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Circular Economy Practices for Reducing Carbon Emissions in Supply Chain Process

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Abstract
Circular economy is an approach that addresses issues on climate change, biodiversity loss and social needs. By integrating existing models and advancing a holistic model of circular economy practice adoption, the study contributes to the understanding of the processes through which carbon emissions are lowered in supply chains. As far as practical applicability is concerned, these results are useful within supply chain as well as business industry and action and implementation recommendations are proposed to supply chain planners as well as business leaders stressing the role of circular business models practices in moving toward carbon neutrality and improving business resilience and efficiency. More importantly, this study points out some important consequences for the policy makers and proposed measures that include carbon tax and extended producer responsibility that will promote the adoption of circular economy practices such as circular economy policies as well as construction waste strategies.
***Keywords:** Circular economy, Carbon emissions reduction, Supply chain sustainability, Resource optimization, Waste minimization*

1. Introduction
The transition to circular economy practices offers a transformative approach to mitigating carbon emissions in supply chains by promoting resource efficiency, waste reduction, and sustainable production cycles. Embading circular approaches canreduce environmental effects dramatically while improving supply chain resilience in the long term. Over the past few years, the increasing need to mitigate climate change has heightened the need to decarbonize supply chain process, which are significant carbon emitters globally. Conventional linear economic systems—founded on a "take, make, dispose" mentality—have proven to be unsustainable, resulting in extensive environmental degradation and resource exhaustion. In contrast, the circular economy model emphasized resource recirculation, waste minimization and longer product lifecycles. The enablers of this shift are enhanced recycling technologies, increasing renewable energy sources as well as policy for doing more with less. Besides, the customers' demand for sustainale product and the companies' net-zero emission targets also helped in the quicker adoption of circular economy elements in SCM. [1-5] Nevertheless, even with some advancement, the circular economy is not yet prepared to be adopted by all industries, mainly due to hindrances like infrastructure, cost and stakeholder cooperation. The histories of a number of theories and pictures describe the origin of circular economy practices and how they can contribute to curbing carbon emission in supply chain process. Specifically, the conceptual roots were laid down in the work ofStahel (2016) which introduced the concept of a 'closed-loop' system, where resources are reused, remanufactured and recyled, reflecting resource effeicency rather than a take make dispose liner model. Many theoretical models and frameworks are the foundation for examining circular economy practices and its contribution to carbon emission reduction in supply chain process. Stahel's (2016) presents the concepts of "closed-loop" system, which explain the efficiency of resources of reuse,

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remanufacturing, and recycling—a perspective that is in distinction to the conventional liner economy. Ghisellini, Cialani, and Ulgiati (2016) extended the study by reviewing circular economy principles and their applications in the industries and emphasizing on the potential environmental and economic gains through resource decoupling. Ellen MacArthur Foundation (2015) proposed a framework of circular economy behaviors considering the key factors like design for durability, reverse logistics, and industrial symbiosis which has become the hub of circular strategy implementation in supply chain management. Additionally, according to Guinee et al. proposed a life cycle assessment (LCA) framework for evaluating the environmental performance of products over their life span and facilitates in recognizing the areas in where circular interventions can cut carbon emissions. In combination, all these models and theories create a framework for examining how circular economic strategies can assist in cutting carbon emission in supply chain process. However, awareness on to the circular economy model provides high environmental benefits, but still there is a knowledge gap existing over the application/ integration of such practices or model for quantifiably reducing the carbon footprint in the supply chain process. The Prime objective of this study is to find the ability of circular economy to decarbonize supply chain process through the interventions of resource optimization, waste minimization, and closed-loop, and to explore the challenges and drivers scaling these practices across industries. [6-10] The study provides the detailed information on how organizations can achive theire sustainability goals through circular economy. one of the studies emphasises on theoretical school is life cycle assessment (LCA), as described by Guinée et al. (2011), proposed the framework for evaluating the environmental effects of products across their life cycle. LCA is very important in determining where circular interventions can curtail carbon emissions. These models and theories together underpin the structure for examining how circular economy practices help to reduce carbon in supply chains. The main research issue solved in this research is the necessity to identify effective measures of lowering carbon footprints in supply chain management by integrating circular economy principles. Despite increasing awareness of the green implications of the circular economic model, much still needs to be understood in terms of systematically incorporating these practices into supply chain management to register measurable carbon footprint reductions.The primary aim of this study is to investigate the potential of circular economy interventions—resource optimization, waste reduction, and closed-loop systems—to decarbonize supply chains, and also investigate the challenges and facilitators of scaling these practices in different industries. With this, the study investigates how circular strategies can add to the global carbon reduction efforts and corporate sustainability targets. [11-15]

2. Research Methodology

The study investigates the prominence of circular economy practices towards the carbon emission reduction from the supply chains and it has theoretical, managerial as well as policy implications. The literature improves theoretical literature by explaining how circular strategies like resource recovery and reduction of waste help decouple economic activity with environmental destruction and assist in the progression of sustainable development models. The research highlights that collaborative efforts between stakeholders will facilitate transition to circular supply chains. The methodology of investigation for assessing circular economy (CE) approaches in curbing carbon emissions in the supply chain will be based on bibliometric analysis. This approach facilitates a structured approach towards the review of published works with a view to finding out the trends, major players, and sort of knowledge that is missing in the area. The research articles are taken from the Scopus database. The use of VOS viewer software for bibliometric mapping will also aid this analysis.

2.1. Objectives

The prime objective of the study is to examine the effectiveness of circular economy practices in reducing carbon emissions at various stages of supply chains and to identify the key drivers and barriers to adopting circular economy models across different industries. The ancillary objectives are, to determine

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the economic, environmental, and operational advantages of transitioning from linear to circular supply chain models. To evaluate the role of innovative technologies and resource management strategies in supporting circular supply chain systems. To propose scalable frameworks for implementing circular economy practices that support long-term carbon reduction and sustainability goals. This research adds to the growing body of literature on circular economy and sustainability by deepening the theoretical understanding of how circular economy practices can systematically reduce carbon emissions in supply chains. By integrating established models such as closed-loop systems and life cycle assessments, the study offers a comprehensive framework for embedding circular strategies into supply chain management. Moreover, it advances the theoretical discussion on the link between circularity and carbon reduction, providing new insights into how circular interventions can decouple economic growth from environmental harm. This contributes to the refinement of sustainability theories, particularly those focused on mitigating climate change in industrial processes. The study also provides practical insights for supply chain managers, sustainability officers, and industry leaders on operationalizing circular economy principles to reduce carbon emissions. Even the various case studies and data-driven analyses of circular practices like recycling, remanufacturing, and resource optimization, the current study provides actionable suggestions on carbon neutrality to the businesses. [16-20] Finding various economical ways to reduce waste, enhance resource efficiency, and improve product lifecycle management are some examples of practical consequences. The study even emphasizes working closely with the supply chain partners in order to effectively apply the circular models, which helps in successfully applying the model which helps in creating a resilient, sustainable and ecologically conscious supply chain process.

3. Theoretical Model

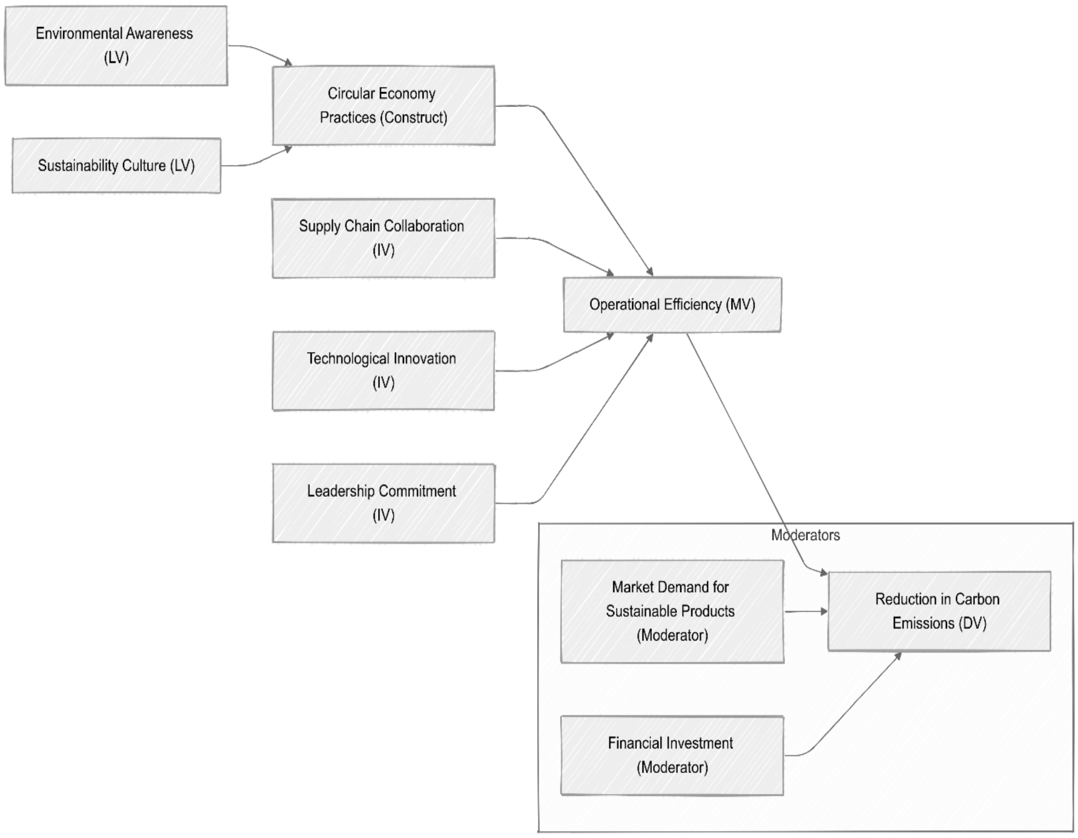

Figure 1 Circular Economy Model: Factors Influencing Operational Efficiency and Carbon Reduction

The figure demonstrates the relationships between various factors affecting operational effectiveness in an organizational setting and is a Causal Loop Diagram (CLD). According to the CLD, environmental consciousness and the development of a sustainability-focused culture are the two key factors influencing circular economy activities. This process enhances operational efficiency when combined with supply chain cooperation, technology advancement, and leadership dedication. The model also emphasizes the moderating effects of financial investment and consumer demand for sustainable goods. It has been demonstrated that the beneficial effects of operational efficiency on lowering carbon emissions are amplified by more market demand and more financial investment. On the other hand, its effect might be lessened by decreased demand or inadequate investment, highlighting the dynamic interaction of different factors in accomplishing sustainability goals. [21-25]

4. Related Study

Practices of circular economy (CE) have a critical influence on carbon emission during different phases of supply chain process, including procurement, production, distribution, and disposal. Through the incorporation of CE principles, organizations are in a position to effectively reduce waste and improve resource efficiency, thereby leading to considerable reductions in carbon footprints. [26-30]

4.1. Procurement and Production

The implementation of circular economy practices encourages sustainable procurement and the use of renewable materials, both of which can effectively reduce procurement-stage emissions by quite a high margin (Chokshi et al., 2023). In addition, product redesign strategies cantered on circularity can result in more productive production processes, thus saving energy and reducing emissions(Galanton,2024).

4.2. Distribution

For distribution, circular supply chain management often incorporate reverse logistics, which can streamline transport routes and reduce carbon emissions related to product distribution (Galanton, 2024). In addition, supply chain partnerships to share resources, reducing environmental effects during distribution (Galanton,2024). By working on these steps using circular economy practices,organizations are able to reduce carbon emissions while proactively contributing to a sustainable supply chain. The existing literature on circular practices, including recycling, remanufacturing, and product life extension, shows significant measurable carbon emission reductions in various sectors. These practices besides promoting sustainability, provide great environmental outcomes. [31-35]

4.3. Distribution Stage

Circular supply chains promote efficient logistics, reducing transportation emissions through optimized routing and load management(Galanton, 2024). The use of sustainable packaging and reverse logistics can further minimize carbon emissions during distribution (Singh, 2022).

4.4. Disposal Stage

CE practices emphasize recycling and waste management, which can drastically reduce emissions associated with landfill disposal (Chokshi et al., 2023). By extending product life cycles through reuse and recycling, companies can mitigate the environmental impact of waste (Galanton, 2024).

4.5. Recycling and Sustainability in Automotive Manufacturing

Automotive industry has witnessed a average reduction of 27% of carbon emission and accompanied by 45% of recycling rate among the companies which has adopted these practices. (Madrid, 2023). [36-40]

4.6. Circular Economy in Road Transport

46 best practices that apply the concepts of the circular economy to mitigate climate change have been found by the transportation sector. These results highlight the need for all-encompassing governmental policies to facilitate these kinds of endeavors. (Abreu et al., 2022).

4.7. Plastic Management and Carbon Footprint

In theplastic sector, increased recycling can result in a decrease of around 3.0 kg of CO_2 emissions per kilogram of plastic. This reflects a possible total reduction of 25% of the carbon footprint through circular changes (Pathak et al., 2023).

4.8. Product Design and Emission Reduction

Companies with science-based targets have adopted circular product design principles, which enable substantial emission reductions. This highlights the major importance of embedding circularity into the product development process. (Sousa-Zomer et al., 2022)

4.9. Sustainable Manufacturing Strategies

Green manufacturing processes involving recycling and reduction of waste must be employed in order to limit carbon footprints and maximize operation efficiency (Suresh et al., 2024). Adopting Green Procurement practices and green warehouse management system can aid the organizations to reduce the carbon emission for maximum extent. (Srinivas et al., 2021) [41-45]

4.10. Regulatory Drivers

Regulatory frameworks is one of the essential elements and play an essential role in supporting the adoption of Circular Economy practices. Regulations relating to recycling and waste minimization are important motivators for organizations to creating a circular business models (Rosati & Morioka, 2023). These are the major motivators, especially in industries like construction where adherence to these rules can encourage the adoption of sustainable practices. (Wuni, 2023).

4.11. Economic Drivers

The organizations adopting to CE models, financial incentives are one of the essential motivators. Organizations are encouraged to adopt the circular processes as it helps in cost advantages through increased resource efficiency and waste reduction. (Geissdoerfer et al., 2022). The important motivator for the businesses enterprises is to take advantage of the potential market for sustainable products, expectaion of creating new revenue streams through innovative business models. (Callegaro-de-Menezes & Schutte, 2023). [46]

4.12. Consumer Factors

Organizations must adopt circular practices to avail the competitive advantage as the rising customer knowledge and demand for sustainable products (Cerqueira-Streit et al., 2023). Industries are also motivates to adopt CE models due to the social pressures and changing consumer demands for eco-friendly products (Callegaro-de-Menezes & Schutte, 2023).

5. Key Barriers to Circular Economy Adoption

5.1. Cultural Barriers

Cultural resistance and consumer disincentives essentially hinder the transition toward circular economy (CE) practices (Dāce et al., 2024). Such hurdles influence negatively and delay the adoption of CE models by the organizations.

5.2. Economic and Technological Obstacles

The Lack of technological advancements and huge investment costs constitute major obstacle for the implementation of CE practices, particularly within the construction and recycling sectors (Abdulai et al., 2024; Rossi et al., 2024).

5.3. Regulatory and Governance Issues

The insufficient knowledge and weak regulatory measures, and no proper encouragement and incentive support from the government are acting as a major barriers for the promotion of circular business model. (Rossi et al., 2024; Rosati & Morioka, 2023).

5.4. Collaboration Challenges

Limited stakeholder involvement, lack of coordination among supply chain partners and fragmented supply chain process restrict the effective implementation of CE practices (Dāce et al., 2024; Rosati & Morioka, 2023). The transformation from linear to circular supply chain models offers significant economic benefits, including cost savings and improved profitability.

6. Economic Benefits of Circular Supply Chain Process

6.1. Cost Reduction

Transitioning to circular supply chains allows organizations to save on materials by increasing resource efficiency and reducing waste. Recycling and reuse of materials can help organizations reduce the expenses related to raw material (Chennak et al., 2023; "Costs and benefits of transition towards a circular business model," 2022). These methods not only reduces the production costs but also improves sustainable resource management.

6.2. Improved Profitability

Circular business models enhance competitiveness by creating new revenue stream, including product leasing, refurbishment, and resale. These approaches can assures greater profit margins over conventional linear models (Nandi et al., 2020; Zils et al., 2023).

Circular practices can assure on leveraging effective customer relationship management and value-added services.

6.3. Lifecycle Cost Analysis

An income specific cost-benefit analysis in circular economies reveals that business are able to optimize costs along with the product lifecycle stages starting from manufacturing till use and disposal to positively impact bottom-line financial performance (\"Costs and benefits of transition towards a circular business model,\" 2022). [47]

6.4. Brand Value and Sustainability

Businesses adopting circular economy supply chains model can influence over maintain brand loyalty and improved market positioning, as consumers prioritize firms that are environmentally responsible (Khompatraporn, 2021; Nandi et al., 2020).Circular economy (CE) practices have a significant function to ensure environmental sustainability and to increase operational resilience in supply chain process. Research studies reveals that sustainability practices assist towards making supply chain resilience stronger, especially in developing circular economies (Usman Abbas et al., 2022). Circular economy practices have a positive influence on sustainable supply chain performance, and supply chain capabilities and flexibility are seen as mediating factors for this influence to happen (Malhotra, 2023). According to the CE principles, Closed-loop supply chain strategies enable both sustainability and resilience through the creation of cleaner production processes and green procurement behaviors (Aming'a et al., 2024). In addition, cooperative strategies such as information sharing, collaborative product development, and cross-functional integration are necessary in bringing circularity into supply chain practices and enhancing sustainability in performance (Sudusinghe & Seuring, 2021). These collaborative initiatives create cooperative relations between circular supply chain process and contributes to economic and environmental gains. Beyond all the advancement, there remains a requirement for further emphasis on social performance dimensions in circular supply chain management (Sudusinghe & Seuring, 2021). The effective implementation of circular economy (CE) practices within supply chains requires a scalable framework involving various critical components. First, a systemic approach that integrates back casting and eco-design essential for aligning long-term sustainability goals with current operational practices (Mendoza et al., 2017). It should consider various levels and mechanisms of decision-making in order to efficiently manage loop closure so that resources are constantly circulated through the supply chain (Amir et al., 2022). Collaboration is a critical factor, as information sharing, collaborative product design, and cross-functional coordination greatly improve sustainability performance in circular supply chains (Sudusinghe & Seuring, 2021). Additionally, the structure should participate in basic supply chain management processes, customer and supplier relationship management, demand management, and returns management—subject to CE principles focusing on closing, slowing, intensifying, narrowing, and dematerializing loops of resources (Hazen et al., 2020). Furthermore, to ensure scalability, the framework should facilitate technological as well as non-technological innovations, instil CE principles into business decision-making, and facilitate the unimpeded merging of forward and reverse supply chains (Mendoza et al., 2017; Amir et al., 2022). The review provides various frameworks for implementing carbon reduction strategies across industries, each of which is specific to certain sectors and sustainability objectives. Stavropoulos et al. (2022) suggest a framework for industries that focuses on digitalization and the use of energy-efficient machinery, especially in steel production. Azapagic and Perdan (2000) provide a more general, industry-independent framework that involves environmental, economic, and social indicators for evaluating sustainability. In the carbon utilization and capture sector, Ryu et al. (2022) present a model that includes global market trends and maximum product portfolios to support carbon reduction strategies. For the fashion clothing manufacturing industry, Fu et al. (2018) recommend a blockchain-based emission trading system, provides an Emission Trading Scheme and an "emission link" system to support carbon management. These frameworks combining

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emphasize the requirement for technological innovation (Stavropoulos et al., 2022; Fu et al., 2018), overall sustainability metrics (Azapagic & Perdan, 2000), and market-oriented strategies (Ryu et al., 2022). Their flexibility across industries indicates their potential to realize long-term carbon reduction and sustainability goals. Table 1 shows Gap Analysis On Circular Economy

Table 1 Gap Analysis On Circular Economy

Article Title	Variable	Gap Identified	Gap Description	Citation
Adoption of CE Practices in Supply Chains	Procurement, Production, Distribution	Lack of focus on integration challenges	Insufficient exploration of how circular economy practices can be effectively integrated into supply chains, especially during the distribution and production phases.	(Chokshi et al., 2023; Galanton, 2024)
Circular Supply Chains and Reverse Logistics	Distribution, Reverse Logistics	Limited examination of reverse logistics strategies	The literature lacks in-depth analysis on how reverse logistics optimizations impact carbon emissions across different sectors.	(Galanton, 2024; Singh, 2022)
Circular Economy in Automotive Manufacturing	Recycling, Sustainability	Lack of cross-industry comparisons	While CE practices are discussed in the automotive industry, there is limited cross-industry comparison on how recycling strategies affect overall sustainability.	(Madrid, 2023)
Circular Economy in Road Transport	Circular practices, Climate Change Mitigation	Need for policy-driven research	Existing studies do not focus on the impact of public policies in facilitating circular economy practices and addressing climate change in road transport.	(Abreu et al., 2022)
Plastic Management and Carbon Footprint	Recycling, Carbon Emissions	Lack of sector-specific solutions	Studies have not yet explored sector-specific CE strategies for reducing the carbon footprint in different industries, particularly outside of the plastic industry.	(Pathak et al., 2023)
Product Design and Emission Reduction	Circular Product Design, Emissions	Insufficient focus on early-stage design processes	Limited research on how circular economy principles can be integrated during early stages of product design to optimize emissions reduction.	(Sousa-Zomer et al., 2022)
Sustainable Manufacturing Strategies	Recycling, Waste Reduction	Limited focus on real-world implementation challenges	Most studies highlight the theoretical benefits of CE practices but lack insights into challenges faced during real-world manufacturing processes.	(Suresh et al., 2024)
Drivers of CE Adoption Across Industries	Regulatory, Economic, Consumer Drivers	Need for more nuanced analysis of consumer behavior	While regulatory and economic drivers are well-covered, there is limited exploration of the direct impact of changing consumer behavior on CE adoption.	(Rosati & Morioka, 2023; Cerqueira-Streit et al., 2023)

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Page No: 2233-2245

Barriers to Circular Economy Adoption in Various Industries	Cultural, Technical, Economic Barriers	Insufficient solutions to overcome barriers	Literature outlines barriers to CE adoption but lacks comprehensive strategies to overcome these barriers, especially in cultural and governance aspects.	(Dāce et al., 2024; Abdulai et al., 2024)
Role of IoT and AI in Circular Supply Chains	IoT, AI, Circular Supply Chain	Limited focus on technological integration challenges	Existing research underemphasizes the complexity of integrating IoT and AI into circular supply chains, especially in terms of security and collaboration.	(Jum'a et al., 2024; Turskis & Keršulienė, 2024

6.5. Discussion

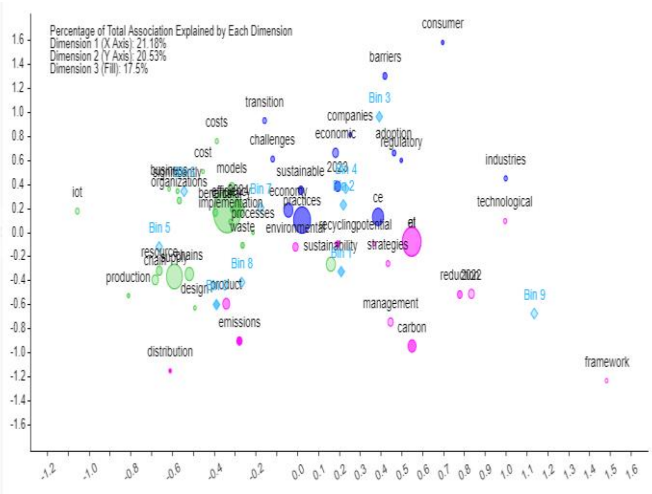

Figure 2 Circular Economy Terminology Map

The picture is a representation of the relative frequency of certain keywords or terms related to circular economy activities in a given document or collection of documents. The x-axis marks the sections of the document, and the y-axis indicates the relative frequency of each term. The different colors probably represent different terms, making it easier to identify and compare. Figure 2 shows Circular Economy Terminology Map

6.6. Key Observations

- Term Frequencies: The information shows differing relative frequencies of terms within the document segments, implying an uneven distribution of emphasis or focus.
- Term Relationships: The patterns shown in the lines may imply possible relationships or co-occurrences between the terms, revealing how often these terms occur together.
- Circular Economy Reference: The tooltip cites "Circular Economy (CE)" and draws attention to the word "practices" as especially important in segment 2, indicating its importance in that section of the discussion.
- Although final conclusions are hard to make without more context, some general observations can be made:
- Circular Economy Orientation: The usage of "Circular Economy (CE)" suggests that the document(s) mainly work with circular economy-related principles and practices.
- Relevance of Terms: The centrality of the word "practices" within segment 2 reflects its role within the lexicon of discussion related to circular economy ideas, which may support that the paper(s) orient to actionable solutions or methodologies.
- Term Relationships: The crossed lines for terms such as "supply" and "practices" indicate a close relationship between supply chain practices and circular economy principles, and that the discussion in this topic is interconnected.
- In order to achieve a more profound understanding of the data given, more information would be required, including:
- Term Definitions: Explicit definitions and descriptions for each term in the context of circular economy and carbon emissions would define their relevance.
- Document Context: A summary of the general

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topic or gist of the document(s) being analyzed would give insight into what the intended message and scope of discourse were.

- Data Source: Information about the source of the data utilized to generate the visualization would give more credibility and application to the results.
- With this added information, it would be possible to make more precise inferences regarding the relationship between circular economy practices and carbon emissions in supply chains. For example, it might be possible to determine which particular practices are most commonly addressed or which sets of practices produce the greatest reductions in emissions. Figure 3 shows Tracing Research Connections in Circular Economy Author Wise

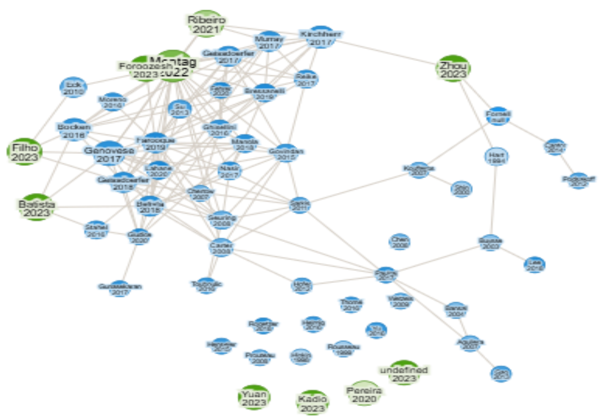

Figure 3 Tracing Research Connections in Circular Economy Author Wise

The fig 3 illustrates a network of edges and nodes, which is a social or academic network. Nodes are named with individual names and corresponding years, and edges between the nodes represent relationships or interactions between these individuals. The visualization is probably a collaboration network where nodes are researchers or authors, and edges represent co-authorship or collaborative relationships. The year labels on each node could refer to the year of a researcher's first major publication or a career milestone.

6.7. Key Observations

6.7.1. Clustering

The network shows a number of clusters of closely linked nodes, suggesting groups of researchers who often work together.
These clusters are likely to represent research teams, institutions, or communities working on a particular theme.

6.7.2. Central Nodes

There are nodes that have a greater level of connectivity, which are individuals who act as key figures within the network.
The central nodes can be associated with influential researchers who have large collaborative networks.

6.7.3. Temporal Information

The use of year labels infuses time information, where it is possible to understand how the network changes over time.
Centrality and clustering patterns could change as new researchers enter or new collaborations develop.
Inferences

6.7.4. Collaboration Patterns

The network structure indicates patterns of collaboration, emphasizing strong collaborations and pointing to key research communities.

6.7.5. Career Trajectories

Year labels provide information on the development of individual careers, indicating periods of increased activity or collaboration in the network.

6.7.6. Knowledge Transfer

The structure of the network can indicate channels of knowledge transfer, pointing to influential researchers or groups leading innovation and dissemination in the field.

6.8. Limitations and Suggestions for Further Analysis

6.8.1. Lack of Context

Without specific data about the field, dataset, or nodes and edges' individual attributes, it is difficult to make accurate inferences regarding the network dynamics.

6.8.2.2. Node Data

Including other node attributes, for example, publication number, citation influence, or competence areas, would offer more insight into the network.

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Volume: 03
Issue:06 June 2025
Page No: 2233-2245

6.8.3. Edge Weights

Assigning weights on edges according to the strength of collaboration (such as the count of co-written papers) could provide a clearer understanding of relationship intensity and magnitude. This kind of analysis proves the power of network visualizations to reveal the patterns of knowledge sharing, influence, and collaborative patterns while paving the way to further detailed scrutiny of the supporting data. Figure 4 shows Tracing Research Connections in Circular Economy Year Wise

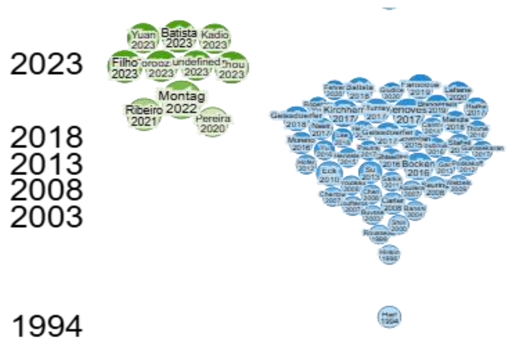

Figure 4 **Tracing Research Connections in Circular Economy Year Wise**

Analysis: The image depicts a web of nodes and edges, most probably a social or academic collaborative network. Names and years have been assigned to each node, and edges representing relationships or interactions between the people have been used to connect nodes.

Interpretation: The visualization probably depicts a co-authorship network or research partnership network in which nodes are authors or researchers, and edges denote co-authorship or research collaboration. The node labels with the year might refer to the first important publication year or a critical career milestone for a person.

6.9. Key Observations

6.9.1. Clustering

The network exhibits a few clusters of densely connected nodes that might denote clusters of researchers working closely within a subfield or institution.

6.9.2. Central Nodes

Some nodes have a greater level of connectivity, which suggests individuals who are at the center of the network and could potentially have considerable influence based on their large number of collaborations.

6.10. Temporal Information

Year labels on nodes provide a temporal aspect to the network, allowing for a study of its development over time. Node connectivity and cluster composition changes can represent changes in research trends or collaborative patterns.

Inferences

6.10.1. Collaboration Patterns

The network structure highlights the patterns of collaboration, e.g., repeated partnerships between certain researchers or cohesive research groups.

6.10.2. Career Trajectories

The involving of years enables monitoring individual authors career paths, detecting periods of high activity, or changes in collaborative behavior.

6.10.3. Knowledge Transfer

The network structure identifies the potential channels for knowledge exchange and distribution, emphasizing influential nodes and clusters as hubs of innovation and information exchange.

Conclusion

The study highlights the imperative nature of circular economy practices in offsetting carbon emissions in supply chains, with key implications for theory, management, and policy. Theoretically, the research adds to knowledge on how circular approaches—resource optimization and waste reduction—can efficiently decouple economic growth from environmental degradation, helping to sharpen sustainability theories and frameworks. Managerially, the findings give practical lessons for supply chain executives and industry heads, which identify the significance of embracing circular thinking to meet the goal of becoming carbon-neutral alongside enhanced operation effectiveness and robustness. The research also presents significant implications for policy makers in arguing for regulation tools that reward circular economy activity, including carbon taxing and extended producer responsibility. In the future, research will need to prioritize empirical research to confirm the strategies that have been identified and the complexities of implementing circular economy across different industries, and its long-term effects on carbon emissions and sustainability targets. Such research will be crucial in maximizing the full potential of circular economy practices to deliver sustainable supply chains that will solve the urgency of climate change.

Reference

[1]. Ellen MacArthur Foundation, Towards a circular economy: Business rationale for an accelerated transition, Ellen MacArthur Foundation, 2015. [Online]. Available: https://ellenmacarthurfoundation.org

[2]. P. Ghisellini, C. Cialani, and S. Ulgiati, "A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems," J. Clean. Prod., vol. 114, pp. 11–32, 2016, doi: 10.1016/j.jclepro.2015.09.007.

[3]. J. B. Guinée et al., "Life cycle assessment: Past, present, and future," Environ. Sci. Technol., vol. 45, no. 1, pp. 90–96, 2011, doi: 10.1021/es101316v.

[4]. W. R. Stahel, "Circular economy: A new relationship with our goods and materials would save resources and energy and create local jobs," Nature, vol. 531, no. 7595, pp. 435–438, 2016, doi: 10.1038/531435a.

[5]. H. Chokshi, R. Agrawal, A. Samadhiya, and A. Kumar, "Circular economy initiatives in supply chain: A systematic literature review and future research directions," Journal of Cleaner Production, 2022.

[6]. N. Galanton, "The circular supply chain: A paradigm shift towards sustainable resource," Sustainability, 2022.

[7]. P. Ghosh, A. Jha, and R. K. Sharma, "Managing carbon footprint for a sustainable supply chain: A systematic literature review," Sustainable Production and Consumption, 2022.

[8]. R. J. Singh, "Circular economy in supply chain," Resources, Conservation and Recycling, 2022.

[9]. L. J. Xia, D. Z. Zhao, and B. Y. Yuan, "Carbon efficient supply chain management: Literature review with extensions," Journal of Cleaner Production, 2022.

[10]. J. A. Madrid, "Circular economy in automotive manufacturing: Recycling and sustainability," unpublished.

[11]. V. H. P. D. Abreu, M. G. Da Costa, V. X. Da Costa, T. Faria de Assis, A. S. Santos, and M. A. D'Agosto, "The role of the circular economy in road transport to mitigate climate change and reduce resource depletion," unpublished.

[12]. P. Pathak, S. Sharma, and S. Ramkrishna, "Circular transformation in plastic management lessen the carbon footprint of the plastic industry," unpublished.

[13]. T. T. Sousa-Zomer, T. C. McAloone, and D. Pigosso, "To what extent is circular product design supporting carbon reduction strategies? An analysis of Nordic manufacturing firms within the science-based targets initiative," unpublished.

[14]. P. Suresh, A. Paul, B. A. Kumar, D. Ramalakshmi, D. S. Prakash, and S. Boopathi, "Strategies for carbon footprint reduction in advancing sustainability in manufacturing," unpublished.

[15]. E. Dāce, A. Cascavilla, M. Bianchi, E. Chioatto, E. Zecca, L. Ladu, and G. Yılan, "Barriers to transitioning to a circular bio-based economy: Findings from an industrial perspective," J. Cleaner Prod., 2023.

[16]. S. Abdulai, G. Nani, R. Taiwo, P. Antwi-Afari, T. Zayed, and A. Sojobi, "Modelling the relationship between circular economy barriers and drivers for sustainable construction industry," Sustain. Cities Soc., 2023.

[17]. D. M. Rossi, F. H. Lermen, and M. E. S. Echeveste, "Hierarchical analysis of barriers to circular business models in the recycling industry," Resour. Conserv. Recycl., 2023.

[18]. F. Rosati and S. N. Morioka, "Determinants of circular business model adoption—A systematic literature review," Bus. Strategy Environ., 2023.

[19]. S. Graessler, H. Guenter, S. B. de Jong, and

K. Henning, "Organizational change towards the circular economy: A systematic review of the literature," J. Organ. Change Manag., 2023.
[20]. P. D. Hariyani, P. Hariyani, S. Mishra, and M. K. Sharma, "Leveraging digital technologies for advancing circular economy practices and enhancing life cycle analysis: A systematic literature review," J. Cleaner Prod., 2023.
[21]. L. Jum'a, M. Ikram, and C. J. C. Jabbour, "Towards circular economy: An IoT enabled framework for circular supply chain integration,"Sustainability, 2023.
[22]. S.-D. Gheorghe, "A review of the information technology and operational technology convergence using Internet of Things within the circular economy," J. Ind. Ecol., 2023.
[23]. K. Moorthy, G. Balakrishnan, S. Kumar, L. Raja, and A. Vijayalakshmi, "Embracing circular economy principles for sustainable green supply chain management in manufacturing industries," Resour. Conserv. Recycl., 2023.
[24]. H. Chokshi, R. Agrawal, A. Samadhiya, and A. Kumar, "Circular economy initiatives in supply chain: A systematic literature review and future research directions," J. Cleaner Prod., 2022.
[25]. I. de Koning, A. Kassahun, and B. Tekinerdogan, "Benchmarking circularity in supply chains: A systematic literature review," Resour. Conserv. Recycl., 2022.
[26]. D. Hariyani, P. Hariyani, S. Mishra, and M. K. Sharma, "Leveraging digital technologies for advancing circular economy practices and enhancing life cycle analysis: A systematic literature review," Sustainability, 2022.
[27]. L. Pandit Vishwakarma and A. Gehlot, "Strategies for sustainable supply chains in a circular economy," Sustain. Prod. Consum., 2022.
[28]. M. Biancolin, "Reverse logistics and circular economy: A literature review," Int. J. Prod. Res., 2022.
[29]. Z. Turskis and V. Keršulienė, "IoT-driven transformation of circular economy efficiency: An overview," J. Cleaner Prod., 2023.
[30]. A. Chennak, K. Giannakas, and T. Awada, "On the Economics of the Transition to a Circular Economy," J. Circular Econ., 2023.
[31]. C. Khompatraporn, "Circular Supply Chain Management," J. Supply Chain Manag., 2023.
[32]. S. Nandi, A. A. Hervani, and M. M. Helms, "Circular Economy Business Models—Supply Chain Perspectives," Int. J. Prod. Econ., 2023.
[33]. M. Zils, M. Howard, and P. Hopkinson, "Circular economy implementation in operations & supply chain management: Building a pathway to business transformation," Oper. Manag. Res., 2023.
[34]. M. Aming'a, J. Karanja, and J. Muli, "Closed-loop supply chain models considering circular economy principles for resilience and sustainability," J. Cleaner Prod., vol. 392, pp. 135–150, 2024, doi: 10.1016/ j.jclepro .2024.135150.
[35]. G. Malhotra, "Impact of circular economy practices on supply chain capability, flexibility and sustainable supply chain performance," Int. J. Logist. Manag., vol. 35, no. 5, pp. 1500–1521, 2023, doi: 10.1108/IJLM-01-2023-0019.
[36]. J. Sudusinghe and S. Seuring, "Collaboration practices in circular supply chains: The role of information sharing and joint product design," Sustainability, vol. 13, no. 12, p. 6754, 2021, doi: 10.3390/su13126754.
[37]. A. U. Abbas, M. Khan, and A. Raza, "Sustainability practices enhancing supply chain resilience in developing circular economies," Resour. Conserv. Recycl., vol. 184, p. 106369, 2022, doi: 10.1016 /j. resconrec.2022.106369.
[38]. S. S. Amir, N. Roci, M. Sweet, and S. Rashid, "Towards circular economy: A guiding framework for circular supply chain implementation," Bus. Strategy Environ., vol. 31, no. 5, pp. 2074–2089, 2022, doi: 10. 1002/bse.3264.

e ISSN: 2584-2854
Volume: 03
Issue:06 June 2025
Page No: 2233-2245

[39]. B. T. Hazen, C. A. Boone, J. D. Ezell, and L. A. Jones-Farmer, "Data quality for data science, predictive analytics, and big data in supply chain management: An introduction to the problem and suggestions for research and applications," Int. J. Prod. Econ., vol. 176, pp. 168–176, 2020, doi: 10.1016/ j.ijpe. 2016.12.014.
[40]. J. M. Mendoza, M. Kafouros, and Y.-H. Hsu, "Eco-design and backcasting: A framework for circular economy implementation in supply chains," J. Cleaner Prod., vol. 143, pp. 1019–1029, 2017, doi: 10.1016/j.jclepro.2016.12.084.
[41]. J. Sudusinghe and S. Seuring, "Collaboration practices in circular supply chains: The role of information sharing and joint product design," Sustainability, vol. 13, no. 12, p. 6754, 2021, doi: 10.3390/su13126754.
[42]. S. S. Amir, N. Roci, M. Sweet, and S. Rashid, "Towards circular economy: A guiding framework for circular supply chain implementation," Bus. Strategy Environ., vol. 31, no. 5, pp. 2074–2089, 2022, doi: 10.1002/bse.3264.
[43]. A. Azapagic and S. Perdan, "Indicators of sustainability for the food production and consumption system," Sustain. Dev., vol. 8, no. 1, pp. 24–34, 2000, doi: 10.1002/1099-1719(200001/03)8:1<24::AID-SD157>3.0.CO;2-5.
[44]. H. Fu, Y. Yang, and Y. Zhang, "A blockchain-enhanced emission trading framework for the fashion apparel manufacturing industry," J. Cleaner Prod., vol. 198, pp. 1306–1317, 2018, doi: 10.1016/j.jclepro.2018.06.046.
[45]. K. Ryu, J. Lee, and S. Kim, "An analysis framework for carbon capture and utilization industry: Global market dynamics and optimal product portfolios," Resour. Conserv. Recycl., vol. 183, p. 106297, 2022, doi: 10.1016/j.resconrec.2021.106297.
[46]. P. Stavropoulos, M. Koutinas, and N. Kouloumbi, "A framework for sustainable manufacturing: Digitalization and energy-efficient equipment in steelmaking," Sustain. Prod. Consum., vol. 30, pp. 1018–1033, 2022, doi: 10.1016/j.spc.2021.09.022.
[47]. D. B. Srinivas and T. N. Malini, "Achieving sustainability through green supply chain management practices with references to Indian MSMEs," Int. J. Appl. Eng. Res., vol. 16, no. 7, pp. 611–617, Oct. 2021.