theories in sustainable supply chain management: a structured literature review. International Journal of Physical Distribution & Logistics Management, 45(1/2), 16-42. https://doi.org/10.1108/ijpdlm-05-2013-0106

UNEP. (2024). Global Waste Management Outlook 2024. United Nations Environment Programme.

Ya, C., Masukujjaman, M., Sobhani, F., Hamayun, M., & Alam, S. (2023). Green logistics, green human capital, and circular economy: the mediating role of sustainable production. Sustainability, 15(2), 1045. https://doi.org/10.3390/su15021045

Zhang, A., Wang, J., Farooque, M., Wang, Y., & Choi, T. (2021). Multi-dimensional circular supply chain management: a comparative review of the state-of-the-art practices and

research. Transportation Research Part E Logistics and Transportation Review, 155, 102509. https://doi.org/10.1016/j.tre.2021.102509

Zhang, A., Wang, J., Farooque, M., Wang, Y., & Choi, T. (2021). Multi-dimensional circular supply chain management: a comparative review of the state-of-the-art practices and research. Transportation Research Part E Logistics and Transportation Review, 155, 102509. https://doi.org/10.1016/j.tre.2021.102509

Zhou, X., Jiang, J., Zhou, C., Li, X., & Yin, M. (2024). Circular supply chain management: antecedent effect of social capital and big data analysis capability and their impact on sustainable performance. Sustainable Development, 32(5), 5311-5330. https://doi.org/10.1002/sd.2963

Zhu, Q., Geng, Y., & Lai, K. (2010). Circular economy practices among chinese manufacturers varying in environmental-oriented supply chain cooperation and the performance implications. Journal of Environmental Management, 91(6), 1324-1331. https://doi.org/10.1016/j.jenvman.2010.02.013