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RESEARCH PAPER

Circular economy in supply chain sustainability: From bibliometric analysis to conceptual model

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Abstract. This study aims to analyze research trends on the circular economy and supply chain sustainability using a bibliometric approach and to develop a conceptual model that can guide the implementation of circular economy practices. Data were obtained from the Scopus database and analyzed to identify publication trends, scientific contributions, and collaborations among researchers. The results show a significant increase in research related to the circular economy since 2020, especially in the manufacturing and technology sectors, with a primary focus on recycling, reuse, and remanufacturing as key elements of supply chain sustainability. The developed conceptual model emphasizes the importance of integrating technologies such as the Internet of Things (IoT), blockchain, and Big Data, alongside the Triple Bottom Line approach, that includes economic, environmental, and social aspects. Collaboration among stakeholders, governments, and consumers is also identified as an important factor in accelerating the adoption of the circular economy. This study contributes to the development of circular economy implementation strategies across various sectors and highlights future research opportunities, such as circular bioeconomy and green innovation. The proposed model is expected to serve as a guide for companies and policymakers in strengthening supply chain sustainability.

Keywords: Circular economy; sustainable supply chain; conceptual model; technology; bibliometrics.

1. Introduction

The concept of a circular economy is an innovative approach aimed at reducing waste by extending the life of products and maximizing the use of resources through recycling and reuse (Calzolari et al., 2022). These practices hold great potential for addressing the environmental and social challenges currently facing global supply chains. In addition to reducing environmental impacts, such as greenhouse gas emissions and excessive waste, the circular economy also creates new economic opportunities through more efficient resource management (Binsuwadan et al.,

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2023). Companies that adopt circular economy practices in their supply chains can lower operational costs, reduce supply risks, and meet the expectations of increasingly sustainability-conscious consumers (Lieder & Rashid, 2016). Elia et al., (2024) highlight the importance of integrating sustainability into supply chains as a response to global environmental challenges, while Shekarian et al. (2022) emphasize that sustainability strategies in supply chain not only reduce the carbon footprints but also optimize resource use and address social concerns.

As the concept evolves, Cerqueira-Streit et al. (2021) emphasizes the relevance of the circular economy in achieving supply chain sustainability by encouraging a shift from the traditional linear model, prone to waste generation, toward a more sustainable circular model. Franco (2017) also shows the importance of practices such as recycling, reuse, and remanufacturing as more sustainable alternatives in the global economy. Although the circular economy is gaining momentum, challenges remain in achieving supply chain sustainability, especially in identifying and implementing effective solutions to measure and manage its impacts. The linear economic model, that tends to generate excessive waste, must be replaced by a more efficient circular model that optimizes resources use and reduces overall environmental impacts (Rabbi & Amen, 2024).

Nobre and Tavares (2021) conducted a literature review with a bibliometric analysis on circular economy across supply chains, particularly in the manufacturing and retail sectors, focusing on recycling, reuse and remanufacturing practices. Likewise, Salas-Navarro et al. (2024), using a bibliometric approach, present a comprehensive overview of the circular economy and sustainability, with an emphasis on recycling, and remanufacturing in the manufacturing sector. Meanwhile, Kirchherr et al. (2017) revealed that the conceptual model for adopting the circular economy in the supply chain is still not well defined, And many companies face practical challenges in implementing this concept. This aligns with the findings of Ho et al. (2024), who suggest that conceptual models supporting circular economy adoption in supply chains remain underdeveloped.

Thus, while the circular economy and supply chain sustainability have become important topics in the literature, studies using bibliometric approaches to analyze trends and build conceptual models are still limited. Most prior studies have focused on literature reviews or qualitative studies, often lacking a comprehensive quantitative analysis of how circular economy and sustainability interact within the supply chain (Rajeev et al., 2017). In-depth, systematic, bibliometric-based conceptual models to assess the potential of this strategy remain scarce.

Therefore, this study adopts a bibliometric approach to explore research impact and development in the field of supply chain sustainability within the context of a circular economy. It also aims to identify future research trends and directions to this area. In addition, this study aims to develop a conceptual model that can serve as a reference framework for understanding and effectively implementing circular economy practices in sustainable supply chains. This model will assist in identifying innovative strategies and approaches to strengthen circular economy adoption across various sectors, while also offering guidance for companies and policymakers to enhance the efficiency and sustainability of supply chain operations.

This study consists of four parts. Part 1 is introduction that reviews the background and objectives of the study, outlining the context of the research problem and the objectives to be achieved. Part 2 is research method describes the research steps, including the process of searching for articles in the Scopus database, conducting a bibliometric analysis, and implementing the supplier selection method. Part 3 results and discussion presents the findings of the bibliometric analysis, followed by a detailed literature review that discusses the results in relation to relevant studies. Part 4 conclusions summarize the research findings and discusses limitations that may have arisen during the research process.

2. Material and method

This study adopts a bibliometric approach utilizing the web-based Biblioshiny application from the R package. it consists of three main phases: the first phase is initial initiation, the second

phase is data collection, and the third phase of data analysis. The initial initiation phase consists of selecting a database, formulating search criteria, and conducting the literature search. The data collection phase involves gathering the relevant articles. The data analysis phase consists of research trend analysis, scientific contribution mapping, inter-publication collaboration analysis, research impact evaluation, and identification of research trends. A more detailed overview of the research stages is presented in Figure 1.

The first phase of initial preparation in this research involves the following steps:

- *Database selection*: This study uses the Scopus database. The selection of the article is based on several factors, including its broad coverage in science and technology, recognized quality, and the availability of abundant bibliometric data. Scopus is also known for its strict curation process, ensuring that the literature it contains tends to meet high-quality standards. Additionally, Scopus provides rich bibliometric data, including information on citations, author affiliations, and research collaborations. Therefore, the selection of Scopus for this study is justified because of its advantages in supporting bibliometric analysis.
- *Formulation of search criteria*: Relevant keywords were formulated by combining three key phrases covering aspects of sustainability, circular economy and supply chain management.
- *Literature search*: After formulating the search criteria, the researcher conducted a literature search in the Scopus database using the keywords: (TITLE-ABS-KEY (sustainability) AND TITLE-ABS-KEY (circular AND economic) AND TITLE-ABS-KEY (supply AND chain)). This search produced a list of literature potentially suitable for bibliometric analysis.

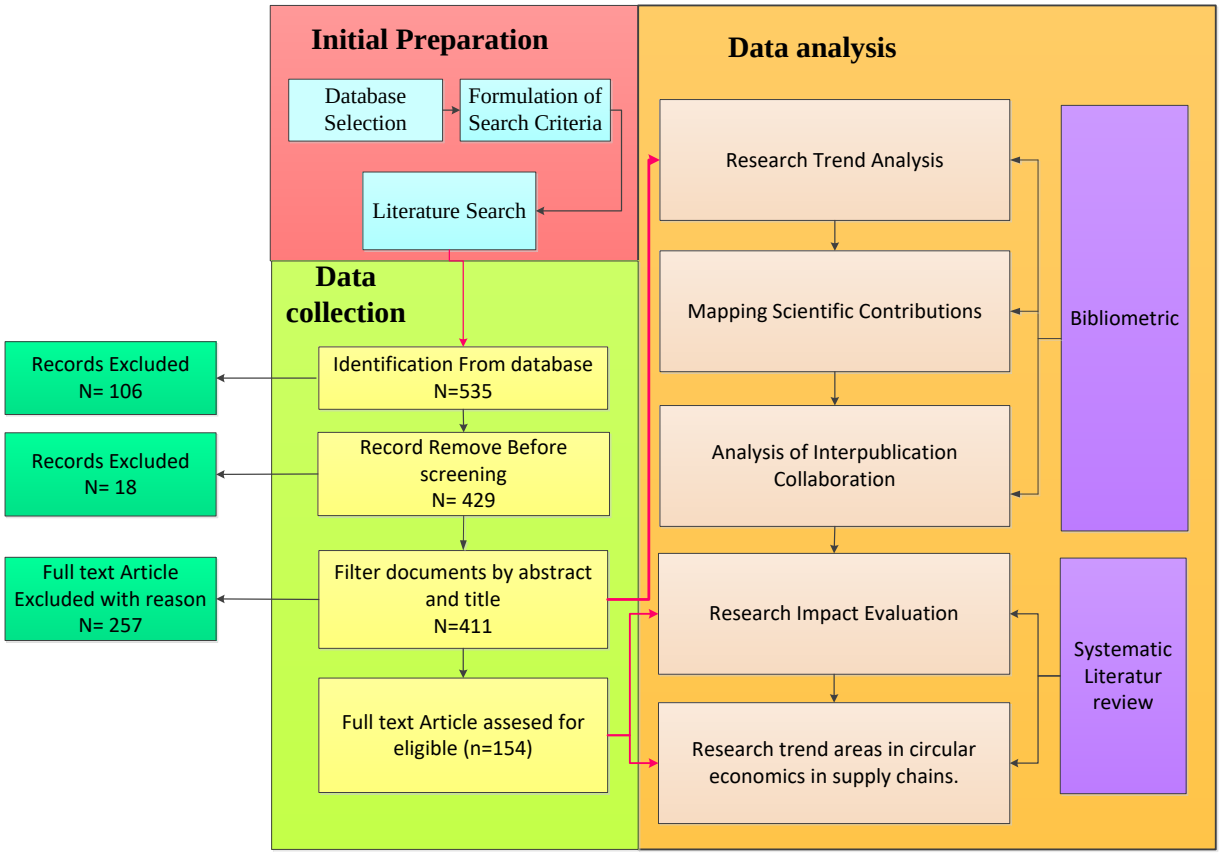

Figure 1. Research stages

The second phase of data collection consists of four process stages:

- *Identification*: Using the specified keywords, 535 scientific articles relevant to the research topic were identified. Further selection based on document type a language was carried out. A total of 106 articles were excluded, consisting of 5 non- English articles, 41 conference proceedings, 30 book series entries, 29 books, and 1 trade journal article.
- *Record removal before screening*: From the initial 535 articles, 429 articles remained after the first elimination. Further filtering base on the year of publication was conducted, retaining only articles published between 2017 and 2023. As a result, 18 articles were removed for being outside the time frame, focusing the analysis on the most recent and relevant literature.
- *Screening based on abstract and title*: After the year-based elimination, filtering continued based on the relevance of abstracts and titles. This resulted in 411 articles retained for further bibliometric analysis, while irrelevant articles were eliminated.

The third phase, data analysis, involves the following steps:

- *Research trend analysis*: This step identifies and analyzes the main research trends related to the circular economy in supply chains, including the number of publications per year, the development of research topics, and shifts in research focus. These findings help understand how the topic has evolved within the academic community.
- *Mapping scientific contributions*: Co-citation and co-authorship analyses are performed to identify key researchers, measure researcher productivity, and map collaboration trends among researchers, institutions, and countries.
- *Research impact evaluation*: This stage assesses the influence and impact of published research in the field.
- *Analysis of emerging research trends*: This final step identifies new concepts, and the latest developments in circular economy research related to supply chain sustainability.

3. Result and discussion

The results and discussion section present the findings of bibliometrics analysis and literature review based on three main focuses: analyzing research trends, mapping scientific contributions, and evaluating research impacts.

3.1. Bibliometric analysis

The bibliometric analysis in the study uses article data covering the number of author publications, the preferred publishers, the number of citations for each paper, collaboration patterns between authors and institutions, and keyword analysis to identify research topic trends. The aim is to provide an overview of the influence of scholarly works within the scientific community, the patterns of collaboration among authors and institutions, and the emerging trends in research topics within the literature.

3.2. Number of publications

Figure 2 shows the number of articles published from 2016-2023. The average number of articles published per year is 51 articles. In 2016, only two articles were published. However, over time, the number of published articles has increased from 10 articles per year starting in 2017, reaching 105 articles in 2022. In 2023, the highest number of articles was recorded, with 107 publications. This indicates that interest in the topic of the circular economy in sustainable supply chains has increased significantly, making it an increasingly attractive area for research.

3.3. Most relevant sources

Source analysis identifies the publishers of articles relevant to the research topic of circular economy and sustainability. Figure 3 shows a list of the top twenty journals, where the journals in the top two positions are marked with darker colors. This highlights journal with a high number of publications and strong relevance to the topic. The journal of Sustainability (Switzerland)

published the most articles, totaling 60, demonstrating its close alignment with the subject matter. The Journal of Cleaner Production holds the second position with 52 articles.

In addition to these top two journals, several others are actively publishing research on the circular economy in sustainable supply chains, such as Resources Conservation and Recycling, Science of the Total Environment, and others. The number of articles from these journals reflects the strong and growing interest in this topic within the academic community.

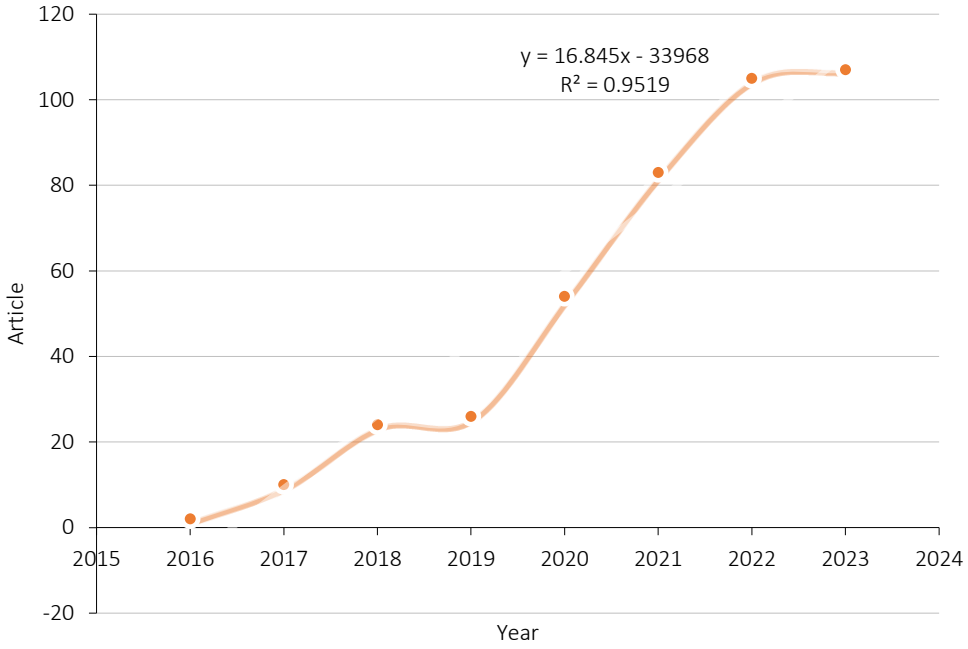

Figure 2. Number of publications

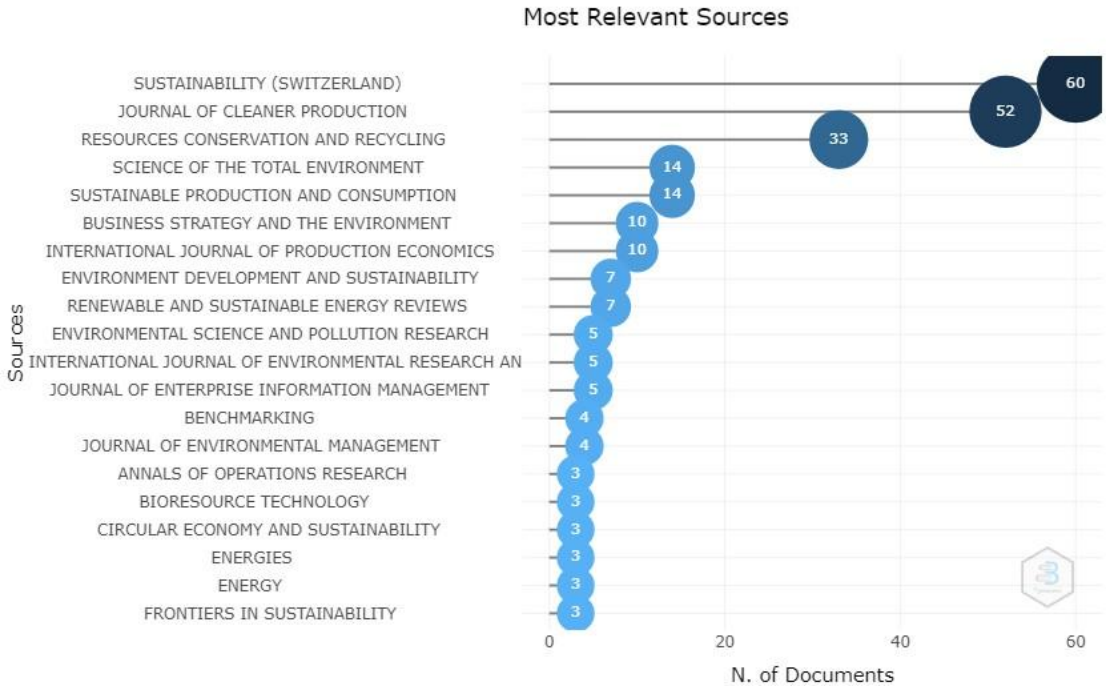

Figure 3. Most relevant source

3.4. Local impact source

In addition to considering the most relevant source, this study also examines the local source impact, as indicated by the h-index shown in Figure 4. This analysis aims to assess the influence of journals publishing articles on the topics of circular economy and sustainability, with the results visualized in a bar graph. Journal with the darkest colors represent those with the highest impact, while journals with lighter colors indicate lower impact. This color shading is determined by each journal's h-index value, which in this study ranges from 1 to 27. The Journal of Cleaner Production has the highest h-index at 27, while journals such as Applied Energy, with an h-index of 2, are represented with lighter colors.

3.5. Source growth

Source growth is illustrated by the curve in Figure 5, which shows the development of journal publications from 2016-2023. The topic of circular economy and sustainability is visualized with a curve line, indicating whether journal publications on the topic have increased or decreased over the research period. In early 2016, the *Sustainability* journal had no relevant articles published on the topic. However, starting in 2017, it experienced a significant spike in publications. Similarly, four other journals, such as the Journal of Cleaner Production; Resources, Conservation and Recycling; Science of the Total Environment, and Sustainable Production and Consumption, also showed an increase in publications. The topic of circular economy and sustainability began to grow notably starting in 2020. By 2023, all five journals reached their peak in publishing on this topic, indicated by a stable, straight line. This trend reflects a growing interest in research on the circular economy in supply chain sustainability.

3.6. Most Relevant Authors

Figure 6 shows the most relevant authors based on the number of articles produced in research on the circular economy in supply chains. The number of articles per author ranges from 3 to 7.

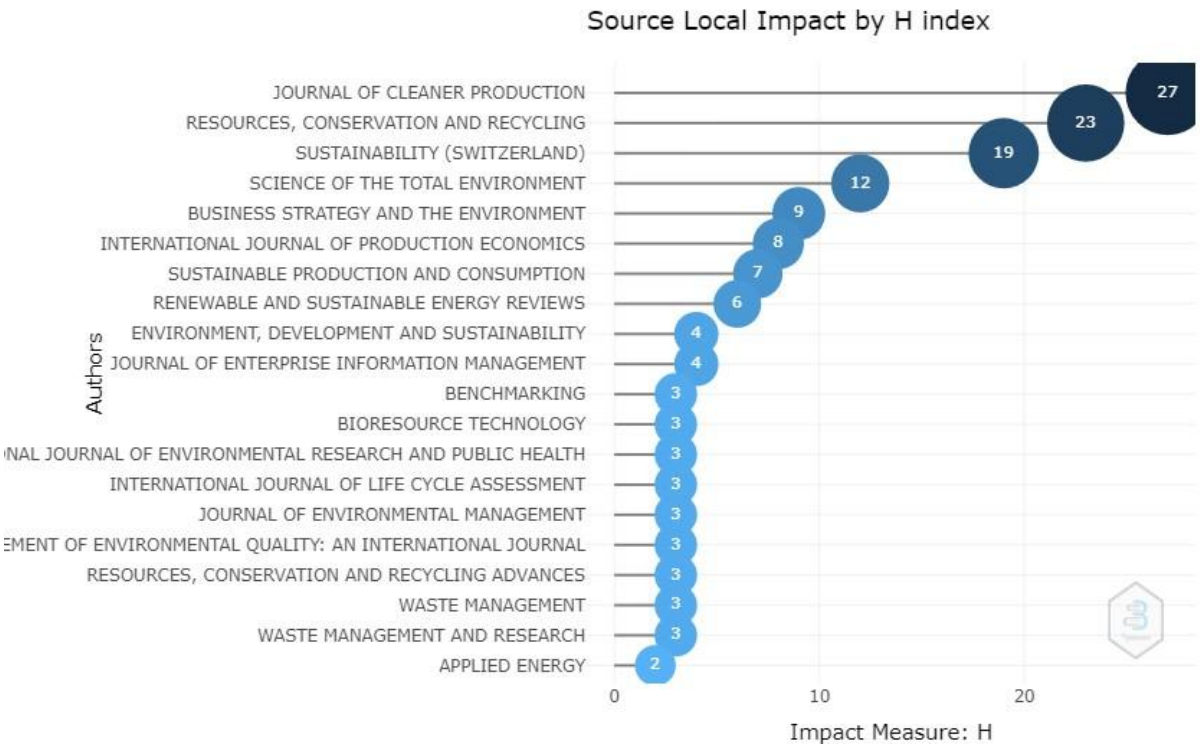

Figure 4. Most relevant source

Author Sarkis ranks first with the most articles, totaling 7. Four authors: Kazancogluy, Mangla SK, Tseng ML, Wang Y, each have produced 6 articles. The lowest number of articles among the listed authors is 3. The variation in the number of articles published between 2016 and 2023 reflects the level of researcher engagement and interest in the topic of circular economy and supply chain sustainability.

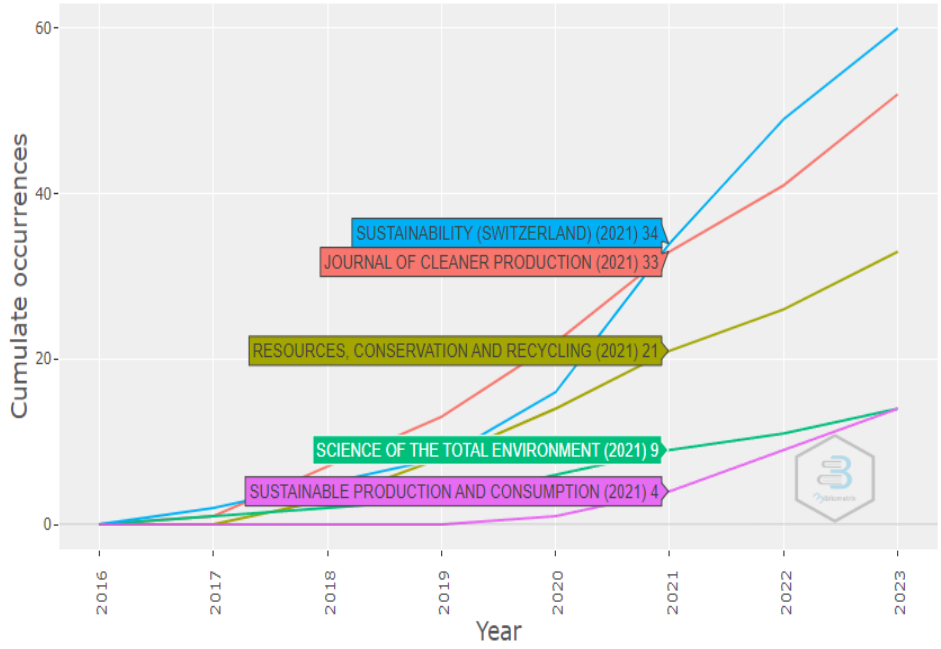

Figure 5. Source growth

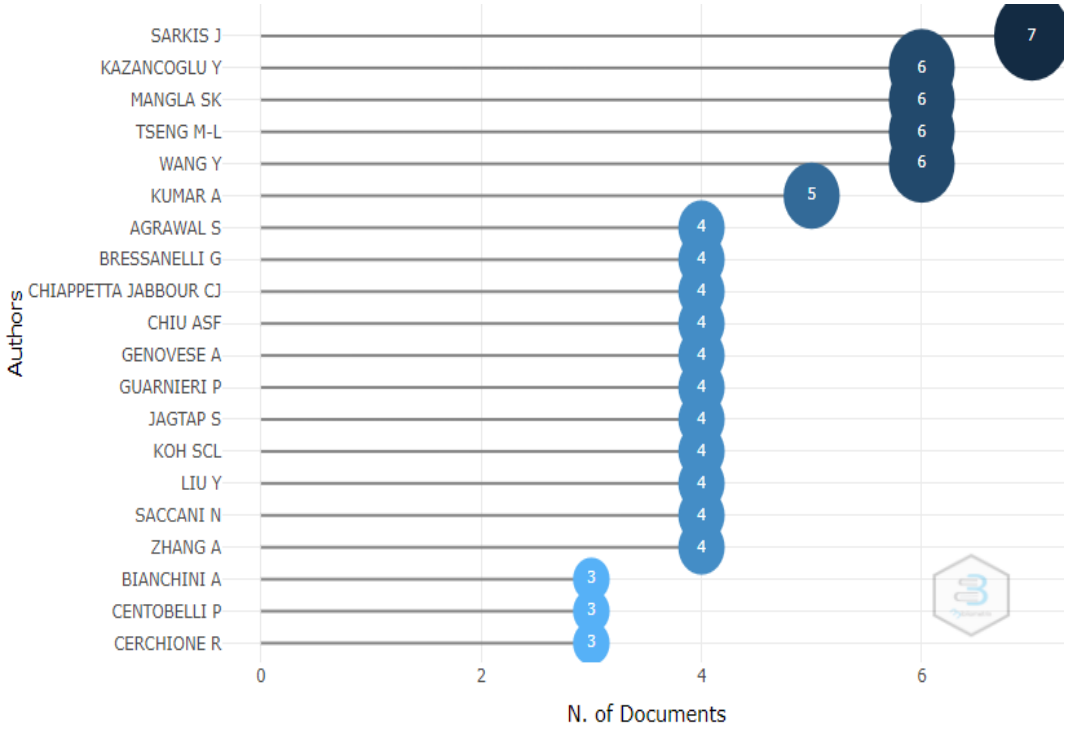

Figure 6. Most relevant authors

3.7. Top author's production over the time

Author productivity on the topic of circular economy and supply chain sustainability during the research period from 2016 to 2023 is shown in Figure 7. Productivity is illustrated by a red line, which indicates the span from an author's first publication to their most recent. The blue circles on the red line represent the number of papers published in each corresponding year. Figure 7 provides an overview of authors who have conducted research related to the circular economy and supply chain sustainability. Author productivity began to emerge in 2019 and continued through 2023. The most productive author, based on the number of papers published each year, is Sarkis, followed by Kazancogluy, Mangla SK, Tseng ML, Wang Y. Genovese is noted as the author with the longest publishing track record, spanning from 2016-2023.

3.8. Most cited documents

This section discusses twenty authors with the highest impact and relevance in the field of circular economy and supply chain sustainability. These authors were selected based on their high number of citations, indicating that their published research is recognized and utilized by other researchers in the field. Identifying and understanding the most frequently cited articles can help guide new research and provide a strong foundation for future studies. In addition, frequently cited articles can serve as key references for researchers seeking to develop and expand existing knowledge. Figure 8 displays the names of these authors along with the journals in which the most frequently cited articles were published. The number of citations reflects the extent of an article's impact and relevance within the research domain of circular economy and supply chain sustainability. Furthermore, TC per year (the average number of citations per year) provides insight into how often each article is referenced annually.

3.9. Most relevant words

The list of keywords and their frequencies aims to identify the main themes that frequently appear in the literature (Figure 9). Among the most relevant words, circular economy appeared

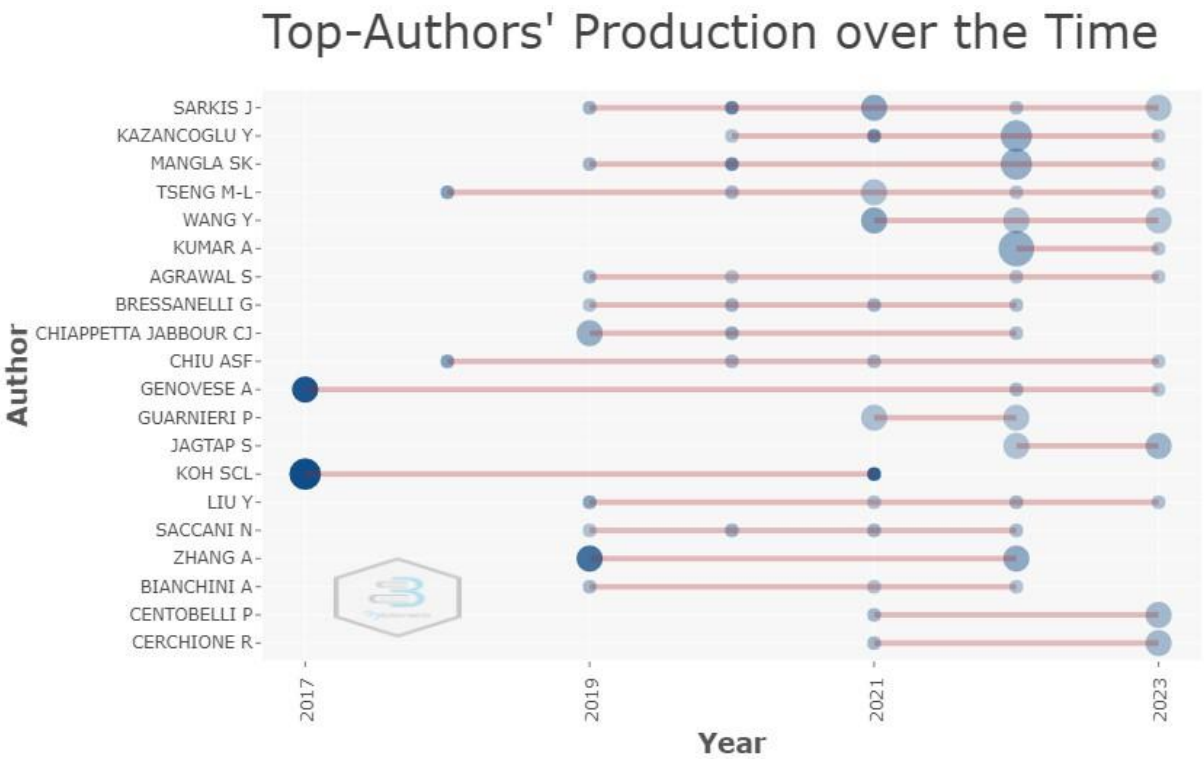

Figure 7. Top author's production over the time

271 times, indicating that this topic is one of the main focuses in the literature. Meanwhile, sustainability appeared 168 times, highlighting the importance of maintaining sustainability in the food supply chain. In addition, the keyword Industry 4.0 appeared 27 times, showing its relevance to the industrial revolution and the use of technology in the supply chain. The keyword supply chain management appeared 24 times, underlining the role of management in improving supply chain efficiency.

The next keyword sustainable development appeared 22 times, indicating that the literature pays attention to how the food supply chain can contribute to broader sustainable development goals. Furthermore, the keywords sustainable supply chain, sustainable supply chain management, and sustainable supply chain (noting that there might be a duplicate here) each appear 8

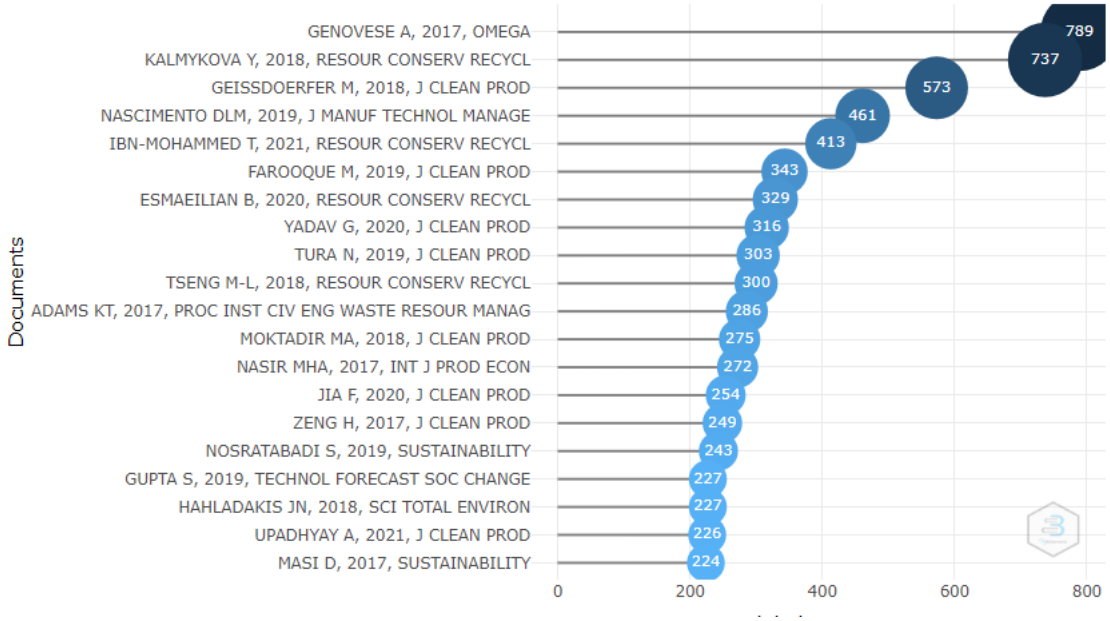

Figure 8. Most cited documents

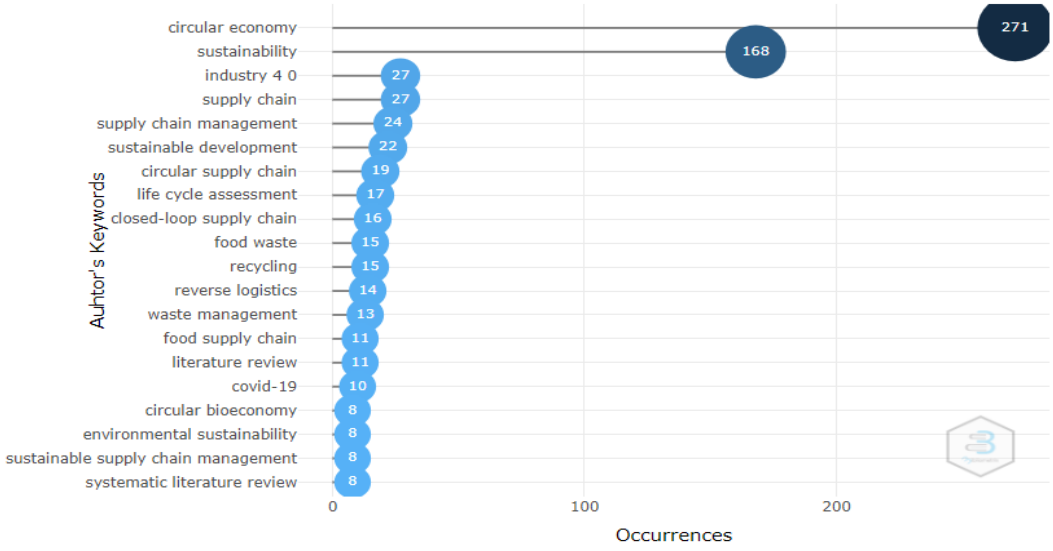

Figure 9. Most relevant words

times, highlighting the important role of building a sustainable supply chain. By analyzing the frequency of these keywords, we can identify the main trends and research focuses in the literature on the circular economy and supply chain sustainability.

3.10. WorldCloud

The WorldCloud in Figure 10 provides a visual representation of the most dominant topics or concepts, such as circular economy and sustainability, which appear most frequently. Other words are shown in smaller sizes due to their lower frequency of occurrence. Circular economy appears 271 times, indicating that this research is concerned with how supply chains can contribute to circular economy practices, which aim to reduce waste and improve resource use. Sustainability appears 168 times, reflecting attention to maintaining sustainability across all aspects of the supply chain.

Industry 4.0 appears 27 times, although it appears less frequently than other keywords, it indicates growing interest in the use of Industry 4.0 technologies and concepts within the supply chain. Supply Chain and Supply Chain Management appear 27 and 24 times, respectively. This shows the central role of supply chains and their management in the context of a circular economy.

Sustainable Development appears 22 times, reflecting the attention on how supply chains can support broader sustainable development goals. Circular Supply Chain appears 19 times, indicating interest in applying circular economy principles directly to supply chains. Overall, this analysis shows that the main focuses in the literature are on sustainability, circular economy, and efficient supply chain management.

3.11. Tree map

The tree map is a visual representation that shows the proportion of various elements in a dataset using different sized boxes, where the size of each box reflects the quantity or value of the corresponding element (Figure 11). Sustainable Development has the highest value in this dataset, indicated by the largest box in the tree map, showing that it is the main topic.

The second largest element, Circular economy, also represents an important topic in the data. Supply chains have a fairly large box size, suggesting it is a significant topic, although it is a more general term compared to supply chain management. Sustainability has a similar box size to supply chains, indicating it is also an important topic. Supply chain management shares a comparable box size with sustainability, reinforcing its relevance. Waste management has a

Figure 10. Word cloud

smaller box size than the topics mentioned above but remains a fairly significant element. Recycling has a smaller box size compared to waste management, yet it still reflects a relevant topic in dataset. Overall, this tree map analysis provides a visual representation of the extent to which different elements contribute to the dataset. From this analysis, it is clear that sustainable development, circular economy, and supply chains are the dominant topics in this study.

3.12. Word growth

Word growth analysis aims to provide insight into the development of research topics over time. This study analyzes growth from 2017 to 2023, focusing on the topic of circular economy and sustainability in the supply chain.

Figure 11. TreeMap

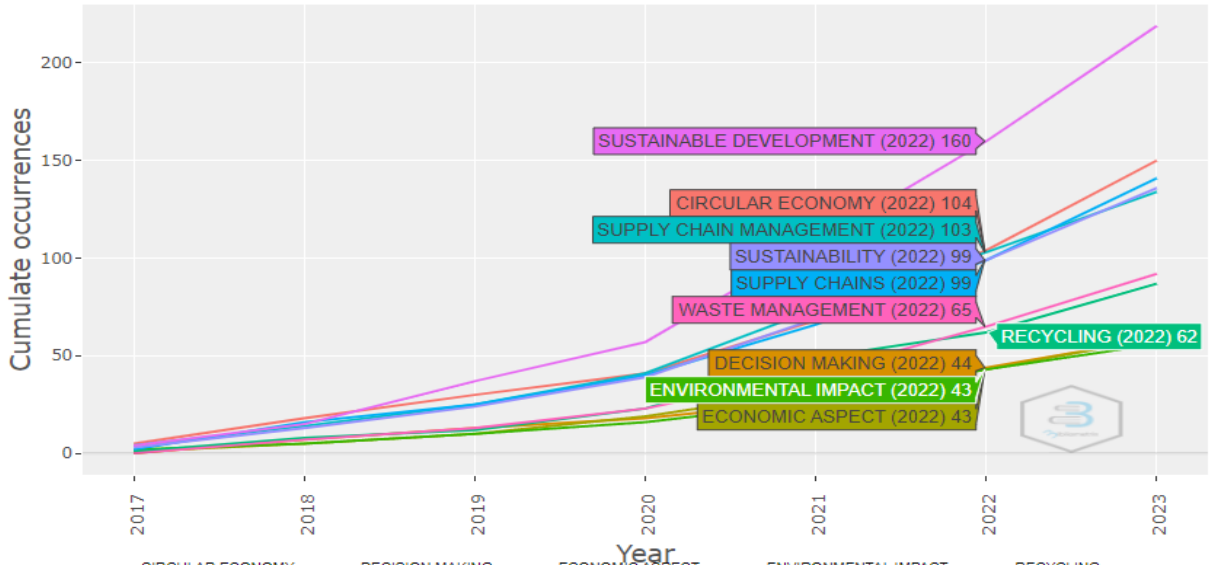

Figure 12. Word growth

Figure 12 shows the time span from 2017 to 2023, during which there have been significant changes in the concepts and topics related to sustainability and the circular economy. One of the concepts that has experienced the most striking growth is sustainable development. In 2017, the keyword sustainable development appeared only four times. However, in 2023, its occurrences had dramatically increased to 219 times. This indicates that sustainable development has become highly dominant and significant issue in discussions and planning across various sectors.

Sustainable development reflects efforts to achieve a balance between economic growth, environmental sustainability, and social justice. The substantial increase in the use of this term suggests that sustainability issues have become a major concern at different sectoral and policy levels. This trend reflects the global community's growing awareness of the importance of addressing sustainable challenges and finding lasting solutions for the future.

3.13. Trending topics

Trend topics during the period 2017 to 2023 show tha, various concepts related to sustainable development, circular economy, sustainability, supply chains, supply chain management, waste management, recycling, decision making, economic sspects, and environmental impact experienced significant growth, as illustrated in Figure 13. This increase reflects a shift in awareness and attention to sustainable issues across various contexts, including business management, decision making, and economic and environmental impacts. In particular, sustainable development has become one of the most dominant topics, experiencing the most dramatic growth and highlighting its importance on the global agenda.

In addition, circular economy and supply chains have also emerged as increasingly relevant topic, underscoring the significance of sustainable resource and supply chain management in reducing environmental impacts and increasing efficiency. Overall, this trend reflects a growing shift towards greater awareness and action in support of sustainability and contributes to global efforts to address environmental and social challenges. In recent years, this concern has increasingly become a major focus across sectors.

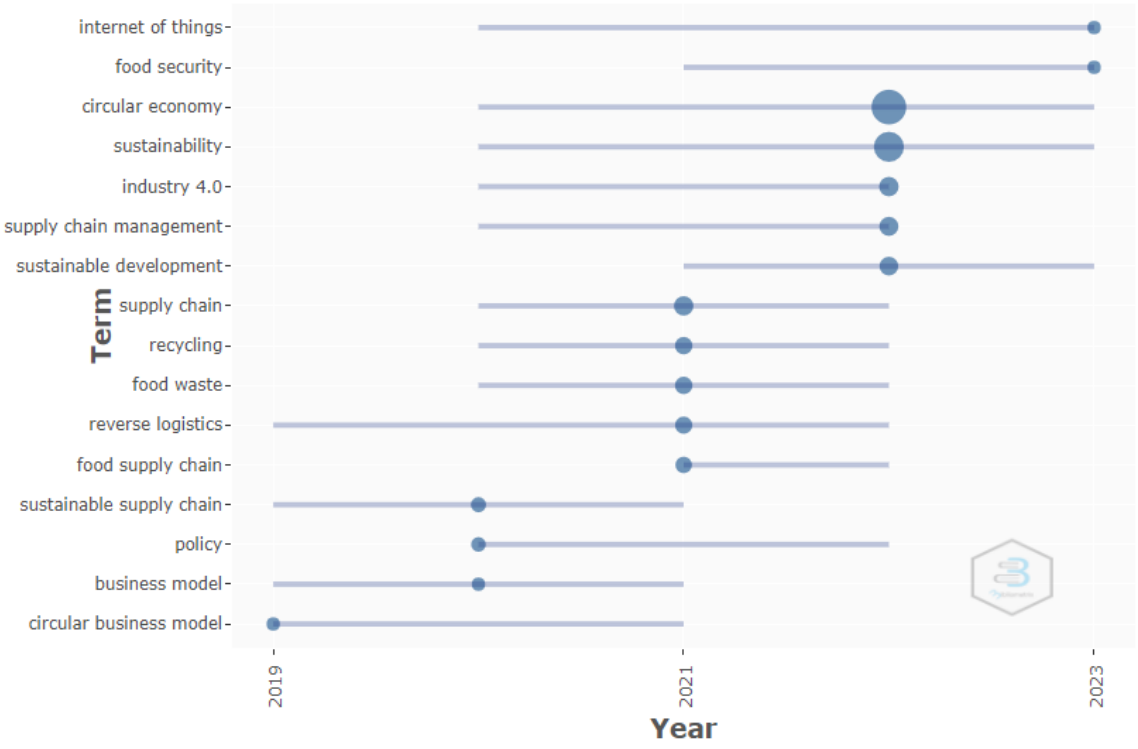

Figure 13. Trend topic

3.14. Co-occurrence network

In co-occurrence network analysis, relationships between keywords (nodes) are depicted as a network. These relationships reflect how often two keywords appear together in the same text or document. The more frequently two keywords co-occur, the stronger the relationship between them in the network. Figure 14 shows five clusters, each represented by a different color. Below is an analysis of the five clusters, where each group contains related keywords and highlights important issues concerning to sustainability, technology, and supply chain management.

Cluster 1 – Supply chain management and sustainability:

This cluster focuses on topics related to supply chain management, with an emphasis on sustainability and technology. It includes Industry keywords such as Industry 4.0, supply chain management, circular supply chain, reverse logistics, systematic literature review, and sustainable supply chain.

Cluster 2 - Sustainable development and resources:

This cluster covers topics related to sustainable development and resource management, including sustainable development, life cycle assessment, food supply chain, literature review, circular bioeconomy, and biorefinery.

Cluster 3 - Circular Economy and Environmental Sustainability:

This cluster focuses on the circular economy and environmental sustainability, involving keywords such as circular economy, waste management, COVID-19, environmental sustainability, sustainable supply chain management, and industrial symbiosis.

Cluster 4 - Closed supply chain and three aspects consideration:

This cluster addresses topics such as closed-loop supply chain, which focuses on recycling and reusing products or materials to reduce waste, as well as the riple bottom line approach, which considers the economic, environmental, and social impacts of actions or policies.

Cluster 5 - Sustainability in supply chain:

This cluster focuses on sustainability within the supply chain context and includes keywords such as sustainability, supply chain, food waste, recycling, blockchain, circular supply chain management, and Internet of Things (IoT).

Figure 14. Co-occurrence network

3.15. Thematic map

Thematic map analysis based on density and centrality is shown across four quadrants. The upper left quadrant represents highly developed but isolated themes, characterized by high density but low centrality (Figure 15). This quadrant highlights specific and rarely studied themes that have high value. Keywords in this quadrant include game theory, logistics, agriculture, food, and sustainable production, important but less explored areas with great potential for improving sustainability and efficiency in supply chain management.

Game theory helps to understand strategic interactions between stakeholders (De Giovanni, 2020), while sustainable logistics focuses on optimizing the flow of goods while minimizing environmental impact (Tetteh et al., 2024). Sustainable agriculture and more sustainable food systems are needed to support population growth in an environmentally friendly manner. Sustainable production emphasizes environmentally friendly processes that also support economic growth and quality of life. All of these themes are essential for creating a greener and more sustainable future (Chen et al., 2024).

Keywords located in the lower left quadrant represent emerging and declining themes, characterized by low density and centrality. This quadrant includes themes that have either emerged or are starting to be abandoned. Four keywords fall into this quadrant: life cycle sssessment, packaging, green supply chain management, environmental sustainability. The position of Life Cycle Assessment (LCA) on the strategic map suggests that, although it is important tool for sustainability analysis, its use and development in academic literature may still be limited (Prasad et al., 2020). This may be due to the complexity of the LCA process, the extensive data required, or the emergence of newer methods in the field of sustainability.

Packaging plays a vital role in supply chain management, focusing on product protection, logistics optimization, and environmental impact (Sastre et al., 2022). However, based on the strategy map analysis, there appears to be a lack of research and innovation related to sustainable packaging, indicating significant opportunities for further research and development in this area to reduce waste.

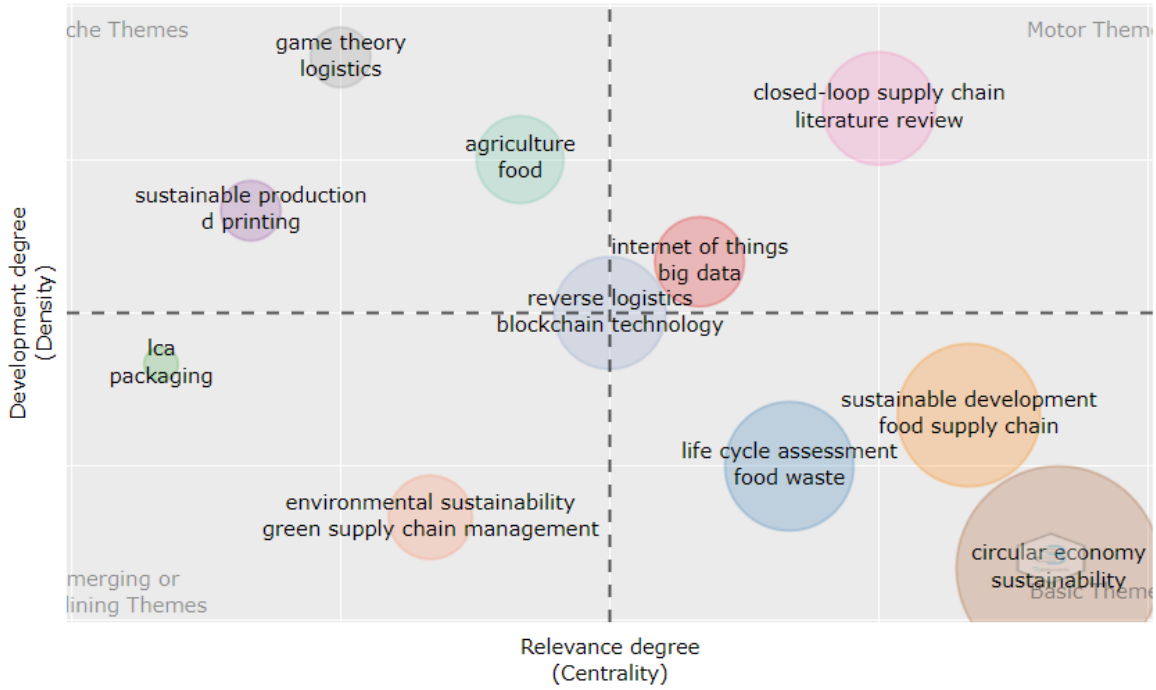

Figure 15. Thematic map

Green supply chain management, located in the lower middle of the map, suggests a moderate level of relevance but a low level of development. Although the concept is recognized as important, it may still be in the early stages of research or underrepresented in the literature (Deste et al., 2024). Environmental sustainability is positioned slightly further to the right than green supply chain management, indicating slightly higher relevance but still low development. This suggests growing interest in this theme, although significant room for further research or practical application remains.

The lower right quadrant is characterized by high centrality but low density, representing basic themes. Keywords in this quadrant are important because they are widely recognized and frequently studied. The themes here include sustainability development, food supply chain, circular economy, food waste, and LCA. Sustainable development contributes to responsible economic growth, improved social welfare, and environmental protection, ensuring resource availability for future generations. Food supply chain is crucial for enhancing food security, reducing food waste, and supporting local economies. Circular economy practices can reduce a country's dependence on imported resources, foster innovation, and support sustainable economic development through waste reduction and improve resource efficiency. Food waste reduction offers economic benefits by minimizing costs associated with the production, processing, and disposal of unconsumed food, while also delivering environmental benefits through reduced greenhouse gas emissions from decomposing food waste. Finally, LCA can help identify and implement more efficient and environmentally friendly production practices, contributing to reduce environmental impacts and improved sustainability of domestic products.

The next quadrant is the upper right quadrant, which represents motor theme, those characterized by high density and centrality. These themes are important, well-developed, and need to be further explored in future research. The themes in this quadrant include Internet of Things, Big Data, close-loop supply chain, and literature review.

3.16. Thematic evolution

The thematic evolution on the left shows some of the most commonly used themes from 2016 to 2022, including reverse logistics, circular economy, LCA, sustainable development, literature review, closed-loop supply chain (Figure 16). The right side of the diagram displays the concepts from 2023, including circular economy, supply chain management, sustainable development, triple bottom line, circular supply chain management, circular bioeconomy, food security, supply chain, food waste, systematic review, and Industry 4.0.

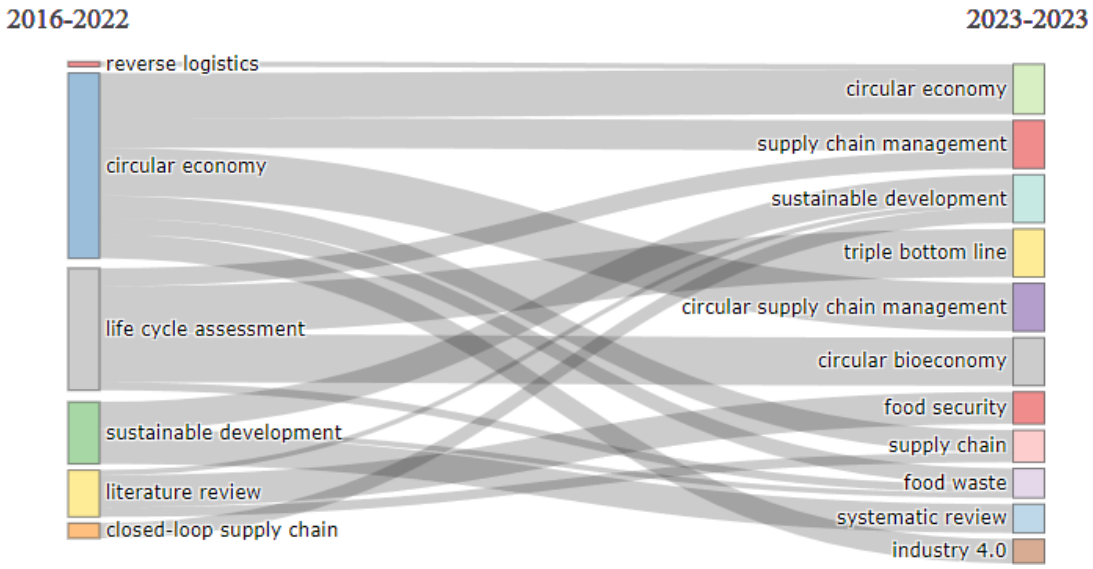

Figure 16. Thematic evolution

The circular economy theme ranks first, followed by LCA and sustainability development. However, circular economy and sustainable development is evolving topics in this study. As shown in Figure 16, concepts such as circular economy and sustainable development remain relevant throughout the period, while other concepts such as closed-loop supply chain into circular supply chain management, show development. New concepts, such as industry 4.0, also emerged in 2023. The gray lines illustrate the relationships and transitions between older and newer concepts, signaling a shift in focus and approach in this field over time.

3.17. Research trends and future research opportunities

Research trends in the topic of sustainability in the circular economy from 2016-2022 to 2023 show some interesting patterns. First, there is consistency in research topics, particularly circular economy, supply chain management, and sustainable development. These topics have remained the main focus over time, indicating their continued importance in research and global attention to sustainability and efficiency in supply chain management.

Based on the bibliometric results, the circular economy topic primarily focuses on waste reduction and resource efficiency, which align with finding by Chowdhury and Asiabanpour (2024). Likewise, sustainability remains a highly popular topic, reflecting sustained interest in sustainable practices across various sectors. This indicates a significant increase in research and interest in sustainable development. Meanwhile, supply chain management continues to be important research area, especially concerning efficiency, sustainability, and resilience.

Topics such as reverse logistics and closed-loop supply chains show that they have evolved and been integrated into broader concepts, such as the circular economy or circular supply chain management (Fu et al., 2021). In contrast, topics such as industry 4.0 and the IoT highlight the application of technological advancements in industry. LCA, circular supply chain, and closed-loop supply chain have shown a significant number of occurrences, indicating opportunities for further research focusing on environmental impact analysis and resource management (Bhatnagar et al., 2024). In addition, waste management has emerged is an important area due to the growing need to reduce the environmental impact of waste. Likewise, recycling remains an important topic in sustainability discussions.

Figure 17 visualizes new research opportunities, where the yellow marks new and emerging topics and blue marks older or declining topics. New areas of research consist of the circular bioeconomy, which focuses on sustainable solutions utilizing biological resources and waste reduction. Green innovation within the circular supply chain also presents significant opportunities for innovation and the development of new technologies in the circular economy and waste management sectors.

Other important emerging research area includes food security and food waste, which are gaining attention in addressing global food security challenges and reducing food waste through changes in global food policy. Systematic reviews will continue to be an important approach, helping researchers synthesize evidence-based practices. Furthermore, digital technologies such as AI, blockchain, and IoT are becoming increasingly popular and have to the potential to revolutionize the field of sustainability. Meanwhile, circular economy and sustainability are expected to remain important key topics, with a focus on developing more efficient and environmentally friendly systems.

3.18. Conceptual model circular economy in sustainable supply chains

The circular economy is the main approach to creating a sustainable supply chain. As shown in Figure 18, this circular economy emphasizes the reduce, reuse, recycle (3R) principle and the closed-loop supply chain approach, both aiming to reduce waste and maximize resource utilization (MahmoumGonbadi et al., 2021). Meanwhile, technology can support the implementation of the circular economy through tools such as IoT, Blockchain, and Big Data to

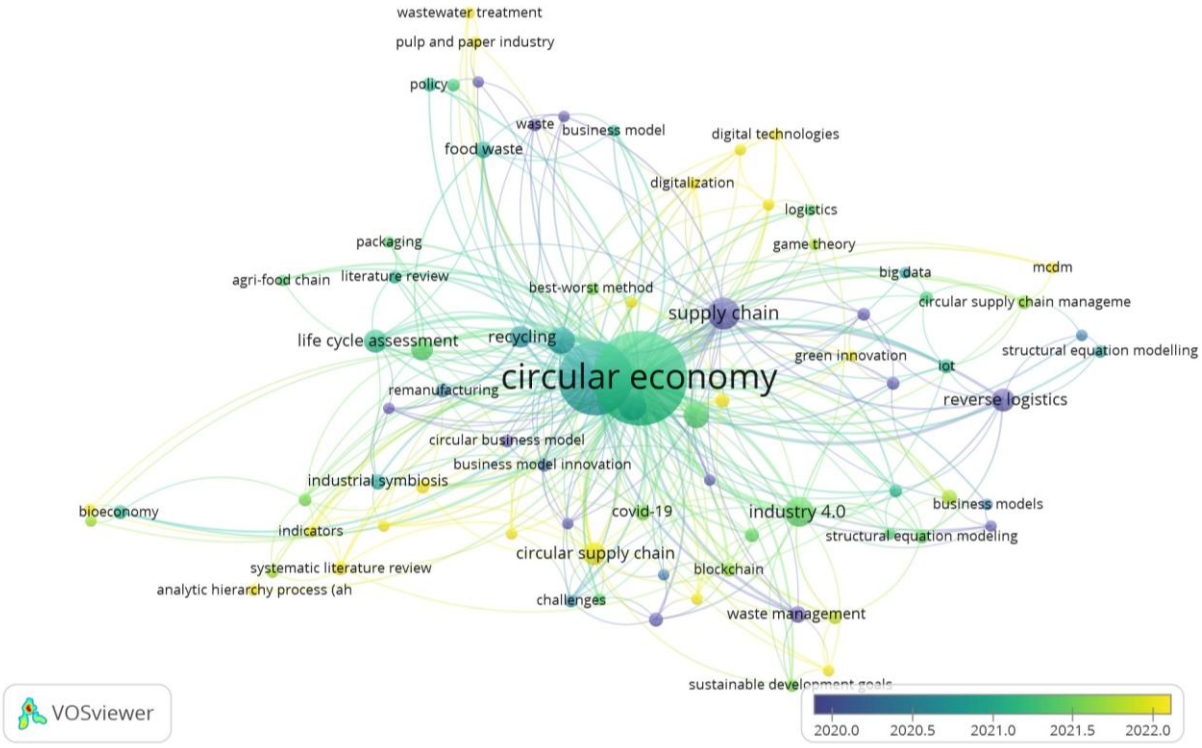

Figure 17. Research trends and future research opportunities

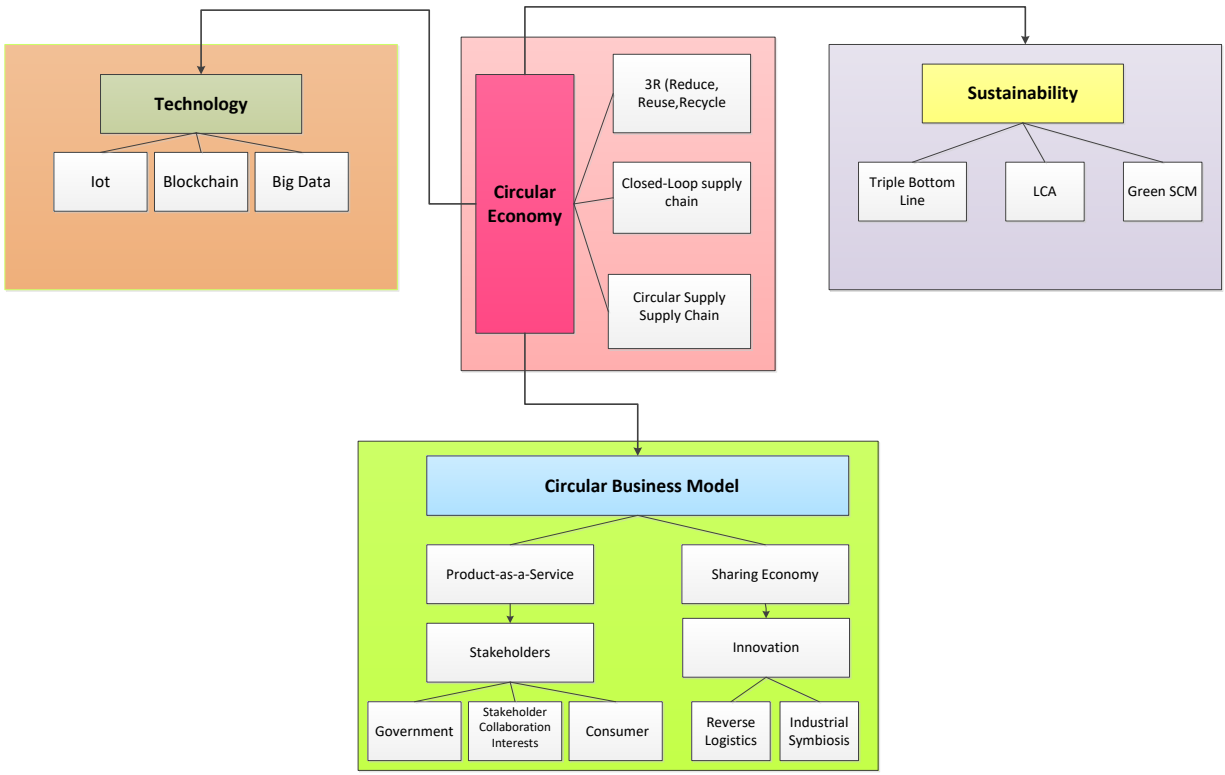

Figure 18. Conceptual model of circular economy implementation in sustainable supply chains

manage supply chains more efficiently, track products, and increase transparency in waste management (Caldarelli, (2024). Sustainability as also key elements directly connected to the circular economy (Mukherjee et al., 2023). Three important elements, Triple Bottom Line (3BL), LCA, and green supply chain management (green SCM), illustrate the focus of sustainability within the context of a sustainable supply chain.

Based on Figure 18, the circular economy is directly linked to technology, sustainability and circular business models, indicating that these three elements serve as key drivers for strengthening the circular economic system (Matarneh et al., 2024). The relationship between business models, innovation, and stakeholders highlights how actors inside and outside the organizations collaborate to implement sustainable circular solutions. Circular business models offer innovative strategies to extend product life and minimize waste in the supply chain (Mukherjee et al., 2023). Additionally, the role of stakeholders, including governments, consumers, and collaboration between stakeholders, is important for implementing a circular economy across various industrial sectors.

4. Conclusion

The study shows a significant increase in interest in circular economy within supply chains, particularly since 2020, with a primary focus on the manufacturing and technology sectors. The bibliometric analysis identifies that research in this field broadly highlights recycling, reuse, and remanufacturing practices as critical elements for supply chain sustainability. The conceptual model developed in this study offers a systematic framework to assist companies in adopting circular economy practices. This model emphasizes the importance of integrating technologies such as IoT, Blockchain, and Big Data, alongside the Triple Bottom Line approach, which considers economic, environmental, and social aspects. However, it is crucial to recognize that these efforts are not individual but collective. Collaboration among stakeholders, governments, and consumers is identified as a critical factor in accelerating the adoption of the circular economy, underscoring the importance of collective efforts in this transition.

The bibliometric analysis also successfully maps current research topics, such as circular supply chains, digital technologies, the economy, food security, and food waste. This study reveals several gaps that require further attention, including the need for broader case studies across various industries. Addressing this need is not just a suggestion but a necessity to ensure the generalization of findings and to close gaps in current research. Additionally, future research should focus on developing stronger methodologies and algorithms to support sustainability and the circular economy initiatives. The exploration of emerging technologies such as AI, blockchain, and IoT also promises significant improvements in supply chain efficiency and sustainability. Thus, this research not only makes an essential contribution to development of strategies for circular economy implementation but also paves the way for further research that can enrich methodological approaches and improve sustainable supply chain management. Future research is expected to strengthen responsible economic development and enhance resource management efficiency, ultimately supporting better global sustainability.

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