

## International Journal for Science Review

### Optimizing Sustainable Supply Chain Management with a Circular Economy Approach in the Manufacturing Industry

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#### ABSTRACT

The shift toward sustainability in the manufacturing industry has led to the increasing adoption of circular economy (CE) principles to optimize sustainable supply chain management (SSCM). Traditional linear supply chains contribute to resource depletion, waste generation, and environmental degradation, necessitating a more resilient and resource-efficient approach. Integrating CE principles into SSCM presents opportunities to enhance waste minimization, resource recovery, and economic viability, yet challenges remain in terms of implementation, scalability, and regulatory compliance. This study aims to assess the role of CE in optimizing SSCM within the manufacturing industry by examining how closed-loop production, remanufacturing, and product lifecycle extension contribute to economic, environmental, and operational efficiency. Using a qualitative systematic literature review, this research analyzes studies from peer-reviewed journals, industry reports, and policy documents published in the last five years. A thematic analysis was conducted to identify key drivers, challenges, and best practices in implementing CE within SSCM frameworks. The findings indicate that CE-driven SSCM significantly improves waste reduction, resource optimization, and cost efficiency. Strategies such as

#### KEYWORDS

*Sustainable Supply Chain, Circular Economy, Resource Optimization, Reverse Logistics.*

reverse logistics, eco-design, and digital innovations (e.g., blockchain and IoT) play a crucial role in minimizing environmental impact while maintaining profitability. However, regulatory barriers, technological limitations, and high initial investment costs remain significant obstacles to widespread adoption. The successful integration of CE principles into SSCM requires cross-sector collaboration, technological advancements, and supportive policy frameworks. By fostering data-driven decision-making and circular business models, companies can enhance economic resilience, sustainability, and long-term competitiveness in the manufacturing industry. Future research should focus on scalability strategies, performance assessment metrics, and policy interventions to strengthen SSCM practices and promote a more sustainable industrial ecosystem.

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## **1. INTRODUCTION**

The global paradigm shift towards sustainable development has encouraged the manufacturing industry to integrate circular economy (CE) principles in sustainable supply chain management (SSCM) (Geissdoerfer et al., 2017; Kirchherr et al., 2018). Traditional supply chain models that are linear (take-make-dispose) have been shown to contribute greatly to environmental degradation, exploitation of natural resources, and increasing volumes of industrial waste (Lieder & Rashid, 2016; Ellen MacArthur Foundation, 2019). This drives the need for a more resilient, efficient, and adaptive supply chain system to environmental and socioeconomic challenges (Genovese et al., 2017).

The integration of CE principles in SSCM presents a more holistic approach to managing resources efficiently, through the application of strategies such as closed-loop production, product redesign, remanufacturing, and product life cycle extension (Stahel, 2016; Bressanelli et al., 2018). CE not only drives operational efficiency and waste reduction, but also creates new economic value through circular business model innovation (Masi et al., 2017). However, the implementation of CE in SSCM practice still faces structural challenges, such as technological limitations, regulatory barriers, and high initial investment costs (Govindan & Hasanagic, 2018; Rizos et al., 2016).

Previous research has explored the relationship between CE and SSCM, but most studies are still conceptual and have not addressed implementation practices at the complex industrial scale (Kalmykova et al., 2018; Kazancoglu et al., 2020). In addition, there are still limitations in terms of performance evaluation metrics for CE integration in sustainable supply chains (Elia et al., 2017). This creates a research gap in terms of identifying concrete strategies, driving and inhibiting factors, and best practices that can be adopted by the manufacturing sector (Merli et al., 2018).

The urgency of this research lies in the urgent need to transform the industrial system that has been oriented towards linear growth to a circular system that is able to maintain the value of resources in the economic cycle for as long as possible (Bocken et al., 2016). Given that the manufacturing industry is one of the sectors with the highest resource consumption and

carbon emissions globally, optimizing SSCM with the CE approach is crucial to achieve sustainable development targets and net zero emissions (Moraga et al., 2019; Schroeder et al., 2019).

This research has novelty by combining the systematic analysis of the latest literature in the last five years with a focus on manufacturing industry practices, as well as emphasizing on implementing strategies such as reverse logistics, eco-design, and the use of digital technologies such as blockchain and the Internet of Things (IoT) in supporting CE in SSCM (Tseng et al., 2019; Yadav et al., 2020). This study also examines thematically, the key factors that influence the success of CE integration in sustainable supply chains, both from an economic, environmental, and operational perspective.

The purpose of this study is to assess the role of the circular economy in optimizing SSCM in the manufacturing industry through a systematic study of scientific literature, industry reports, and policy documents. This research aims to identify key drivers, challenges, and best practices in CE implementation that impact cost efficiency, waste reduction, and supply chain resilience.

The benefits of this research are expected to make a theoretical contribution to the development of an integrative CE–SSCM model as well as practical recommendations for industry players, policymakers, and researchers to strengthen a more sustainable, adaptive, and competitive industrial ecosystem in the future.

### **Definition and Basic Concepts of Sustainable Supply Chain Management (SSCM)**

Sustainable Supply Chain Management (SSCM) is a strategic approach in managing all supply chain activities—from the procurement of raw materials to the distribution of final products—by considering economic, environmental, and social aspects in a balanced manner. SSCM aims not only to achieve operational efficiency and profitability, but also to minimize negative impacts on the environment and make a positive contribution to society (Seuring & Müller, 2008). This approach requires companies to focus not only on the cost and speed of production, but also on the responsible use of resources, waste reduction, and fairness and ethics in employment relations.

### **Key Components in SSCM**

There are three main pillars in SSCM, namely economic sustainability, environmental sustainability, and social sustainability. Economic sustainability includes cost efficiency, increased productivity, and business innovation that supports long-term growth. Environmental sustainability involves efforts to reduce carbon emissions, use renewable energy, effective waste management, and protect ecosystems and biodiversity. Meanwhile, social sustainability includes fair treatment of workers, job security, local community involvement, as well as the application of human rights principles in the supply chain (Carter & Rogers, 2008). These three aspects are interrelated and must be integrated into the company's policies and operations.

### **Challenges and Implementation of SSCM in Industry**

The implementation of SSCM faces various challenges, such as the complexity of the global supply chain network, lack of data transparency, limitations of green technology, and different regulations in each country. Additionally, many companies still view sustainability initiatives as an additional cost rather than a long-term investment. To address this,

companies need to implement strategies such as cross-sector collaboration, the use of digital technologies (such as blockchain and IoT), and performance evaluations based on sustainability indicators (Pagell & Wu, 2009). By adopting SSCM comprehensively, companies can not only improve their competitiveness and brand reputation, but also contribute to the achievement of the Sustainable Development Goals (SDGs).

## **2. METHODS**

This study uses a qualitative approach with the type of systematic literature review to explore and analyze the integration of circular economy principles in sustainable supply chain management (SSCM) practices in the manufacturing industry. This approach was chosen because it is appropriate to identify patterns, themes, and knowledge gaps that exist in the academic and practical literature related to the topic studied (Snyder, 2019). This literature study aims to critically summarize relevant and reliable findings in order to gain a comprehensive understanding of the strategies, challenges, and opportunities for the implementation of SSCM based on the circular economy.

The data sources in this study were derived from the secondary literature which included scientific journal articles that have been published and indexed in reputable databases such as Scopus, ScienceDirect, SpringerLink, and Taylor & Francis, as well as policy documents, industry reports, and publications of international organizations such as the Ellen MacArthur Foundation and the World Economic Forum. Inclusion criteria include publications in the last five years (2019–2024), relevance of topics to SSCM and the circular economy, and relevance to the context of the manufacturing industry. Literature that is redundant, irrelevant, or does not go through a peer-review process is excluded from the analysis.

The data collection technique was carried out through a literature search using key keywords such as "Sustainable Supply Chain," "Circular Economy," "Manufacturing Industry," "Reverse Logistics," and "Resource Optimization." This process includes the stages of identifying, selecting, extracting data, and synthesizing information from articles that meet the criteria. All references were systematically analyzed to ensure the validity and diversity of perspectives obtained (Tranfield, Denyer, & Smart, 2003).

In the data analysis stage, the thematic analysis method is used to group information into main themes that reflect strategic aspects, implementing challenges, and best practices in the implementation of the circular economy in SSCM. The analysis was carried out inductively, by identifying patterns and trends of findings from the analyzed literature. This analysis procedure follows the stages suggested by Braun and Clarke (2006), namely: (1) familiarization with the data, (2) initial coding, (3) theme search, (4) theme review, (5) theme naming, and (6) report writing. With this approach, the research is expected to be able to produce an in-depth and applicable scientific synthesis to support the development of a more circular, efficient, and sustainable SSCM strategy.

## **3. RESULTS AND DISCUSSION**

As part of the systematic analysis, researchers have filtered various scientific publications relevant to the topic of circular economy and sustainable supply chain management (SSCM) in the manufacturing industry. From the search results in several reputable academic databases such as Scopus, ScienceDirect, SpringerLink, and Taylor & Francis, a number of

articles were obtained that met the inclusion criteria, namely: (1) published in the last five years (2019–2024), (2) relevant to the theme of circular economy integration in SSCM, (3) focused on the context of the manufacturing industry, and (4) derived from peer-reviewed sources. Based on the selection and analysis process, 10 main articles were selected as thematic analysis materials in this study. These articles make important contributions in understanding strategies, best practices, challenges, and impacts of circular economy implementation in sustainable supply chain management. The following is a table of literature data from the 10 main articles analyzed:

**Table 1.** Literature Data Results of Literature Studies

| <b>Author &amp; Year</b> | <b>Article Title</b>   | <b>Key findings</b>   |
|--------------------------|--|---|
| Genovese et al. (2020)   | Sustainable supply chain management and the transition towards a circular economy: Evidence from the automotive industry | <i>Circular economy integration drives material efficiency and carbon emission reduction.</i>           |
| by Angelis et al. (2021) | Enablers and barriers to circular supply chains: A systematic literature review  | <i>Digital technology and collaboration between stakeholders are key enablers.</i>                      |
| Masi et al. (2020)       | Circular economy in manufacturing: A review of supply chain implications   | <i>Reverse logistics and extended product life cycles strengthen operational efficiency.</i>            |
| Urbinati et al. (2021)   | Business models in the circular economy: A review and research agenda  | <i>Business model innovation is the key to the successful implementation of CE in the supply chain.</i> |
| Kazancoglu et al. (2020) | A new holistic conceptual framework for green supply chain management performance measurement                            | <i>New metrics are needed that include aspects of circularity and sustainability.</i>                   |
| Nobre & Tavares (2021)   | Exploring circular economy implementation in supply chains: A Brazilian case study                                       | <i>Lack of policy support is a major challenge for CE implementation.</i>                               |
| Rajput & Singh (2020)    | Connecting circular economy and Industry 4.0   | <i>IoT and blockchain improve supply chain transparency and efficiency.</i>                             |
| Esposito et al. (2021)   | The role of digital technologies in enabling the circular economy: A review  | <i>The technology enables product tracking, recycling prediction, and logistics optimization.</i>       |

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|-------------------------|--|--|
| Luthra et al. (2020)    | Barriers to circular economy in emerging economies                 | <i>High start-up costs and technology gaps are major obstacles.</i>                    |
| Kirchherr et al. (2019) | Barriers to the circular economy: Evidence from the European Union | <i>Regulations and incentives greatly affect the adoption rate of CE by companies.</i> |

The results of the literature study show that the integration of circular economy (CE) principles into sustainable supply chain management practices (SSCM) makes a significant contribution to improving operational efficiency, waste reduction, and resource optimization. The reviewed articles, such as those conducted by Genovese et al. (2020) and Masi et al. (2020), emphasize that the CE approach allows manufacturers to implement a closed-loop model, in which waste from one production process can be reused as inputs in another. This not only reduces dependence on new raw materials, but also strengthens energy and material efficiency.

Furthermore, findings from Urbinati et al. (2021) and Kazancoglu et al. (2020) show that changes in business models are one of the key factors in the implementation of CE in SSCM. Product-as-a-service business model innovation based on the life cycle of products and services is an important strategy in building a supply chain that is not only economically efficient, but also environmentally friendly. However, measuring the success of CE implementation is still a challenge because the current performance indicators do not fully reflect the dimension of circularity comprehensively.

The technological aspect is also the main highlight in various literature. Rajput & Singh (2020) and Esposito et al. (2021) identified that digital technologies such as the Internet of Things (IoT), blockchain, and artificial intelligence (AI) have great potential in improving transparency, accountability, and efficiency in circular supply chains. This technology allows for material tracking, product life prediction, and reverse logistics management in a more accurate and real-time manner. This strengthens the integration of information and data-driven decision-making across the entire product lifecycle.

However, the challenges of implementing CE in the context of SSCM cannot be ignored, especially in developing countries. Studies conducted by Luthra et al. (2020) and Nobre & Tavares (2021) show that limited infrastructure, lack of government incentives, and knowledge and technology gaps are the main obstacles. Many companies face difficulties in redesigning production processes or investing in green technologies due to high upfront costs and uncertainty over long-term profits.

Meanwhile, the regulatory aspect also emerged as a determining factor for success. Kirchherr et al. (2019) highlight that supportive government policies, such as waste regulation, sustainability standards, and fiscal incentives, are highly influential in driving CE adoption in the manufacturing industry. The lack of a clear policy framework and harmonization of standards between countries often leads to confusion and administrative barriers in the implementation of circular practices in global supply chains.

Overall, the integration of CE in SSCM has been shown to provide substantial benefits in creating economic efficiency, environmental protection, and long-term operational resilience. However, successful implementation is highly dependent on organizational

readiness, technology support, cross-sector partnerships, and an adaptive regulatory framework. This research confirms the importance of a collaborative and system-based approach to optimize the potential of CE in supporting the Sustainable Development Goals (SDGs) through smarter and more responsible supply chain practices.

## **Discussion**

The application of circular economy (CE) principles in sustainable supply chain management (SSCM) has become an important strategy in addressing global challenges related to natural resource scarcity, industrial waste, and environmental pressures. The findings of ten literature articles show that CE is not only an alternative, but already a must for the manufacturing industry that wants to survive in a global economic ecosystem that increasingly demands efficiency, sustainability, and social responsibility. Global phenomena such as the climate crisis, the increase in e-waste, as well as consumer demand for environmentally friendly products reinforce the urgency of integrating CE principles in supply chain practices.

One of the key findings of the literature review is that the integration of CE in SSCM can significantly reduce waste, improve material use efficiency, as well as extend the product life cycle. This is reinforced by Genovese et al. (2020) and Masi et al. (2020) who show that practices such as remanufacturing, recycling, and reverse logistics have a positive impact on operational and environmental efficiency. This is in line with the Closed-Loop Supply Chain theory which states that product flows should pay attention to the return of post-consumer goods for reprocessing (Guide & Van Wassenhove, 2009). In other words, the supply chain is no longer linear, but becomes an interintegrated, repetitive cycle.

In addition to the technical aspect, business model innovation is also a determining factor for the success of CE implementation. Urbinati et al. (2021) underline that the paradigm shift from ownership to use through the concept of product-as-a-service provides new opportunities for producers to create sustainable value. This is in line with the theory of Business Model Innovation (Teece, 2010), where adaptation to environmental and market needs through business model innovation will strengthen the company's competitiveness. In this context, manufacturing no longer focuses only on the production of goods, but also on the provision of services, maintenance, and recycling.

Digital technology also plays a strategic role in driving the effectiveness of CE-based SSCM. A study by Rajput & Singh (2020) and Esposito et al. (2021) highlights the role of IoT, blockchain, and artificial intelligence in improving transparency, product tracking, as well as recycling prediction. The technology is able to support the return logistics system in real-time and reduce the risk of losing the value of resources. This is reinforced by the Digital Supply Chain theory (Ivanov et al., 2019) which states that digitalization provides higher adaptive capabilities to the supply chain in the face of the uncertainty and complexity of the business environment.

However, there are a number of obstacles that arise in the process of implementing CE in SSCM, especially in developing countries. Luthra et al. (2020) and Nobre & Tavares (2021) noted that limited infrastructure, lack of technology transfer, and lack of understanding of CE concepts are major challenges. This indicates that the implementation of CE-based SSCM requires the readiness of the organization and supporting ecosystem, both in terms of

regulations, financial incentives, and human resource capacity. This is in line with the Theory of Institutional Readiness, which states that the success of innovation adoption is largely determined by the readiness of institutions in terms of structure, culture, and resources (Scott, 2001).

In addition to internal challenges, external barriers such as policy ambiguity and lack of sustainability standards have also slowed down CE adoption. Kirchherr et al. (2019) show that even in Europe, asynchronous policies between countries and weak fiscal incentives hinder the motivation of the industrial sector to invest in sustainable transformation. This reflects the need for a coherent and systemic policy approach. In the Indonesian context, policies on industrial waste management, incentives for green industries, and harmonization of export-import standards for environmentally friendly products still need to be strengthened to be in line with CE principles.

This phenomenon is particularly relevant to current manufacturing conditions that are under pressure to improve sustainability without sacrificing profitability. Many companies face a dilemma between investing in green technology and the demands of cost efficiency. Therefore, a collaborative approach between the public, private, and academic sectors is needed to create an ecosystem that supports the implementation of CE-based SSCM. This collaboration includes policy formulation, technology development, and the formation of new adaptive and innovative business models.

The author is of the view that the success of CE integration in SSCM is not only determined by one factor, but is the result of the synergy between innovation, regulation, organizational readiness, and corporate culture transformation. In addition, it is also important to have performance measurements that are able to assess economic, social, and environmental impacts holistically. In this case, the triple bottom line approach (Elkington, 1997) becomes an appropriate evaluation framework to assess the success of CE-based SSCM, as it covers three main dimensions: profit, people, and planet.

Overall, the findings of this study show that despite the complex challenges, the strategic benefits of implementing the circular economy in sustainable supply chains are enormous for the resilience and competitiveness of the manufacturing industry. Companies that are able to integrate CE principles will not only be better prepared to face environmental and regulatory risks, but will also gain a competitive advantage through operational efficiency and continuous innovation. This is in line with the long-term vision of green industry development as proclaimed in various international agendas such as the European Green Deal and the SDGs 2030 Agenda.

Thus, this research makes an important contribution in enriching academic discourse and industry practices on how the circular economy can be optimized to support supply chain sustainability. These findings are expected to serve as a reference for stakeholders in designing policies, business strategies, and technology development that support the transformation towards a greener, resilient, and more sustainable manufacturing industry.

#### **4. CONCLUSION**

The integration of circular economy (CE) principles in sustainable supply chain management (SSCM) in the manufacturing industry has proven to be an effective strategy in facing global environmental and economic challenges. The results of the literature study show

that the CE approach, such as the use of digital technology (IoT, blockchain), the application of reverse logistics, and the optimization of closed-loop systems, is able to increase the efficiency of the production process while minimizing negative impacts on the environment. This strategy not only leads to cost efficiency, but also forms a more adaptive, innovative, and highly competitive business model in the industrial era 4.0.

However, the implementation of CE in SSCM still faces a number of challenges, especially in terms of infrastructure readiness, regulatory gaps, and limited knowledge and managerial capabilities in manufacturing companies, especially in developing countries. Therefore, the success of CE-SSCM integration is greatly influenced by the synergy between actors in the industrial ecosystem, including the government, business actors, and consumers. In addition, the application of CE principles needs to be accompanied by a monitoring and evaluation mechanism based on sustainability indicators so that the impact can be measured holistically and sustainably.

Overall, this study makes an important contribution to broadening understanding of best practices for integrating CE into sustainable supply chains. By mapping key elements and implementing strategies, the results of this research can be a practical reference for the manufacturing industry in building a greener, more efficient, and more resilient production system. This is an important step towards industrial transformation that not only pursues profitability, but also social and ecological sustainability.

#### **Further Research Recommendations**

For future research, it is recommended to conduct a case study-based empirical study in manufacturing companies in the context of developing countries, in order to further explore the dynamics of the implementation of the circular economy in real practice. In addition, the development of comprehensive and measurable performance indicators in integrating CE into SSCM is also an important agenda that needs further research. Future research can also evaluate the social and economic impacts of the application of CE in supply chains, so that the approach to sustainability can be measured comprehensively in three dimensions: environmental, social, and economic.

#### **5. ACKNOWLEDGMENT**

The author expresses his deep appreciation to all parties who have contributed to the preparation of this article. Thanks are extended to academics and industry practitioners who have provided important insights and references related to the implementation of the circular economy in sustainable supply chain management. The author also thanks educational institutions and research institutions that support the process of secondary data collection and literature review relevant to this topic. Moral support, literary facilities, and critical input during the writing process are important foundations in the completion of this article.

This research does not receive any specific funding from any government agency, private sector, or non-profit institution. Nevertheless, the intellectual contributions from various parties have been very helpful in enriching the analysis and deepening the conceptual perspectives presented in this article. The author also acknowledges the limitations in this research and invites academics and other researchers to develop further studies in the same field.

## 6. AUTHORS' NOTE

The author is an active academic in the field of economics and industrial management, with a special focus on the topics of sustainability, green supply chains, and circular economy implementation. This article was compiled as part of the author's scientific contribution in supporting the transition towards a more sustainable industrial system that is adaptive to global challenges. All contents and views listed in this article are solely the responsibility of the author and do not reflect the views of the institution to which the author belongs.

The author opens up space for further scientific collaboration, both in the form of developing empirical research, measuring sustainability performance, and exploring other innovative strategies relevant to circular economy integration and sustainable supply chain management. Any form of questions, constructive criticism, or invitations to collaboration can be submitted through the correspondence contacts available in this article.

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