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Global Trends of Circular Economy and Innovation Research: A Bibliometric Analysis

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ABSTRACT

In recent years, the circular economy has gained significant attention as a sustainable alternative to traditional linear production and consumption models. This study conducts a bibliometric analysis of circular economy and innovation literature from the Scopus database, covering 2016 to July 2024. Utilizing VOSviewer and Biblioshiny to create knowledge maps and visualizations for examining co-occurrence, co-authorship, and international collaboration patterns. The analysis of 401 documents revealed significant insights into current and emerging publication trends. Predominant author keywords included "circular economy", "innovation", "sustainable development", and "sustainability." The journal Sustainability (Switzerland) emerged as the leader in productivity, while Ecological Economics garnered the highest citation count. Notably, the United Kingdom ranked as the most productive country in this field. The thematic evaluation maps highlighted a concentration on critical research topics such as development of sustainable business models, technological advancements for waste valorisation, product design and innovation, collaborative innovation networks, policy and regulation-induced innovation, and digital transformation for circular economy. The findings can contribute researchers, policymakers, and industry leaders regarding the transition to a circular economy through innovation to achieve Sustainable Development Goals (SDGs).

1. INTRODUCTION

The circular economy represents a paradigm shift in our approach to production, consumption, and waste management. Unlike the traditional linear economy, which follows a "take, make, dispose" model [1], the circular economy emphasizes sustainability through the continuous use of resources. This approach seeks to minimise waste and maximise the value derived from products and materials by keeping them in use for as long as possible [2]. Central to this model is the idea of a closed loop, ensuring that products are returned to the economy as valuable resources at the end of their lifecycle through recycling, refurbishment or remanufacturing [3, 4]. Innovation plays a crucial role in the transition to a circular economy. As the world's population grows and natural resources decline, the development of innovative technologies, business models, and practices that enable sustainable growth is essential [5]. Advances in circular strategies, which aim to reduce dependency on limited resources and mitigate environmental damage, are driven by innovations in product design, materials science and business practices. Advances in biodegradable materials, renewable energy and digital technologies enable improved resource management and reduced waste [6].

Recent bibliometric studies on the circular economy have made significant contributions to the field. For instance, Goyal et al. [7] and Camón Luis and Celma [8] explored general aspects of the circular economy, while Ruiz-Real et al. [9] examined the relationship between the circular economy and environmental issues. Martinho and Mourão [10] focused on the impact of the circular economy on economic development, and Negrete-Cardoso et al. [11] investigated its application in waste management. Additionally, Razmjooei et al. [12] studied the circular economy in the context of sustainability in maritime industries, and Correa et al. [13] explored reverse logistics within the circular economy.

Despite these contributions, there remains a notable gap in the literature regarding the intersection of the circular economy and innovation, particularly through bibliometric analysis. This research aims to fill this gap by conducting a comprehensive bibliometric analysis to identify key research themes, collaboration patterns, and emerging areas of focus within the realm of circular economy and innovation. The subsequent research questions (RQs) will be examined:

RQ1: What are the main characterisations and dynamic trends in the circular economy and innovation research?

RQ2: Who are the most prolific, collaborative authors, countries, and institutions in the field of circular economy and innovation research?

RQ3: Which journals have published the most research on the circular economy and innovation?

RQ4: Which keywords are most commonly utilised in research pertaining to the circular economy and innovation?

RQ5: What is the present state of knowledge generation regarding co-occurrence, collaboration, and co-authorship connections in the circular economy and innovation research?

RQ6: What are the major themes and future research direction of circular economy and innovation research and their evolution?

This study utilized bibliometric analysis to examine the publication of research on the circular economy and innovation, using data from the Scopus database. The objective was to present a comprehensive overview of the current global research trends in this field.

To address the research questions, the study is organised into the following sections. The "Introduction" section offers a succinct summary of the subject, encompassing the current comprehension of circular economy and innovation, previous research, the gap in knowledge, and the objective of the study. The "Research methodology" section outlines the specific approach employed in this study, encompassing bibliometric analysis and *Biblioshiny* techniques, as well as providing a flowchart and data analysis framework. The "Results" section provides a detailed analysis and answers the study questions mentioned earlier, the discussion and future research direction suggest potential themes for future research. Finally, the "Conclusion" section provides a summary of the contributions, limitations, and potential areas for future research.

2. RESEARCH METHODOLOGY

2.1 Bibliometric analysis

Bibliometric studies offer a comprehensive framework for understanding the significance of research outputs and allows for the examination of journals and article publications, alongside their respective citation patterns over time [14]. Furthermore, it generates statistical outputs that facilitate the calculation and estimation of growth patterns within specific domains [15]. This methodology is widely adopted across many disciplines for bibliometric analysis, including supply chain and logistics [16, 17], medical research [18], business and finance [19], education [20], industry sector [21, 22]. The methodology functions as a standardised approach for assessing written communication among authors, thereby quantifying trends and attributes within a particular research domain, emphasising research titles, keywords, affiliations, authors, and publication metrics [23, 24], It encompasses the analysis of co-authorship links, co-citation links, and bibliographic coupling links, facilitating citation mapping to visualize thematic clusters [25].

Thematic evaluation offers a novel approach to quantifying the evolution of research fields. By analysing the thematic development over time, researchers can gain insights into the systematic growth and progression of their respective domains [15].

2.1.1 Data collection and search strategy

The Scopus database was selected for data collection regarding this study, spanning the years from 2016 to July 29, 2024. Scopus is the largest global collection of citations and abstracts for scholarly works published by many publishers, offering a centralised platform for academic researchers. Compared to alternative databases such as Web of Science (WoS), PubMed and Google Scholar, Scopus provides a broader range of publications and facilitates effective keyword searches and bibliographic analysis [26]. Notably, Scopus yields a 20% greater coverage than WoS in citation analysis, while Google Scholar often produces uneven results. Although PubMed is a normally utilised resource in scientific research, Scopus's comprehensive coverage makes it particularly suitable for this study [26]. Figure 1 depicts the search strategy and the methods used for data collection in this study.

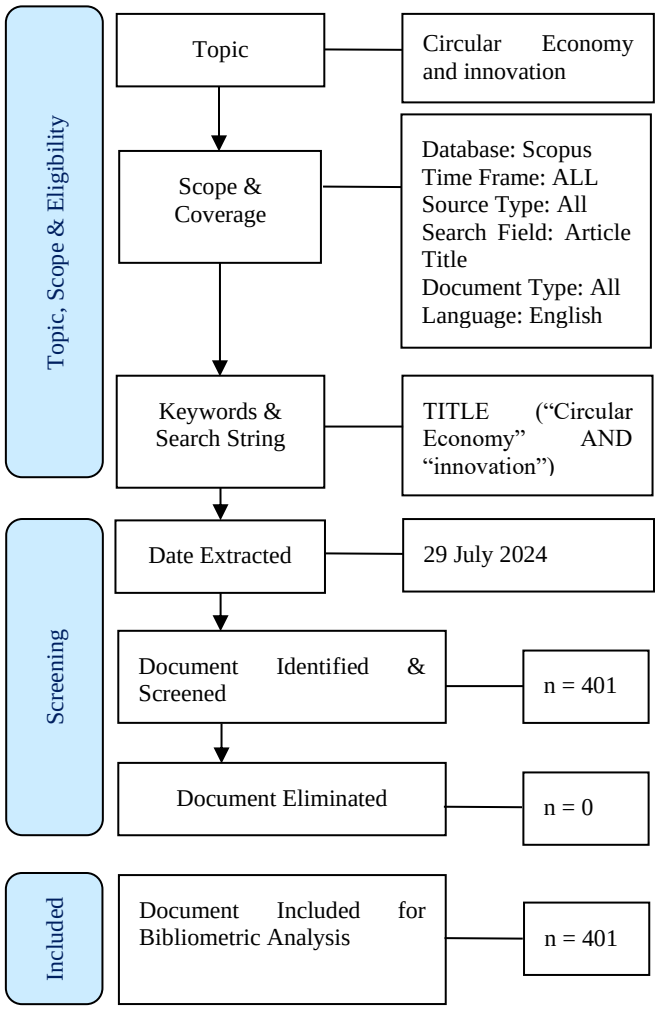

Figure 1. The article search strategy implemented in this analysis

In this study, we selected the appropriate keywords to align with the research questions; this study focused on two primary keywords for the title: "circular economy" and "innovation." Consequently, the research encompassed two relevant keyword combination strings. The title of an article should convey pertinent information to engage readers, as it is the first element they encounter. The study utilised the following search query: (TITLE ("circular economy") AND TITLE (innovat*) AND (LIMIT-TO (LANGUAGE, "English")). The term "innovat*" incorporates the asterisk symbol in the search strategy to ensure the inclusion of various forms of the root

word, such as innovation, innovations, innovate, innovating, innovator, among others. A total of 401 research documents published between 2016 and July 29, 2024, were retrieved from the Scopus database, with no exclusion criteria applied during the search, as depicted in Figure 1.

2.1.2 Tools and data analysis

The analysis in this study used *VOSviewer* software to visually represent geographic distributions, authorship patterns, citation networks, keywords, and collaborations among countries, This software employs multiple techniques to create visual bibliometric maps, highlighting distinct structural elements of the literature, also integrated methodology for mapping and clustering, which is grounded in a normalised word co-occurrence matrix and a similarity measure that quantifies the strength of associations between terms [25]. By exploiting citation data and bibliographic coupling, *VOSviewer* creates clusters based on authors' keywords, countries, and institutions, illustrating the concentration of documents, keywords, and institutional involvement in specific studies. Furthermore, primary data extracted from Scopus in CSV format were analysed using *Microsoft Excel* 2019.

Additionally, *Biblioshiny* a tool within the *Bibliometrix R* package, was employed to conduct thematic evaluation mapping in this research.

Next, we analyse data that split into two parts of analysis Figure 2 shows the various stages and analyses conducted throughout this investigation. Lastly, the result and discussion sections, this study has been split into three parts of result: descriptive analysis, network analysis and thematic evaluation.

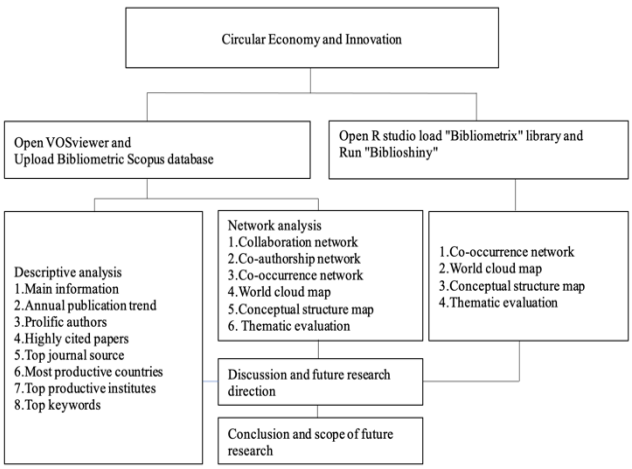

Figure 2. Step of bibliometric analysis

3. RESULT

3.1 Descriptive analysis

This section examines the research profile of circular economy and innovation from 2016 to 2024. As summarized in Table 1, current publication data, research trends, the most productive authors, frequently cited papers, publication sources, the most productive institutions and countries, and author keywords are taken into account.

Table 1. A summary of bibliographic information related to the circular economy and innovation

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2016:2024
Sources (Journals, Books, etc)	233
Documents	401
Annual Growth Rate %	61.38
Document Average Age	2.21
Average citations per doc	20.82
References	22,248
DOCUMENT CONTENTS	
Keywords Plus (ID)	1,713
Author's Keywords (DE)	1,093
AUTHORS	
Authors	1,293
Authors of single-authored docs	46
DOCUMENT TYPES	
article	255
book	3
book chapter	61
conference paper	45
editorial	5
erratum	1
note	3
review	27
short survey	1

3.1.1 Annual publication trends

The analysis of yearly publication trends considered total publications, total citations, citations per article, and citations per year for articles published between 2009 and 2024. Table 2 and Figure 3 illustrate the annual publication trends in the circular economy and innovation. Notably, the number of publications increased significantly from 30 articles in 2020 to 92 articles in 2024, indicating a dramatic upward trajectory in research output post-2020. It indicates evidence of a growing global attraction in academic discourse on the circular economy as a means to convert production and consumption models into more sustainable ones. Scholars are progressively investigating circular economy practices in the context of the COVID-19 pandemic, exploring them as a pathway to building more resilient economic models. Besides, advancements in research methods and publication processes have facilitated the dissemination of findings. This flow in scholarly output is also driven by enhanced collaboration among researchers from diverse areas, fostering a dynamic exchange of ideas.

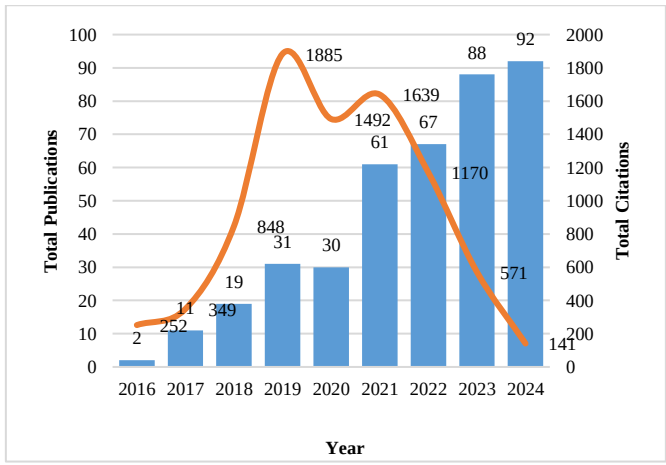

Figure 3. The annual publications trend

Table 2. Yearly publications trend

Year	Total Publications (TP)	Total Citations (TC)	Citation per paper (C/P)	Citations per year (C/Y)
2016	2	252	126.00	9
2017	11	349	31.73	8
2018	19	848	44.63	7
2019	31	1885	60.81	6
2020	30	1492	49.73	5
2021	61	1639	26.87	4
2022	67	1170	17.46	3
2023	88	571	6.49	2
2024	92	141	1.53	1

3.1.2 Most productive authors

To figure out the most impactful authors in the circular economy and innovation domain, metrics such as total publications, total citations, and the h-index were analysed. A total of 49 individual authors contributed to this research area from 2016 to 2024. Table 3 highlights the seven most prolific authors, with S. Sehnem having the highest output, totalling 7 publications, 117 citations, and an h-index of 4.

3.1.3 Highly cited papers

Table 4 presents the top 20 most cited papers, including authors, publication year, total citations, citations per year, and journal names. The paper titled "Lost in Transition? Drivers and Barriers in the Eco-innovation Road to the Circular Economy" by de Jesus and Mendonça [27] received a total of 669 citations, averaging 95.57 citations per year. It was followed by "Business Model Innovation for Circular Economy and Sustainability: A Review of Approaches" [28], which garnered 647 total citations and an average of 107.83 citations per year, and "Digital Technologies Catalysing Business Model Innovation for Circular Economy—Multiple Case Study" [29], with 261 total citations and 65.25 citations per year.

Table 3. Most productive authors in the circular economy and innovation research

Authors Name	Total Publications (TP)	Total Citations (TC)	H-Index	PY Start
Sehnem, S.	7	117	4	2022
Aarikka-Stenroos, L.	6	399	5	2020
McAloone, T.C.	5	938	4	2019
Mendonça, S.	5	1095	5	2016
Pigosso, D.C.A.	5	938	4	2019
Pieroni, M.P.P.	4	755	4	2019
de Jesus, A.	4	1084	4	2016

Table 4. Most highly cited documents published in the circular economy and innovation research

Author Name (year)	TC	TC per year	Title of the Paper	DOI
de Jesus & Mendonça (2018)	669	95.57	Lost in Transition? Drivers and Barriers in the Eco-innovation Road to the Circular Economy	10.1016/j.ecolecon.2017.08.001
Pieroni et al., (2019)	647	107.83	Business model innovation for circular economy and sustainability: A review of approaches	10.1016/j.jclepro.2019.01.036
Ranta et al., (2021)	261	65.25	Digital technologies catalyzing business model innovation for circular economy—Multiple case study	10.1016/j.resconrec.2020.105155
de Jesus et al., (2016)	251	27.89	Eco-innovation in the transition to a circular economy: An analytical literature review	10.1016/j.jclepro.2017.11.111
Chiappetta et al., (2020)	235	47.00	Stakeholders, innovative business models for the circular economy and sustainable performance of firms in an emerging economy facing institutional voids	10.1016/j.jenvman.2020.110416
Cainelli et al., (2020)	231	46.20	Resource efficient eco-innovations for a circular economy: Evidence from EU firms	10.1016/j.respol.2019.103827
Suchek et al., (2021)	211	52.75	Innovation and the circular economy: A systematic literature review	10.1002/bse.2834
Hysa et al., (2020)	211	42.20	Circular economy innovation and environmental sustainability impact on economic growth: An integrated model for sustainable development	10.3390/SU12124831
Smol et al., (2017)	199	24.88	Circular economy indicators in relation to eco-innovation in European regions	10.1007/s10098-016-1323-8
Demirel & Danisman (2019)	184	30.67	Eco-innovation and firm growth in the circular economy: Evidence from European small- and medium-sized enterprises	10.1002/bse.2336
Blomsma et al., (2019)	183	30.50	Developing a circular strategies framework for manufacturing companies to support circular economy-oriented innovation	10.1016/j.jclepro.2019.118271
Bao et al., (2019)	158	26.33	Procurement innovation for a circular economy of construction and demolition waste: Lessons learnt from Suzhou, China	10.1016/j.wasman.2019.08.031
Jakhar et al., (2019)	157	26.17	When stakeholder pressure drives the circular economy: Measuring the mediating role of innovation capabilities	10.1108/MD-09-2018-0990

Note (s): TC = Total citations

3.1.4 Most productive source titles

A total of 401 articles were published across various journals, Table 5 outlines the top source titles that published between 2016 and 2022. The journals Sustainability (Switzerland), Journal of Cleaner Production, and Business Strategy and the Environment emerged as the top three publishers, with 33, 25, and 18 publications, respectively, in the domain of circular economy and innovation, alongside total citations of 761, 1783, and 888.

Table 5. The most productive source title in the circular economy and innovation research

Source Name	TP	TC	h	PYS
Sustainability (Switzerland)	33	757	13	2018
Journal of Cleaner Production	25	1783	15	2016
Business Strategy and the Environment	18	888	10	2019
Research Handbook of Innovation for a Circular Economy	8	19	3	2021
Sustainable Production and Consumption	7	181	5	2021
Technological Forecasting and Social Change	6	213	4	2020
Journal of Innovation Economics and Management	6	31	3	2022
Energies	6	104	5	2021
IEEE Transactions on Engineering Management	5	9	2	2024
Sustainability (Switzerland)	5	4	1	2023
Resources, Conservation and Recycling	5	395	5	2019

Note (s): TP = Total publications; TC = Total citations; h=h-index; PYS = Publication year start

3.1.5 Most productive countries

Following to the Scopus database, research documents on the circular economy and innovation were sourced from 79 countries, Table 6 lists the ten ranks of most productive countries, each contributing more than 20 papers. Among these, the United Kingdom stands out as the most productive, with 55 articles (8.49%), followed closely by Italy with 53 articles (8.18%). China and France each contributed 29 articles (4.48%), while Spain published 28 articles (4.32%). These findings indicate a heightened focus on the circular economy and innovation research in these countries compared to others.

Table 6. Most contributing countries of circular economy and innovation research

No.	Country	Total Publication	Percentage
1	United Kingdom	55	8.49
2	Italy	53	8.18
3	China	29	4.48
4	France	29	4.48
5	Spain	28	4.32
6	India	27	4.17
7	Brazil	26	4.01
8	United States	23	3.55
9	Germany	22	3.40
10	Netherlands	20	3.09

3.1.6 Most prolific institutions

Table 7 lists the twelve institutions with the highest output related to the circular economy and innovation research. The Technical University of Denmark and Universidade Nova de Lisboa were the leading institutions, each contributing 7 articles. Universidade do Oeste de Santa Catarina and Tampere University followed with 6 publications each. Collectively, these twelve institutions accounted for 66 articles, representing 16.41% of total publications, indicating a concentrated contribution to the field.

Table 7. Most productive institutions

No.	Affiliation	Total Publication
1	Technical University of Denmark	7
2	Universidade Nova de Lisboa	7
3	Universidade do Oeste de Santa Catarina	6
4	Tampere University	6
5	Silesian University of Technology	5
5	Università degli Studi di Torino	5
5	Universidade do Sul de Santa Catarina	5
5	University of Sussex	5

3.1.7 Author keywords analysis

In bibliometric analysis, a word cloud of authors' keywords serves as a visual representation of the most frequently employed terms within an article's keywords, facilitating the identification of prevailing themes in an author's research. The size of each term in the cloud corresponds to its frequency of occurrence. Figure 4 presents the word cloud map of authors' keywords in the circular economy and innovation research, revealing that "circular economy," "innovation," "sustainable development," "recycling," and "waste management" are consistently core research topics. This analysis indicates a relationship among sustainability, innovation, sustainable development, and circular economy, underscoring the interconnected nature of these concepts in research.

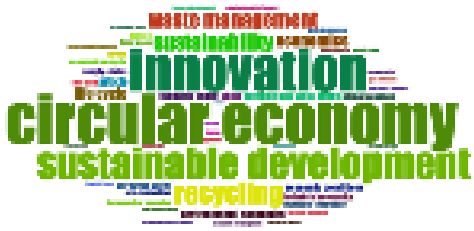

Figure 4. Word cloud by author's keywords

3.2 Network analysis of the circular economy and innovation research

Bibliometric mapping analysis method for identifying specific research fields and gaining a comprehensive understanding of the study area's structure, including its themes, topics, terminology, and their interconnections. *VOSviewer* software can utilises a comprehensive approach that integrates clustering and mapping, primarily relying on standardised term co-occurrence to assess the strength of relationships between terms. Moreover, it serves as an effective instrument for conducting network research [15]. Also allows to visualise the conceptual landscape by colour-coding terms based on the year they first appeared in the scientific literature. The size of the font and surrounding rectangle indicates the popularity of the term; larger rectangles

and fonts indicate terms that appear more frequently. In this study, we used *VOSviewer* to visualize co-authorship and collaboration networks and *R Studio* to examine keyword co-occurrences and conduct a thematic assessment of the topic of circular economy and innovation.

3.2.1 Co-authorship analysis

The visualization of the co-authorship network revealed knowledge domain maps illustrating the principal author groups in the field of circular economy and innovation research. As depicted in Figure 5, each node represents an author, with the node size corresponding to the number of published articles. The links connecting nodes indicate the collaborative relationships between authors, with link thickness representing the strength of these associations. Insights derived from the co-authorship network can inform research institutions about potential collaboration opportunities, assist individual researchers in identifying areas for collaboration, and aid publishers in assembling editorial teams for special issues in journals or books. Figure 6 illustrates that collaboration among prolific authors is robust. The co-authorship network formed distinct groups, such as the red group, which includes Sehnem Simon (7 documents, 18 links), followed by Lopes de Sousa (3 documents, 16 links) in the orange group, with the red group serving as the core. The results suggest that most productive authors primarily engage in collaboration within the same organization, although such collaboration tends to be limited in scope, hindering effective international exchange and cooperation.

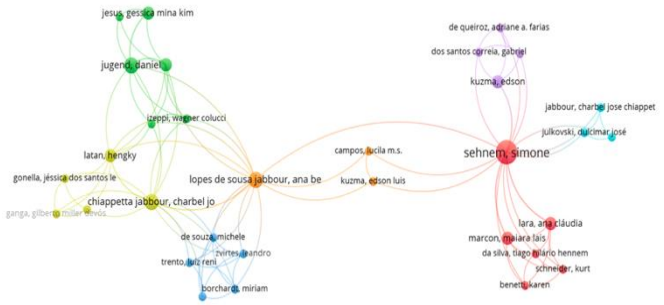

Figure 5. Co-authorship network among productive authors

3.2.2 Countries collaboration network

The network visualization map is shown in Figure 6, Collaboration through co-authorship was identified in 79 countries (minimum threshold value of 1 document). The thickness of the connecting lines reflects the frequency of co-authorship between countries, The map indicates a satisfactory collaboration network, particularly among the United Kingdom, Italy, France, India, China, Spain, the United States, Brazil, Norway, Germany, and Portugal. Notably, the United Kingdom demonstrated extensive collaboration with countries across Europe, Asia, and North America, achieving the highest citation count of 2,847, along with 79 links and 56 documents. Conversely, countries such as Jordan, Tunisia, Singapore, Peru, New Zealand, Namibia, Luxembourg, Lebanon, Kenya, and Ghana exhibited less collaboration with other nations. This highlights two significant implications: firstly, it facilitates a more nuanced exploration of research topics; and secondly, it opens avenues for collaboration with new countries, encouraging engagement among researchers and institutions in these areas.

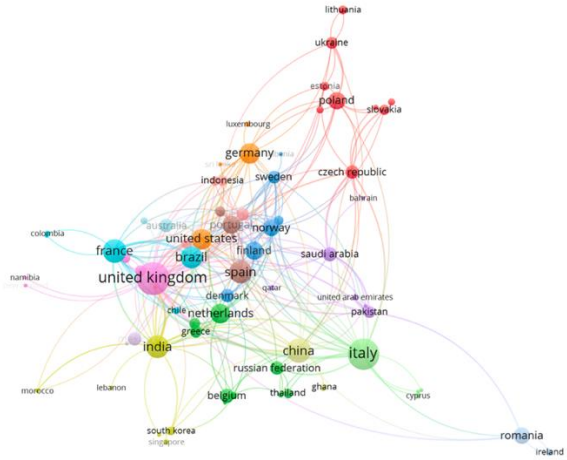

Figure 6. Co-authorship collaboration network among countries

3.2.3 Keyword co-occurrence network

Keywords serve as the focal point of publications, and the objective of keyword analysis is to identify significant research compositions in these fields. A network depicting the co-occurrence of keywords utilised by authors was employed to illuminate the research topics pertinent to this domain. This approach highlights frequently used keywords, represented by larger font sizes and circles. The lines connecting keywords reflect their degree of association [30]. For clarity, associated keywords are often grouped by colour. The absence of lines between keywords indicates a lack of established connections. Terms positioned closer to the centre of the network diagram signify a higher degree of co-occurrence, implying a stronger correlation.

To investigate associated keywords in the circular economy and innovation research, Figure 8 identifies three thematic clusters: (i) Circular Economy, (ii) Innovation, and (iii) Recycling and Waste Management, each represented in distinct colours. The circular economy cluster occupies the centre of the network, indicating it is a significant theme explored by prior scholars. Each colour corresponds to a group of related concepts, illustrating how different aspects of the circular economy are interlinked (Figure 7).

1. Red Cluster keywords: circular economy, sustainable development, economics, economic and social effects, economic growth, government, investments, and decision making. This cluster examines circular economy, economics and society. It emphasises economic growth, policy, and government involvement in the sustainable development. Investment and technical innovation are linked, demonstrating how financial and regulatory support are essential for the circular practices.

2. Green Cluster keywords include waste management and environmental impact keywords include municipal solid waste, food waste, plastic waste, greenhouse gases, gas emissions, carbon, and life cycle. The green cluster focuses on waste management and the environment. It discusses municipal solid waste, plastic trash, greenhouse gas emissions, and carbon management. This cluster is crucial to understand how waste disposal and life cycle analysis support the circular economy.

3. Yellow Cluster keywords include innovation, eco-innovation, recycling, economic conditions, strategic strategy, and social innovation. This cluster emphasises innovation in the circular economy practises. Eco-innovation links

sustainable technology and process innovations to economic conditions and strategy. The integration of social innovation emphasises societal change in the circular practices.

4. Blue Cluster keywords include business model innovation, business models, environmental sustainability, business development, technology advancement, supply chains, and manufacturing. The blue cluster covers business models and circular economy technology. Innovation in business models like product-as-a-service or supply chain optimisation can improve sustainability and economic performance.

5. Grey Cluster includes product design, production, open innovation, and technology innovation. This smaller cluster emphasises the circular economy product design and manufacturing. It links product design to technology and open innovation, claiming that the circular concepts are essential for sustainability.

6. At the network's centre, the circular economy and sustainable development appear as the most connected and fundamental themes. These phrases link economic, environmental, and social components of the circular economy framework, placing them in the centre of all other concepts. The keyword of circular economy is superposed on sustainable development, technological innovation, economic, supply chain, government, open innovation and economic and social effect representing the closeness among them. Furthermore, in the second network of the innovation, the linked keywords are sustainability, eco-innovation and environmental economics. The third link is recycling and waste management, the linked keywords are life cycle, carbon, municipal solid waste, food waste and greenhouse gases. This analysis highlights the importance of the circular economy and innovation research and has proven the field as an emerging field.

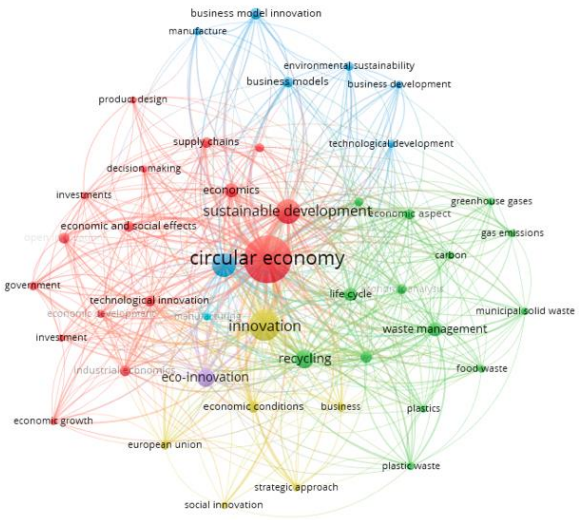

Figure 7. Author's keywords co-occurrence analysis

3.3 Thematic evaluation

Biblioshiny software was used to analyse the author's keywords of the circular economy and innovation research and evaluate the main research topics from 2016 to 2022.

Figure 8 provides an overview of current research and future trends in the circular economy and innovation, as illustrated by the themes in the four quadrants. The Motor Themes are the driving forces in this field, highlighting areas that are both well-researched and critical to the implementation of circular economy practices. Topics such as waste management, food waste, carbon management, and greenhouse gases are not only mature but also pivotal in advancing the circular economy. The Niche Themes represent specialised areas that, while not widely applicable, are important within specific contexts. For instance, the construction industry, ecosystem management, and wastewater treatment are essential within certain sectors, even if they may not be as broadly relevant to the circular economy as a whole. The Basic Themes form the foundation of the circular economy, representing essential concepts that are widely applicable but may require further development or research. Core topics like the circular economy itself, sustainable development, and environmental economics are fundamental to the field, indicating their broad importance but also suggesting that more detailed work is needed to advance in these areas. The Emerging could either be new areas that are just beginning to gain traction or older topics that are becoming less relevant. In this case, themes related to business model innovation and manufacturing may represent emerging areas of interest within the circular economy that are still in the early stages of research or practice.

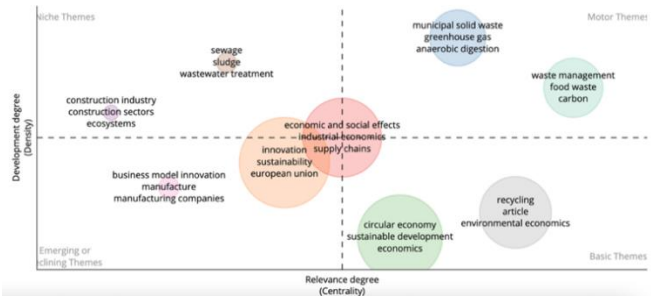

Figure 8. The strategic thematic map based on author's keywords

The conceptual structure map, derived from Multiple Correspondence Analysis (MCA) and shown in Figure 9, illustrates two key groups, each represented by different colours, which direct the logical construct of the circular economy and innovation studies. The Red group focuses on themes related to business models and innovation within the circular economy, with particular emphasis on collaboration and upcycling. The close relationship between collaboration and open innovation suggests that successful circular business models often rely on these collaborative efforts and practices. Upcycling further highlights the importance of adding value to waste materials as part of these models, aligning with the overall goal of sustainability. The Blue group is broader, encompassing a wide range of concepts related to the circular economy, eco-design, and sustainable practices. The presence of terms like SMEs (Small and Medium-sized Enterprises), resource efficiency, and eco-design suggests that this cluster emphasizes the practical implementation of circular economy principles, particularly in smaller businesses and through design practices. The inclusion of environmental sustainability and innovation underscores the strong focus on these areas as drivers of the circular economy, further supported by related concepts like waste management, recycling, and eco-innovation. The positioning of SMEs and resource efficiency indicate that these are crucial elements for achieving sustainable business practices, especially in smaller enterprises.

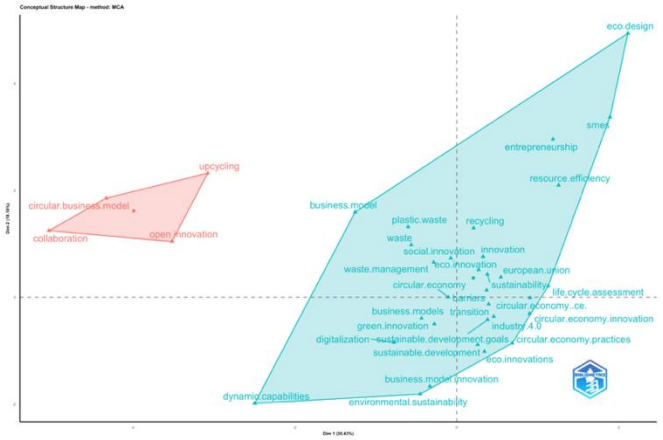

Figure 9. Conceptual structure map based on author's keywords

4. DISCUSSION AND FUTURE RESEARCH DIRECTION

Regarding the significance findings reveal the diverse features of research contributions within a certain topic, providing as a guide for researchers aiming for high-impact production. This study focused on papers related to the circular economy and innovation from the Scopus database. The total count of published documents in this category was 401, acquired by a specified search query. Literature has examined the implications of circular economy and innovation, including waste management, sustainable development, technological innovation, economic, supply chain, government, open innovation and economic and social effect.

Furthermore, publications on the circular economy and innovation have shown a (steady rising pattern year until 2021 and beyond). Despite developments in the field, there remain areas for research that future investigations may explore. The papers were disseminated in over 79 countries, with the United Kingdom emerging as the foremost contributor; however, Italy, China, and France also played significant roles during the developmental phases.

While our analysis shows the key theme for future research trends Figure 10 offers a framework of circular economy and innovation roadmap. Also, it highlights future research trends in the circular economy (CE) and innovation, and it has four key components: innovation business models, circular economy practices, sustainable development goals (SDGs), and ecological-friendly approaches.

Firstly, research trends in the innovation business models focus on developing business models that integrate eco-friendly innovations and design processes [31]. Companies and industries need to rethink traditional business practices, incorporating eco-design principles to create products with minimal environmental impact. Lifecycle assessments (LCAs) are crucial for evaluating the environmental effects of products from creation to disposal. Furthermore, cleaner production techniques emphasize reducing resource usage and waste in manufacturing processes, leading to more sustainable industrial systems [32, 33]. Future research will likely focus on enhancing these methods and creating frameworks for applying them at a larger scale across industries.

Secondly, circular economy practices trends will focus on optimizing circular economy practices that address the key environmental challenges, such as water resource management, food waste reduction, and carbon emissions mitigation. These practices aim to close resource loops and minimize waste by reusing and recycling materials within production cycles [33, 34]. For example, innovative water management solutions could address both water conservation and pollution issues.

In addition, tackling greenhouse gas (GHG) emissions and carbon footprint reduction is a significant part of the circular economy, requiring advancements in low-carbon technologies and carbon-neutral processes. Food waste management research will likely explore new ways to reuse and repurpose organic waste in sustainable ways, including biogas production and composting [35]. Thirdly, research in the area of sustainable development goals (SDGs) aligned with the United Nations' SDGs, focusing on the integration of sustainable practices within both economic and social systems [36]. The circular economy aims to achieve sustainable development by balancing environmental sustainability with the economic growth and social equity. Research might explore how the CE can support diverse SDGs, such as responsible consumption and production, climate action, and reduced inequalities. Additionally, economic research will look at the cost-benefit analysis of adopting circular practices at a systemic level and how they can be scaled to benefit developing economies, while addressing social issues like job creation, fair labour practices, and community well-being [37].

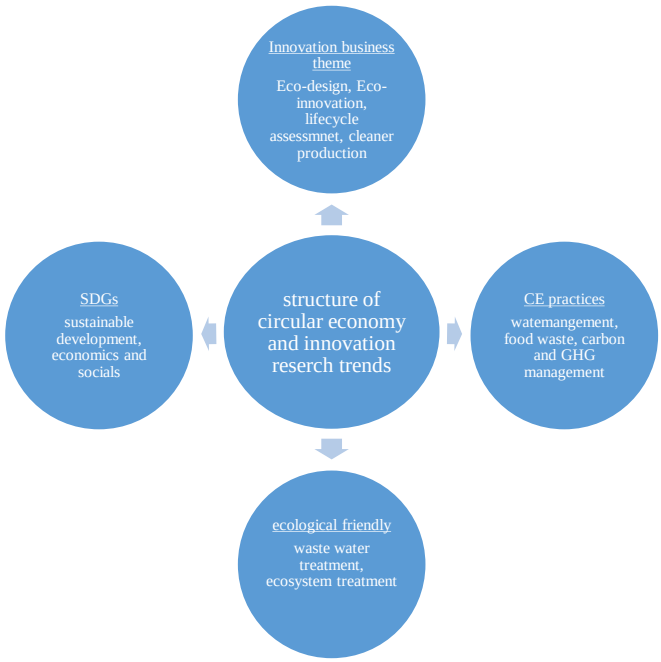

Figure 10. A structured framework for circular economy and innovation research

The last component is ecologically friendly approaches will emphasize the development of wastewater treatment technologies that not only purify water but also recover valuable resources like nutrients and energy. Ecosystem treatment involves strategies for reducing pollution and restoring biodiversity, aligning with ecological sustainability [38]. Future research could explore the application of nature-based solutions and bioengineering techniques for ecosystem

restoration, as well as how these strategies can be integrated into urban and industrial settings to promote sustainability.

The following implications could guide researchers, policymakers and managers to sustain their businesses and countries and could make a significant impact on the global environment

(i) Development of sustainable business models such as product-as-a-service and leasing systems, support the transition to a circular economy by creating value through extended product life cycles and resource efficiency.

(ii) Technological advancements for waste valorisation by exploring role of emerging technologies like blockchain, and IoT in optimizing resource recovery, waste tracking, and recycling processes in CE frameworks.

(iii) Product design and innovation, such as modularity and recyclability, enable circularity by reducing material waste and enhancing product reusability and reparability.

(iv) Collaborative innovation networks like cross-industry collaborations and partnerships in fostering innovation for circular economy practices, including closed-loop supply chains and reduce GHG emissions

(iv)Policy and regulation-induced innovation such as government incentives on stimulating innovation in waste reduction, sustainable materials, and circular supply chains.

(vi) Digital transformation for Circular Economy like 3D printing, advanced analytics, and digital twins foster innovation in designing and managing circular systems in manufacturing and logistics.

5. CONCLUSIONS

The findings of the study make a significant contribution to the existing body of knowledge by shedding light on the current research trends in the fields of circular economy and innovation. A total of 401 papers on these topics were analysed, employing *VOSviewer* software to construct a scientific mapping and R software for thematic evaluation. The research explores key characteristics and dynamic trends within the literature, including the most prolific authors, collaborative networks, leading countries, and prominent institutions. Additionally, the study identifies the journals that have published the most research and provide insights into the state of knowledge generation, particularly in terms of co-occurrence, collaboration, and co-authorship patterns in the circular economy and innovation studies.

Finally, this study highlights thematic evaluations and presents thematic maps as a guideline for future research such as the Development of sustainable business models, Technological advancements for waste valorisation, Product design and innovation, Collaborative innovation networks, Policy and regulation-induced innovation, and Digital transformation for Circular Economy. The findings of this research are expected to assist scholars in identifying gaps within the field of the circular economy and innovation by extending and delving into specific innovations that can circularity in various, whether service or industrial operations. The limitation of this study is the exclusive reliance on the Scopus database as the primary source for document retrieval. Although Scopus is comprehensive database for scholarly works, it still has limitations in its coverage. Future studies would benefit from incorporating additional databases for example WoS etc., as integrating multiple databases is likely to enhance the widely and significance of outcomes.

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