EXPLORING CIRCULAR ECONOMY INSIGHTS TOWARDS SUSTAINABLE DEVELOPMENT: A BIBLIOMETRIC ANALYSIS

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Abstract: *The circular economy is one of the most important topics in addressing the world's environmental problems, aiming to achieve a sustainable future. We are witnessing an increase in awareness of the need to use circularity principles and in the degree of implementation of the circular economy practices by both the business environment and the society in response to the policies practiced by public authorities, mainly in the European Union and China. The need for research on this topic stems from the momentum the concept has gained over the last decade. Using VOSviewer software, our research consists of a bibliometric analysis based on a sample of 9,912 articles published in the last decade, extracted from the Web of Science database. The objective of our analysis is to provide answers regarding the interest in investigating the topic of circular economy in the context of achieving sustainable development. Countries like Italy, China, and England hold the supremacy in terms of the number of papers published and total number of citations, highlighting their important role in research and advancements of the analyzed topic. Researchers from these countries are also heavily engaged in international collaborations with authors from other countries. A few journals dominate regarding the number of publications on this topic and the number of citations of publications, namely the Sustainability journal, the Journal of Cleaner Production, Business Strategy and the Environment journal, and the Resources Conservation and Recycling journal. The research directions in the field can be highlighted through the main themes targeted that, according to our results, are life cycle assessment, recycling, waste management, industry 4.0, environmental sustainability, business models, bioeconomy, innovation, industrial ecology, industrial symbiosis, climate change, and supply chains. We can also highlight the multidisciplinary character of the concept of the circular economy and, consequently, the widespread research directions, with the most papers published in areas like Environmental Sciences Ecology, Science Technology, Engineering, Business Economics and Energy Fuels.*

Keywords: *circular economy; sustainable development; bibliometric analysis.*

JEL Classification: *Q01; Q56*

1. Introduction

The planet Earth is over 4.5 billion years old, during which time it has undergone continuous transformations. Initially, it was a burning inferno without even an

atmosphere, and now we find it as a life-sustaining planet with continents and oceans (Becker, 2014). However, as the planet is in constant flux, the way humanity acts is a subject for analysis. The concepts of sustainable development and sustainability are always relevant, being frequently associated with the circular economy, which addresses the need to minimize humanity's influence on the planet's changes. In response to the global environment challenges in 2012, within a memorandum prepared by members of the European Resource Efficiency Platform, part of the European Commission, the need to implement a system based on regeneration and resource efficiency called the circular economy is discussed, characterized by a systemic change in the way resources are used and recovered, resulting in a reduction in dependence on imports (European Commission, 2012). Therefore, a relationship between the circular economy, including its instruments, and improving sustainability can be highlighted, as Maeder and Fröhling (2024) agree upon.
The objective of our study is to explore, through a bibliometric approach, the interest of researchers regarding the analysis of how the circular economy is linked to achieving sustainable development.

2. Theoretical background

The inspiration for the concept of the circular economy can be considered the cycles found in nature, such as the water cycle or nutrient cycles, based on the principle that elements useless to some become resources for others (Stahel, 2016).
Pearce and Turner (1990) published a book whose main subject is the economics of resources and the environment, with the second chapter titled "The Circular Economy." Even though it was a concept in its early stages, the authors delve into the relationship between the environment and the economy.
Despite the fact that the term circular economy is not explicitly mentioned in this form, the principles on which it is based appear frequently in works over time. For example, the principle of the closed-loop economy is mentioned by various authors (Lowe, 1993; O'Rourke, Connelly and Koshland, 1996; Ehrenfeld and Gertler, 1997), even if in connection with other concepts such as industrial ecology and environmental protection, as Yuan, Bi and Moriguichi (2006) also note that the circular economy is based on concepts such as cleaner production, industrial ecology, and ecological modernization. Thus, even if, terminologically, it is a new concept, the circular economy adopts some principles from concepts that existed before.
Defining and explaining conceptually the circular economy generally involves invoking the principles on which it is based. Kirchherr, Reike and Hekkert (2017) claim that it is "an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes" to achieve sustainable development for the purpose of creating a better environment, a prosper economy and equity in the society.
Murray, Skene, and Haynes (2015) describe the circular economy as one that has no net environmental impact, while also facilitating the regeneration of natural resources through extraction and ensuring production that generates minimal waste.

Zink and Geyer (2017) describe the circular economy as an approach focused on closing material loops to keep products, components, and materials circulating within the industrial system, thereby maximizing their utility.
Prieto-Sandoval, Jaca, and Ormazabal (2018) identify four key components of the circular economy:

- the continuous circulation of resources and energy through waste valorization and the reduction of resource demand;
- an approach implemented across multiple levels;
- the importance in achieving sustainable development;
- the close relationship with innovation.

Some authors consider the fundamental goal of the circular economy to be the decoupling of the pressure exerted on the environment from economic growth (Ghisellini, Cialani and Ulgiati, 2016). This approach can be further developed by decoupling economic growth from resource use (Pauliuk, 2018) and, consequently, maximizing their use and minimizing waste.
Cullen (2017) develops this idea, suggesting that the adoption of the circular economy will lead to a decrease in environmental impact by reducing resource use, but at the same time will facilitate the achievement of desired economic growth without resource depletion.
The principle of closing loops, circuits, or material flows represents the foundation of the circular economy concept, as mentioned by several authors (Stahel, 2010; Kirchherr, Reike, and Hekkert, 2017; Zink and Geyer, 2017; Geissdoerfer et al., 2018). Creating a system based on the circular economy involves the participation and effort of all actors in economic life: the business environment, consumers, and authorities (Lakatos et al., 2021). However, the success of achieving the environmental and economic objectives of the circular economy cannot be realized without the active participation of companies (Briguglio et al., 2021), which should develop products based on the principles of circularity, encourage education programs on the circular economy, and provide professional training for their own employees (Trevisan et al., 2023). At the social level, a significant change would be needed in the way individuals and collectives interact with nature, a change that must be profound and governed by principles such as care and respect for nature, and not by a relationship that denotes only its utilization (Nesterova and Buch-Hansen, 2023).
The practical way to close loops, circuits, or material flows is considered to be the application of the 3R concept. Adopting the principles of the circular economy offers assistance to decision-makers for the application of the concept. Specifically, the 3R concept is an instrument that is applied in the production and for optimizing the supply chain, by allocating resources at lower costs and generating minimal waste, concurrently with a high degree of reuse, remanufacturing, and recycling (Shabanpour et al., 2024).
This concept is one of the foundations of the circular economy model, with waste generated by economic activity being the primary focus of attention. Particular attention is paid to municipal waste, considered crucial in the foundation of the circular economy by Wang et al. (2023).
Stahel (2016) speaks of changing economic logic through the use of the circular economy and consequently replacing production with sufficiency using the 4R:

- reusing goods as much as possible;
- recycling goods that cannot be reused;
- repairing goods that are damaged;
- remanufacturing damaged goods that cannot be repaired.

Another practical way of implementation materializes in one of the strategies promoted at the European Union level and refers to products with high circularity potential, Product-as-a-Service, for improving durability, reuse, upgradeability, and reparability (Golinska-Dawson, Zysnarska and Pender, 2024), in which after-sales maintenance and repair services gain particular importance.
This strategy is considered preferable to remanufacturing, reconditioning, or recycling because it has a higher degree of circularity through its potential to maximize resource efficiency and productivity, as well as the use cycle of the good without the need for material recovery, having a beneficial impact on sustainability (Carissimi, Bin Hameed, and Creazza, 2024).
The involvement of authorities is also desirable through a re-evaluation of existing policies, the identification of legislative gaps, and the creation of a clear regulatory framework, even cross-border cooperation, to facilitate the implementation of circular economy practices (Mubarik, Kontoleon, and Shahbaz, 2024). A systemic approach is necessary, with circular economy policies and strategies being treated as a whole, not at an individual level (Carissimi, Bin Hameed, and Creazza, 2024).
Given the complexity of the circular economy concept and the high number of relationships with other concepts due to its wide scope, including the relationship with sustainable development and sustainability, the research of this concept has recently gained momentum, being analyzed from all perspectives, as will be seen in the study conducted based on bibliometric analysis.

3. Research methodology

Bibliometric analysis is based on quantitative techniques designed to facilitate performance analysis, on the one hand, and science mapping, on the other (Donthu et al., 2021). The objective of our study is to explore, through a bibliometric approach, the interest of researchers regarding the analysis of how the circular economy is linked to achieving sustainable development. Our scientific approach aims to generate answers to the following research questions:

RQ1. What is the evolution of the interest in investigating the circular economy topic in the context of achieving sustainable development?
RQ2. What countries have the highest productivity and impact in scientific research regarding the analysis of how the circular economy is linked to achieving sustainable development?
RQ3. What journals are the most influential, considering the scientific productivity and impact on the analyzed topic?
RQ4. What publications are the most cited in the analyzed topic?
RQ5. What are the international country collaborations in research publications on the topic of circular economy in the context of achieving sustainable development?

RQ6. What are the most relevant concepts, themes, and clusters for research on the circular economy-sustainable development topic?

Therefore, the Web of Science database was investigated to pursue our objectives. The database query was performed on March 29, 2025. The search process included several steps. The first step for dataset generation was a database search, considering the topic criteria which, for Web of Science, implies searching words in the title, the abstract, keyword plus, and author keywords of the documents. We aimed to ensure that our search would identify the most relevant articles to achieve the objectives of our study. The following search query was used:
("circular econom*" OR "circular* principles" OR "circular strateg*" OR "circular business*") AND ("sustainable development" OR "sustainable economic development" OR "sustainable development goals" OR "SDGs" OR "sustainability" OR "2030 Agenda for Sustainable Development")

We used the "*" symbol so that our search would also generate results for words that are part of the same word family. For example, searching for "circular econom*" will find phrases like "circular economy" but also "circular economic", or searching for "circular strateg*" will find phrases like "circular strategy" or "circular strategies".
Our analysis focused on scientific research from the last decade. Also, we excluded articles from 2025, limiting our horizon to 2024, the last completed year for publications. Then, in the second step of generating the dataset, we applied a series of refinements based on different criteria. We limited the document types to "Article" and "Proceeding Paper" categories, excluding categories like reviews, books, book chapters etc. Then, we restricted our search to articles that were published in English. Regarding the research category, after analyzing the relevance of documents from various categories, we decided to keep all categories in our analysis. This was expected since the analyzed theme has a multidisciplinary character, and the research is not limited to a certain direction. After applying all the refinement criteria, a dataset of 9,912 articles resulted.
Our analysis was facilitated using VOSviewer (version 1.6.20), a specialized software for carrying out a bibliometric investigation.

4. Results and discussions

To achieve the objectives and provide answers to the proposed research questions, we conducted a series of analyses of the articles that made up our selection, the results being presented in the following.
In the first part of our analysis, we aimed to see what the interest is in investigating the topic of circular economy in the context of achieving sustainable development (RQ1). In this sense, Figure 1 presents the evolution of the number of publications from our dataset, written on this topic, from the last decade. A significant increase in annual productivity is noted in terms of articles published on the analyzed topic. Therefore, from 52 papers published in 2015, in 2024, the fabulous number of 2,493 articles was reached. Seeing this annual evolution of publications, it becomes obvious that the circular economy subject is of great interest, and its contribution to sustainable development is being explored from all aspects.

The increased research interest in this field is due to the complexity of the concept as well as the fact that circular economy has become the subject of the main policies supported by important international actors like China, since 2008, through Circular Economy Promotion Law (President of the People's Republic of China, 2008) but also the European Union, since 2015, through The Action Plan for the Circular Economy (European Commission, 2015).

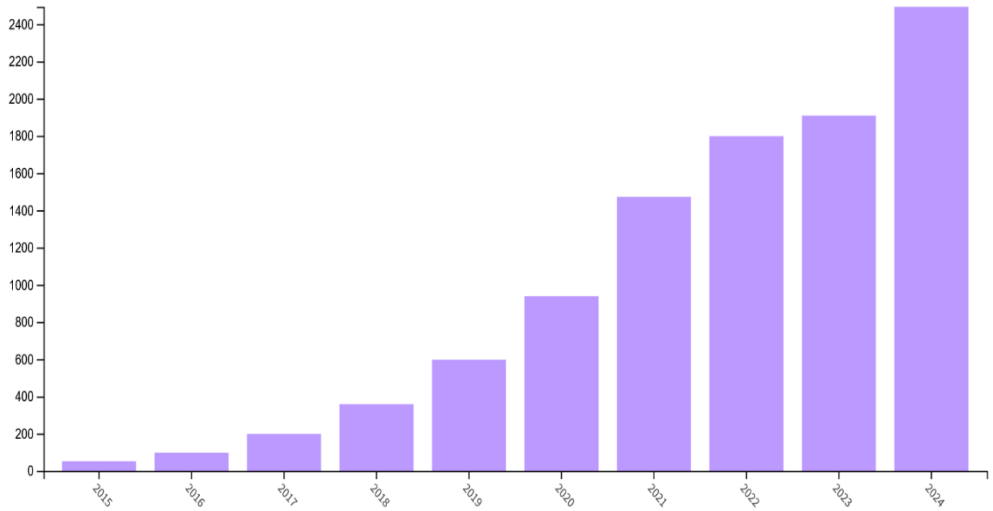

Figure 1: The evolution of the yearly output of publications on the topic of the link between the circular economy and achieving sustainable development
Source: retrieved from Web of Science

The distribution of the articles in the dataset by research areas reveals that most belong to Environmental Sciences Ecology (4,652 records representing 46.933% of the total records), Science Technology Other Topics (3,487 records representing 35.180% of the total records), Engineering (3,108 records representing 31.356% of the total records), Business Economics (1,527 records representing 15.406% of the total records), and Energy Fuels (578 records representing 5.831% of the total records).
A more detailed distribution of the number of articles in the dataset by research areas, containing the first 20 records, can be viewed in Figure 2.

Figure 2: The distribution of the number of articles according to research areas
Source: retrieved from Web of Science

The analysis continued with identifying countries that are the most productive and impactful in the scientific research of the topic addressed in this study (RQ2). The countries that published the highest number of papers regarding circular economy in the context of achieving sustainable development are Italy (1390 documents representing 14.023% of the total records), China (1093 documents representing 11.027% of the total records), England (966 documents representing 9.746% of the total records), Spain (933 documents representing 9.413% of the total records), and India (775 documents representing 7.819% of the total records).

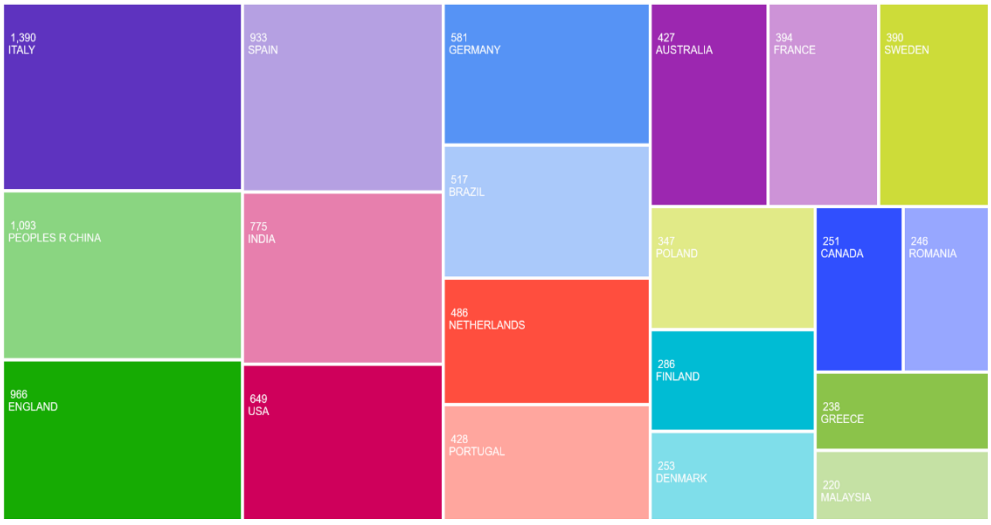

Figure 3: The productivity of countries based on the number of publications
Source: retrieved from Web of Science

The importance of countries, based on the impact of the publications, is measured according to the number of citations. Our analysis reveals that documents from England are the most cited (41,331 citations), followed by Italy (30,213 citations), China (27,081 citations), the Netherlands (20,603 citations), and the USA (19,153 citations).

Table 1: The number of citations by country

Country	Number of citations	Documents
England	41331	966
Italy	30213	1390
China	27081	1093
Netherlands	20603	486
USA	19153	649
Spain	18556	933
India	17867	775
Sweden	15956	390
Germany	15040	581
Finland	13691	286

Source: Authors 'processing

Furthermore, our analysis focused on identifying the most influential journals, taking into account their scientific productivity and impact on the analyzed topic (RQ3). Most of the papers were published in the Sustainability journal, followed by the Journal of Cleaner Production and the Business Strategy and the Environment journal, as shown in Figure 4.

Figure 4: Top 10 journals by the number of published papers
Source: Authors 'processing

A journal's impact is measured by the total number of citations of the papers published in that journal. Table 2 presents the first 10 journals that are the most influential considering this criterion.

Table 2: Top 10 most influential journals

Rank	Journal	Total number of citations
1	Journal of Cleaner Production	40208
2	Sustainability	18137
3	Resources Conservation and Recycling	14618
4	Business Strategy and the Environment	9998
5	Sustainable Production and Consumption	5520
6	Ecological Economics	5316
7	Science of the Total Environment	4825
8	Journal of Industrial Ecology	3974
9	Journal of Environmental Management	3154
10	Waste Management	3006

Source: Authors 'processing

One important aspect that we wanted to know is the ranking of the first 10 most cited articles in our dataset (RQ4). Table 3 lists the hierarchy of the papers with the greatest impact, considering the total number of citations.

Table 3: The first 10 most cited papers

Title	Author(s), publication year	Journal	Total citations
Circular Economy: The Concept and its Limitations	Korhonen,J.; Honkasalo, A.; Seppälä, J. (2018)	Ecological Economics	1833
Product design and business model strategies for a circular economy	Bocken, N.M.P.; de Pauw, I.; Bakker, C.; van der Grinten, B. (2016)	Journal of Industrial and Production Engineering	1778
The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context	Murray, A.; Skene, K.; Haynes, K . (2017)	Journal of Business Ethics	1499
The E factor 25 years on: the rise of green chemistry and sustainability	Sheldon, R.A. (2017)	Green Chemistry	967
Barriers to the Circular Economy: Evidence From the European Union (EU)	Kirchherr, J.; Piscicelli, L.; Bour, R.; Kostense-Smit, E.; Muller, J.; Huibrechtse-Truijens, A.; Hekkert, M. (2018)	Ecological Economics	907

Title	Author(s), publication year	Journal	Total citations
Sustainable supply chain management and the transition towards a circular economy: Evidence and some applications	Genovese, A.; Acquaye, A.A.; Figueroa, A.; Koh, S.C.L. (2017)	Omega-International Journal of Management Science	859
The Relevance of Circular Economy Practices to the Sustainable Development Goals	Schroeder, P.; Anggraeni, K.; Weber, U. (2019)	Journal of Industrial Ecology	804
Circular economy as an essentially contested concept	Korhonen, J.; Nuur, C.; Feldmann, A.; Birkie, S.E. (2018)	Journal of Cleaner Production	792
Metrics of Green Chemistry and Sustainability: Past, Present, and Future	Sheldon, R.A. (2018)	Acs Sustainable Chemistry & Engineering	789
Blockchain technology and the sustainable supply chain: Theoretically exploring adoption barriers	Kouhizadeh, M.; Saberi, S.; Sarkis, J. (2021)	International Journal of Production Economics	659

Source: Authors 'processing

Figure 5 presents a layout of papers that received the most citations from the dataset identified according to the first author's name and publication year.

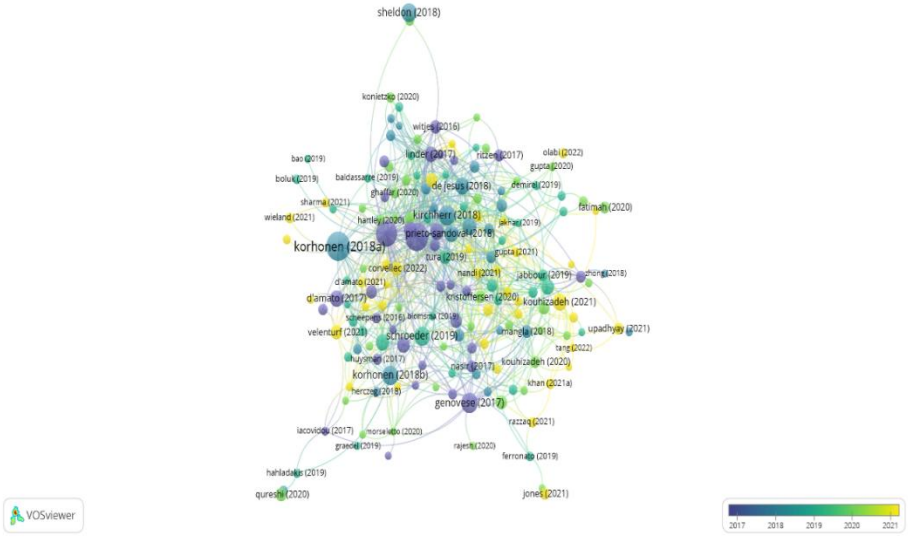

Figure 5: The most cited papers identified according to the first author's name and publication year
Source: Authors 'processing

Collaborative activities are crucial for enhancing research, facilitating the exchange of academic knowledge, and promoting the effective dissemination of research results. In our study, we aimed to illustrate the network map of co-authorship collaborations between countries in publishing research on the topic of the contribution of circular economy to sustainable development (RQ5). We set a minimum of 20 documents and 100 citations per country, and from 148 countries, 75 met the thresholds. The size of the dot indicates the country's contribution and relevance in publishing research papers on the topic analyzed in this study. The thickness of the line and the distance between dots indicate the level of collaboration between authors from different countries. Countries are grouped into 7 clusters, indicating closer collaborative communities. England, China, Italy, the USA, Spain, India, and Germany have engaged the most in international collaborations.

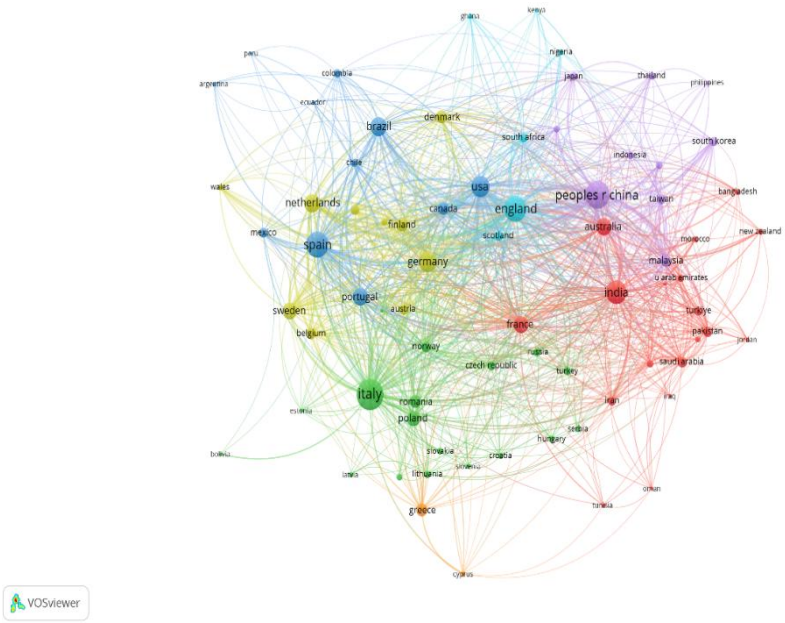

Figure 6: Country co-authorship network map
Source: Authors 'processing

To provide an answer to RQ6, we have conducted a keyword co-occurrence analysis that identified the relevant thematic clusters. Each keyword included in this network is represented by a node, its size indicating the frequency of occurrence and, implicitly, its relevance within the dataset. The connection (link) between nodes signifies the co-occurrence of keywords, indicating that they appear together. A thicker link between nodes indicates a higher frequency of keyword co-occurrences, and a shorter link indicates a stronger relationship between the connected keywords. We performed this analysis based on the keywords that were mentioned by the authors. We set a minimum of 20 occurrences per keyword.

We excluded generic keywords related to circular economy or sustainable development, as they appear in all papers. Also, for a better co-word network representation and analysis, we created and used a thesaurus file through which we unified the terms that refer to the same concept. Therefore, we eliminated redundancies, grouping terms that appeared written in multiple forms, which allowed for a clearer visualization of the keyword network. The co-occurrence analysis was performed on a total of 210 keywords from a total of 20,587.

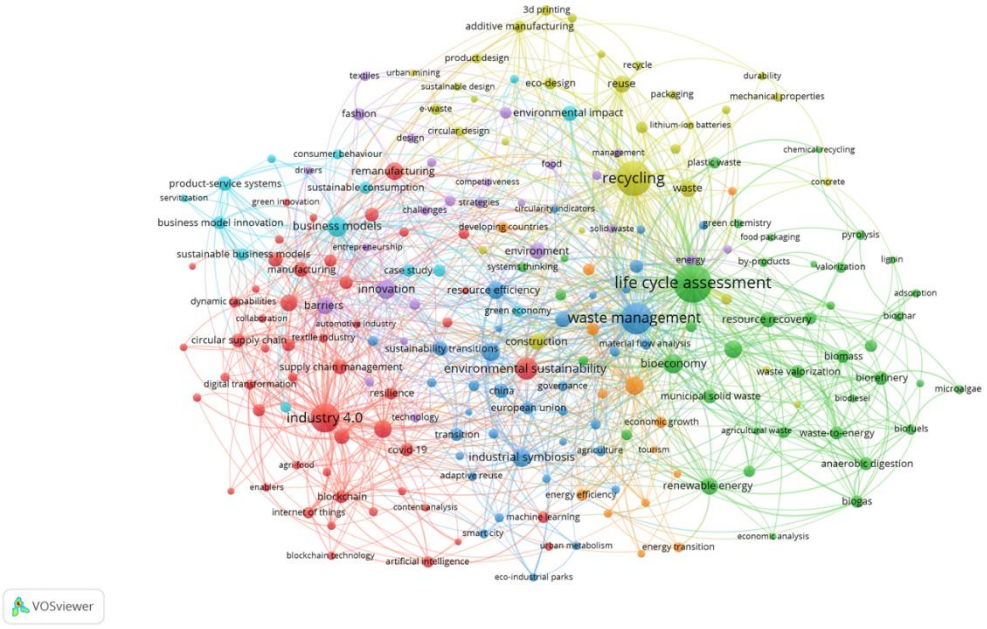

Figure 7: Network visualization of author keywords co-occurrence
Source: Authors 'processing

Consequently, the map revealed 7 clusters of keywords with a total of 3945 links and with 7118 total link strengths. Cluster 1 (red), the largest, comprises 51 items and is centered around the concepts of industry 4.0 (320 occurrences), environmental sustainability (182 occurrences), supply chains (122 occurrences), remanufacturing (115 occurrences), small and medium sized enterprises (104 occurrences), digitalization (93 occurrences), manufacturing (81 occurrences), supply chain management (79 occurrences), corporate social responsibility (77 occurrences), reverse logistics (72 occurrences), blockchain (67 occurrences), eco-innovation (67 occurrences), closed-loop supply chain (66 occurrences), digital technologies (58 occurrences). These concepts in the first cluster highlight the strong connection between integrating new technologies into supply chain management, as a central element of the circular economy implementation in an attempt to achieve sustainable development. Cluster 2 (green) is formed by 40 items, of which the most relevant ones are life cycle assessment (548 occurrences), bioeconomy (141 occurrences), food waste (114 occurrences), renewable energy (111 occurrences), resource recovery (89 occurrences), municipal solid waste (71 occurrences), biorefinery (69 occurrences),

biomass (68 occurrences), waste-to-energy (68 occurrences), waste valorization (64 occurrences). These themes point out the side of the circular economy in relation to the environmental dimension of sustainability, the need to rethink the life cycle of products, underlining circularity as the basic principle, and the importance of waste management as one of the main instruments used.
Cluster 3 (blue) includes 36 items and is centered around the core concepts of waste management (365 occurrences), industrial ecology (131 occurrences), industrial symbiosis (131 occurrences), resource efficiency (119 occurrences), indicators (89 occurrences), and sustainability transitions (83 occurrences). This cluster reveals the need for companies to rethink technological processes on a circular basis, targeting resource inputs and goods outputs that allow the creation of closed loops and the use of secondary raw materials in the manufacturing process.
Cluster 4 (yellow) comprises 30 items, the central core concepts being recycling (456 occurrences), waste (108 occurrences), reuse (106 occurrences), and construction (96 occurrences). These core concepts focus mainly on the principles of the 3Rs, strongly associated with circular economy and sustainable development, highlighting the role of recycling, reuse, repair, reconditioning, and remanufacturing.
Cluster 5 (purple), with 25 items, is formed around the central core concepts of innovation (134 occurrences), barriers (111 occurrences), and environment (102 occurrences), suggesting the importance of innovation for the transition to circular economy, but also the fact that, sometimes, there are barriers to overcome, considering the costs and the access to new technologies.
Cluster 6 (light blue) includes 14 items, of which the most important ones are business models (155 occurrences), environmental impact (86 occurrences), product-service systems (78 occurrences), and business model innovation (66 occurrences), sustainable consumption (61 occurrences), sustainable business models (58 occurrences), and sustainable production (56 occurrences). These core concepts reveal the importance of redefining the business models, rethinking technological production processes, and reshaping consumer behaviour, for fostering the implementation of circular economy and ensuring sustainable development.
Cluster 7 (orange) includes 14 items, the central ones being climate change (128 occurrences), carbon emissions (57 occurrences), economic growth (54 occurrences), energy efficiency (54 occurrences), and carbon footprint (52 occurrences). This cluster focuses on the environmental problems and also highlights the issue of separating economic growth from primary resource consumption, one of the main objectives of the circular economy.

5. Conclusions

The circular economy, as a possible solution to current global problems, is inspired by natural regenerative cycles, and consequently, its main goal is to minimize resource consumption and waste generation and reduce the impact on the environment. To this end, the principles of the circular economy focus mainly on closing the loops, rethinking the life cycle of products, as well as resource management, supply chain management, and waste management.

The concept has gained considerable momentum in academic research, including links to sustainability and sustainable development. The principles of the concept are increasingly used by the economic environment and communities, especially in the European Union and China, the main promoters of this vision of the economy.
As Lakatos et al. (2021) suggested, creating a system based on the circular economy, involves all economic actors: business, consumers, and authorities, but it can also be included here the contribution of the academic research to clarify concepts in this field, generate innovations, create new technologies and help the implementation of the circularity.
Our study conducted a bibliometric analysis targeting the most relevant publications in the Web of Science database on the circular economy-sustainable development topic. We have analyzed the scientific output of research in the chosen field to reveal the interest and impact of circular economy-related scientific research, as well as the concepts and themes that were the most researched in the field.
The topic of the circular economy is certainly one of the main research topics at a global level, analyzed in the broader context of the idea of sustainable development. The past ten years have witnessed a worldwide consistent increase in the interest shown toward publishing research related to the circular economy. Our analysis highlighted the interdisciplinary nature of this concept and of the research related to it. However, most of the papers are published in research areas like Environmental Sciences Ecology, Science Technology, Engineering, Business Economics, and Energy Fuels. Countries like Italy, China, and England hold the supremacy for the number of papers published and total number of citations, highlighting their important role in research and advancements of the analyzed topic. Researchers from these countries are also heavily engaged in international collaborations with authors from other countries. A few journals dominate regarding the number of publications on this topic and the citations of publications, namely the Sustainability journal, the Journal of Cleaner Production, Business Strategy and the Environment journal, and the Resources Conservation and Recycling journal. An important objective of our analysis was to identify key concepts, which revealed that research revolves around the themes of life cycle assessment, recycling, waste management, industry 4.0, environmental sustainability, business models, bioeconomy, innovation, industrial ecology, industrial symbiosis, climate change, and supply chains.

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