BIBLIOMETRIC ANALYSIS OF CIRCULAR ECONOMY AND INTERNATIONAL TRADE

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Abstract:

The themes of circular economy and international trade are two significant areas of study that are complementary to each other in the realization of sustainable development goals. On one side, a circular economy provides an economic model intended to ensure the effective use of natural resources with the least possible generation of waste; on the other side, international trade will help to evaluate the potential success and effectiveness of the model in question all around the world. The aim of this study is to evaluate the academic output and effectiveness in these fields based on a bibliometric analysis of the literature of circular economy and international trade. This work has the main objectives of follow-up of the evolution of research disciplines, identification of scientific networks, and gaps in the existing literature. In the present paper, data were retrieved from papers indexed in the Scopus database from 2008 to 2024 and were visualized in VOSviewer. With a comprehensive assessment of the change and nature of research about the circular economy and international trade, the current study supplies necessary information for future research directions and spots imperative areas for further analysis. Such research brings knowledge to scholars on recent trends, key publications, and authority authors in their field of study.

1. Introduction

The circular economy plays a very important role in the management of resources, especially in relation to waste reduction and increasing material recycling, to alleviate environmental burdens. It also promotes sustainable development by encouraging economic activity that is in sync with the environment and people. There are fundamental differences between the circular economy and the traditional linear economy model. Circular economy is based on the principles of efficient use of resources, reducing waste production and increasing the durability of products. Its primary goal is to minimize waste as much as possible and create a regenerative system in which the use of resources throughout their life cycle is optimized. In fact, the first goal of the circular economy is not recycling, contrary to popular belief, but creating the product by considering circularity while designing the product. In other words, the main goal is to achieve circularity in the first stage, not the last stage. Circular economy aims to decouple economic growth from resource depletion, fostering sustainability and environmental resilience. Accordingly, The circular economy is not merely an environmental strategy but a comprehensive economic transformation that redefines production and consumption patterns. By integrating resource efficiency and innovation, it fosters competitiveness, generates new business opportunities, and supports long-term economic resilience.

International trade is the exchange of goods and services or capital and information between countries. Thanks to globalization, this exchange has increased the amount of foreign trade and contributed significantly to growth, development and job creation. International trade increases welfare by making economies more productive and society richer by taking advantage of countries' comparative advantages (Krugman, 1991). In addition to the

economic and political effects of trade, its environmental impacts are also of undeniable importance. Environmental issues, which have become more important due to resource depletion, global warming, environmental pollution, etc., have also been reflected in trade and have become a subject of discussion. Research on how countries produce and export their goods and whether they include environmental policies in their foreign trade has gained great importance. Being environmentally sensitive in foreign trade can promote or threaten sustainability. When it comes to the environment and sustainability, one of the first concepts that comes to mind today is the circular economy.

Studies examining the relationship between the circular economy and international trade are increasing day by day and gaining importance. The relationship between the circular economy and international trade is being analyzed by researchers from various perspectives, enriching the literature. The widespread adoption of circular economy practices has the potential to change the structure of international trade, as these practices can reshape resource use patterns, waste management strategies, and environmental impacts of trade (Korhonen et al., 2018). Since one of the important steps to be taken in the transition process from a linear economy to a circular economy is the circularization of trade, this issue should be given importance.

This study presents a bibliometric analysis on the circular economy and international trade. The analysis aims to analyze how these two concepts are included in the literature, research trends, and the development of studies on these topics. Therefore, it aims to provide an overview of the existing relevant literature and future research directions regarding the intersection of the circular economy and international trade.

2. Literature Review

2.1. Circular Economy

The concept of circular material flows goes back decades. It was proposed by Boulding (1966) in his book The Economics of the Coming Spaceship Earth. Boulding argued that circular systems in the global economy were inevitable to guarantee human life on Earth in the long run. Pearce and Turner (1990) are among the pioneers in the field of circular economy, centering on Boulding's ideas. They agreed that the traditional linear economy, without any element of recycling, could not be sustainable and consequently needed to be replaced by a circular system. Their foundation is the second law of thermodynamics. They stated that the entropy of an isolated system will increase over time and therefore lower the value of higher-order energy or material (Georgescu-Roegen, 1986).

There are many different definitions of the circular economy. One of the most widely accepted definitions is that provided by the Ellen MacArthur Foundation (2016): "A circular economy is an economy that is restorative and productive by design and aims to keep products, components and materials at their highest utility and value at all times by distinguishing between technical and biological cycles." Another definition in the EU Action Plan is "In a circular economy, the value of products and materials is preserved for as long as possible; waste and resource use are minimized, and when a product reaches the end of its life, resources are kept within the economy to be used again and again to create more value." (European Commission, 2015). The EU's attitude towards the circular economy is to abandon the linear economy model, which is based on taking the raw material, making the product with this raw material and finally discarding it. Considering this situation, most of the products produced today are redesigned and replaced within 2-3 years. If we continue to produce and consume products in this way and at this rate, production will stop as the resources needed for production will be exhausted. Therefore, the current economic model needs to be replaced by a circular economy model based on resource efficiency. Based on this situation, if we look at the EU's definition of circular economy, although it creates a meaning that is derived from the concepts of ecology, design and economy, it is based on the fact that resources are renewable and there is no waste in a restorative system (Ghisellini et al., 2016).

Although there are many different ideas and definitions of the circular economy by different authors and institutions and organizations, the common concept is that of a circular closed loop system (Murray et al., 2017). These systems optimize the use of resources, minimizing waste generation and keeping available resources in a continuous cycle. However, the lack of consensus on the scope, boundaries and key elements of the circular economy makes it difficult to adopt and implement the concept globally. However, developing a common understanding of the circular economy and its most fundamental drivers that is accepted by all would be useful for further adoption and advancement of the concept and would avoid some confusion and problems (Preston, 2012). The development of these concept will contribute to a better understanding of the circular economy objectives and contribute to a more effective and smooth global transition in this area.

2.2. Circular Economy and International Trade

The connection between international trade and circular economy has become a more popular research area day by day in terms of the environmental effects of trade around the world and a more sustainable development. Circular economy is a model that aims to use resources in the most efficient way and, in parallel, extend the life of products and minimize the waste generated as a result of production (Geissdoerfer et al., 2017). This circular economy model aims at a more sustainable growth by reducing the environmental impact of economic activities. International trade examines the services and goods exchanges that countries make with each other and what effects these exchanges have on the global economy. The connection between these two popular concepts is crucial to better understanding the impacts of the circular economy on trade around the world and how these impacts can be optimized.

Recent literature addresses the connection between international trade and the circular economy from a wide variety of aspects. For example, Korhonen et al. (2018) examined the rules applied in the circular economy and the areas where these rules may affect international trade. In this research, the impact of the circular economy on the basis of international trade, waste management and the stages in the supply chain, and especially on the use of resources, is mentioned. Applications in the field of circular economy have the potential to reduce the damage caused by international trade to the environment by making resources in the field of production more efficient. However, the opportunities and obstacles that new regulations, strategies and policies implemented in the circular economy will create in trade all over the world have become a topic of discussion in the literature.

Another important study on the relationship between the circular economy and international trade is by This study investigates how circular business models affect the structure and dynamics of international trade. Bocken et al. (2016) argue that the circular economy has brought about a fundamental shift in business models that can transform the direction and shape of international trade. For example, the proliferation of product-service systems (PSS) is leading to trade not only being limited to products, but also services becoming an important element of trade.

Studies in 2019 examined the effects of circular economy practices on international trade in more specific contexts. For example, Kirchherr and Reike (2019) examined how the circular economy has been implemented in European Union countries and how these practices have been integrated into international trade policies. The study discusses how the circular economy has shaped the sustainability goals of the European Union's trade policies and how these goals affect relations with other trading partners (Kirchherr et al., 2023).

2020 witnessed significant developments at the intersection of circular economy and international trade due to the impact of the COVID-19 pandemic. Carraresi et al. (2020) investigated the effects of circular economy practices on international trade during the pandemic. The study addressed how the disruptions caused by the pandemic in supply chains can be mitigated by circular economy strategies and emphasized the potential of the circular economy to make international trade more resilient in this process.

Trade in goods pertaining to the circular economy involves a range of activities that enable sustainable practice along the value chain, including waste and secondary materials, second-hand goods, and products for refurbishment and remanufacturing. Another report, "Trading Services for a Circular Economy", by the Ministry for Foreign Affairs of Finland and International Institute for Sustainable Development in 2020, also underlines the importance of the relationship between international trade and the circular economy. According to the report, global trade in waste and scrap reached USD 95 billion in 2018, with metals accounting for 82% of exports by value, paper 12% and plastics 3%. This trade would enable materials to be efficiently sorted, recycled, or remanufactured with the leverage of comparative advantages and scale effects toward the global transition to a circular economy. However, the concerns about waste exports to developing countries and emerging economies are well founded, largely due to a lack of developed infrastructure for proper waste management or less stringent environmental standards. This is particularly the case with hazardous wastes such as e-waste, which poses considerable environmental risks if not properly managed. Overall, the report emphasizes the need for effective environmental regulations and treatment standards to ensure that trade in goods makes a positive contribution to the circular economy. First, this will involve targeting the circular economy in trade.

Nakajima and Kimura (2021) provide more in-depth analysis assessing the long-term effects of the circular economy on global trade. They examined the effects of Japan's circular economy policies on its trading partners in Asia. The study analyzed how Japan transformed regional trade dynamics by expanding its circular economy practices and how this transformation was reflected in trade policies in other Asian countries. In addition, some studies contributing to the literature on the subject are given in the table below.

Shunta Yamaguchi (2021) in his report "International trade and the circular economy - Policy harmonization" highlights several key findings on the relationship between international trade and the circular economy. The first of these is related to policy harmonization. There are potential mismatches between international trade policies and circular economy policies. Mapping these mismatches is important to understand how both areas can strengthen each other. Furthermore, the report mentions that international trade plays a critical role for the circular economy transition. It was also discussed that differences in multilateral trade rules and regional trade agreements can create barriers to international trade, as a regulation that applies in one country may apply differently or contain completely different rules in another country. These differences arise because of the diversity of regulations on trade in secondary raw materials and waste. This increases barriers to trade and complicates circular economy practices. In conclusion, the study concludes that the combination of circular economy and international trade plays an important role in achieving sustainability goals.

Title	Authors	Year
Worldwide Research on Circular Economy and Environment: A Bibliometric Analysis	Jose Luis Ruiz-Real, Juan Uribe-Toril, Jaime De Pablo Valenciano & Juan Carlos Gázquez-Abad	2018
Sustainability in the collaborative economy: A bibliometric analysis reveals emerging interest	Myriam Ertz & Sébastien Leblanc-Proulx	2018
Circular Economy: A Review and Bibliometric Analysis	Enric Camón Luis & Dolors Celma	2020
Circular economy and economic development in the European Union: A review and bibliometric analysis	Vítor Domingues Martinho & Paulo Reis Mourão	2020
Effects of circular economy policies on the environment and sustainable growth: Worldwide research	Emilio Abad-Segura, Ana Batlles de la Fuente, Mariana-Daniela González-Zamar & Luis Jesús Belmonte-Ureña	2020
Circular Economy Strategy and Waste Management: A Bibliometric Analysis	Mariana Negrete-Cardoso, Genoveva Rosano-Ortega, Erick Leobardo Alvarez-Aros, María Elena Tavera-Cortés, Carlos Arturo Vega-Lebrijo & Francisco Javier Sánchez-Ruiz	2021
Circular Economy and International Trade: A Systematic Literature Review	Jack Barrie & Patrick Schröder	2021
Circular economy research: A bibliometric analysis (2000–2019) and future research insights	Sandeep Goyal, Sumedha Chauhan & Pavitra Mishra	2021
Waste-to-Energy Technologies Towards Circular Economy: a Systematic Literature Review and Bibliometric Analysis	Ronney Arismel Mancebo Boloy, Augusto da Cunha Reis, Eriko Medeiros Rios, Janaína de Araújo Santos Martins, Laene Oliveira Soares, Vanessa Aparecida de Sá Machado & Danielle Rodrigues de Moraes	2021
A Bibliometric Analysis of the Circular Economy and Sustainability in Maritime Studies	Babam Ramezinoei, Moslem Alimohammadiou, Habib-Allah Ranaei Kordshouli & Kazem Askarifar	2023

When the relevant literature was reviewed, articles on circular economy using bibliometric analysis research method were found. Furthermore, a systematic literature review in which the concepts of circular economy and international trade are discussed together has been reached. Although there are systematic literature reviews on the circular economy and international trade literature, a comprehensive bibliometric analysis of these two concepts has not yet been conducted. Bibliometric analysis aims to quantitatively examine academic production, citation rates, top contributing authors, collaboration networks and research trends in a given subject. Although there are studies in the literature addressing the theoretical and practical intersections of circular economy and international trade, a systematic assessment of the scientific impact and distribution of these studies has been lacking. Therefore, a bibliometric analysis of these two fields would be an important contribution to assess the size of the existing literature, the key actors and the future research potential of these fields.

3. Method and Results

3.1. Methodology of the Research

Bibliometric analysis is a quantitative and qualitative approach for analysing scientific publications. It allows researchers to examine some parameters (e.g., research trends of a specific topic, collaboration networks among authors, and most-cited works) (Donthu et al., 2021). Bibliometric analyses are commonly performed based on certain metrics including, for instance, publication counts, citation counts, journal impact and author social network structures . This approach assists knowledge structure in a discipline to know those past research and inclination of new directions for research.

Maps used in bibliometric analysis visualize the relationships between different publications or researchers. These maps are often expressed in terms such as clusters, links and total link strength. Each of them is detailed below:

Cluster: A cluster refers to groups of publications or authors concentrated on a particular theme. These clusters are formed according to characteristics such as common keywords, citation networks or author collaborations (Van Eck & Waltman, 2010). Studies in a cluster often have similar research questions or methodologies, allowing clusters to represent a particular sub-discipline or theme. Clusters usually address a similar research question or methodology, and can therefore represent a sub-discipline or theme.

Link: A link indicates the relation of pair studies or pair authors A link, for instance, is when an author cites another author or two authors participate in the same work educationally. Links are associated with number and density which reveals the dynamics of collaboration in scientific networks.

Total link strength: Total link strength is the total value of links that a study or author has with other studies or authors. The higher the total link strength for one study, the most closely-related studies are in this field. This could mean that the publication or author is prominent in that particular field (Van Eck & Waltman, 2010).

In this study, how bibliometric mapping in social science research is applied with VOSviewer using data obtained from the Scopus database is examined. Bibliometric analysis refers to the process of quantitatively examining and evaluating various characteristics (e.g., number of authors, journal, subject, publication date, etc.) of documents or publications in a particular field (Yılmaz, 2017). In this study, it is aimed to determine the current situation by analysing academic research on artificial intelligence and international trade in terms of bibliometric indicators. There are various tools for bibliometric analyses and VOSviewer programme was preferred in this study. VOSviewer is a software developed by the Centre for Science and Technology Studies at Leiden University and is widely used in bibliometric analysis of scientific literature (Arruda et al., 2022).

Other qualitative data analysis software such as ATLAS.ti, and NVivo, although effective in text mining and qualitative data coding processes, are limited in bibliometric analysis and citation network building. The software has features to visualise and analyse bibliometric relationships such as co-occurrence, bibliographic linkage, co-citation and co-authorship. It makes it possible to study in depth the relationships between scientific publications and authors, which is the focus of this research. It also offers visualisation, mapping and multidimensional analysis for in-depth analysis of data sets. The VOSviewer programme was considered to be suitable in terms of functionality and it was decided to perform bibliometric analyses through this programme.

In this study, Scopus database was preferred for bibliometric analysis. Scopus is a comprehensive, multidisciplinary database developed by Elsevier and covers academic journals, conference proceedings and books worldwide (Burnham, 2006). The main reason for the preference of Scopus is the breadth and timeliness of its data coverage; it contains approximately 70 million records and more than 1.4 million citations. In addition, Scopus allows a

comprehensive review of the scientific literature with its powerful bibliometric tools and analysis capabilities. Although other databases such as Web of Science, PubMed and Google Scholar are also important resources, Web of Science is more focused on natural and social sciences, while PubMed covers only biomedical literature. Google Scholar has a wider range but has limitations in terms of data quality and consistency. For these reasons, Scopus database, which is the most suitable option in terms of both breadth of scope and data quality, was used in our research.

On 01.09.2024, 144 results were found in a search in Scopus by selecting 'title-abstract-keywords' with the keywords 'international trade' and 'circular economy'.

3.2. Findings

This section of the article presents the findings of the bibliometric analysis. Figure 1 shows the trend of the studies that include the terms international trade and circular economy together in their title, abstract and keywords in terms of number and year. Accordingly, it is seen that the first study using the concepts of international trade and circular economy together in the title-abstract-keywords dates back to 2008. Especially since 2019, it is seen that a remarkable momentum has been reached in studies that include the concepts of circular economy and international trade together in the title-self-keywords. There are several important factors behind the rapid increase in studies on circular economy and international trade since 2019. These factors can be summarised as increasing pressures towards global sustainability goals, environmental concerns, regulatory changes and economic opportunities.

Graph 1. Documents by Year

Source: Scopus, 2024
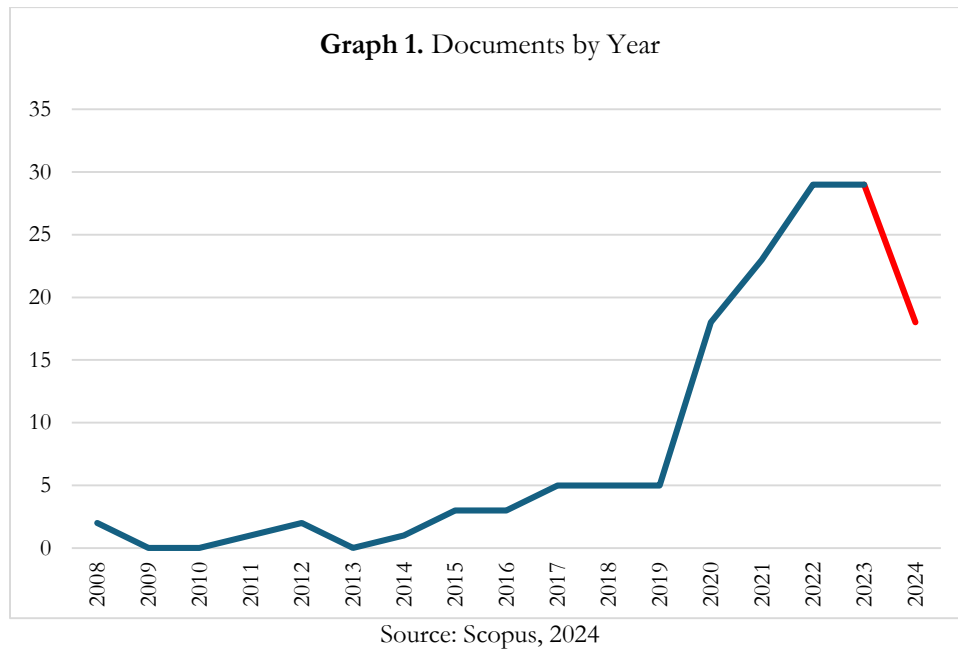
*When the number of documents obtained as a result of bibliometric analysis is analyzed by years, a decline is observed between 2023-2024. However, this downward trend is due to the fact that the publications for 2024 have not yet been completed. Since scientific publications usually increase later in the year, analyses conducted earlier in the year may produce misleading results due to missing data. By the end of the year, when the complete dataset for 2024 becomes available, it is anticipated that the transition from 2023 to 2024 will reflect an upward trend. Rather than a decline, the data is expected to show an increase.

International commitments such as the Paris Climate Agreement have increased the obligation of countries to reduce carbon emissions and promote sustainable development. In this context, circular economy is seen as an important means of achieving these goals through efficient use of natural resources and minimising waste (Geissdoerfer et al.,

2017). In particular, the effects of circular economy practices on international trade have led to an increase in research in this area, as the impact of trade flows between countries on their environmental footprint and sustainability policies has been increasingly scrutinised.

European Union initiatives like the Green Deal have put circular economy front-and-center in international trade policy. The European Green Deal, announced in 2019 and which aims for EU carbon neutrality by 2050, created regulatory structures fostering the circular economy (Kirchherr et al., 2017). These regulatory changes have ignited research examining the link between circular economy and international trade both in Europe but also at some of its most important trading partners.
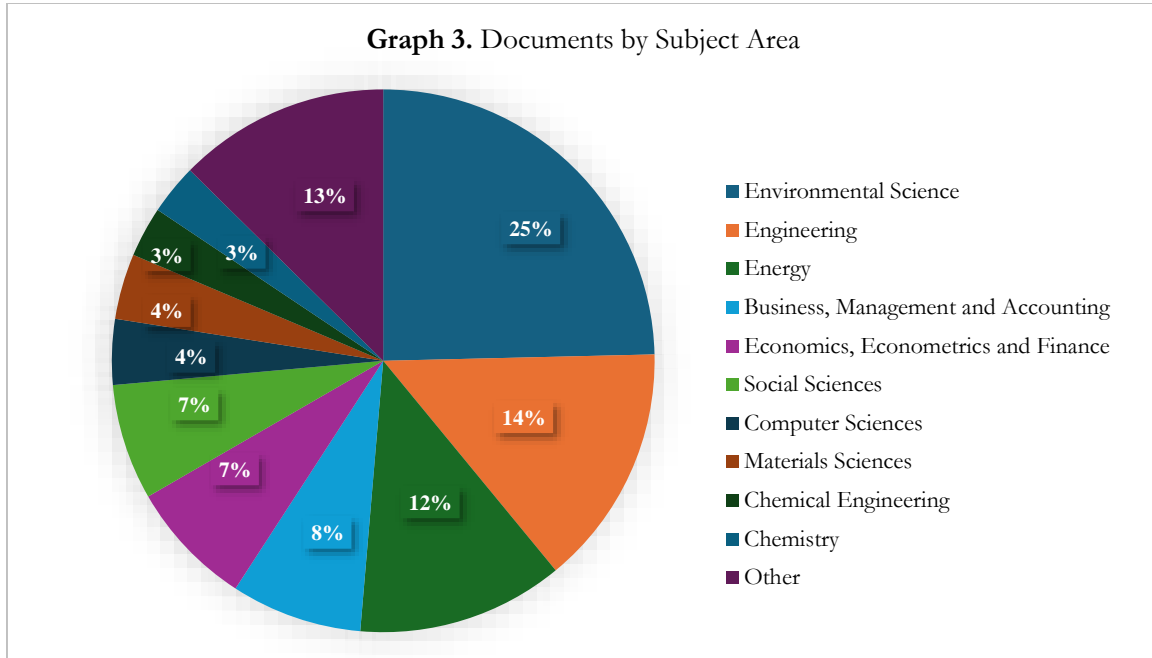
The trade consequences of circular economy strategies have been at the fore of research literature circulation boosts, propelled by disruptions pertaining to global supply chains arising out from COVID-19 Pandemic. During the pandemic, international trade vulnerabilities are better understood and at the same time circular economy strategies to mitigate these vulnerabilities have gained emphasis. More academic studies have been expanded on this subject due to the importance gained by the circular economy with its feature of making supply chains more resilient.

Lastly, with the rapid growth of research on circular economy during the past years, this is due to economic opportunities provided by circular economy. The circular economy provides key economic benefits including new business models, innovation potential and cost savings (Bocken & Ritala, 2023). Consequently, it has attracted more attention from the companies and governments and fosters a more in-depth examination of the relationship between circular economy and international trade. Consequently, post 2019 the studies on circular economy and international trade has increased significantly. This rise stems from both the demands of sustainability objectives and shifting aspects of the world economy.

**Graph 2.** Documents by Type
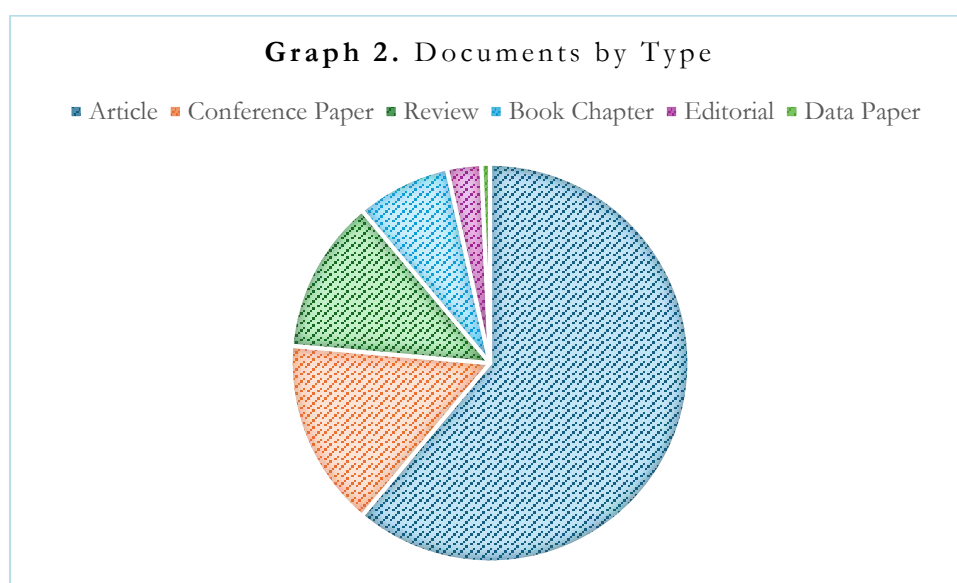
Source: Scopus, 2024

The graph shows the distribution of document types in the bibliometric analysis of circular economy and international trade. The majority are articles, indicating that the topic has gained an important place in the academic literature. Conference proceedings are the second largest segment, indicating that the topic is frequently discussed at academic conferences. Review articles indicate that systematic reviews of the existing literature are common. Book chapters, editorials and data articles have smaller shares, but these documents also make important contributions.

Graph 3. Documents by Subject Area

- Environmental Science
- Engineering
- Energy
- Business, Management and Accounting
- Economics, Econometrics and Finance
- Social Sciences
- Computer Sciences
- Materials Sciences
- Chemical Engineering
- Chemistry
- Other

Source: Scopus, 2024

In terms of disciplines, the majority of studies in environmental sciences (82), engineering (48), mathematics (93), energy (41), business, management and accounting (26), economics, econometrics and finance (25), social sciences (23), environmental science (25), energy (24), chemistry and chemical engineering (20), computer science (13), material sciences (13), agriculture and biological sciences (9), mathematics (6). The data obtained were analysed through author-citation-journal-country-institution and keyword analyses. The most common language used in the works is English with 138 studies, followed by Chinese.

Co-authorship of Author Analysis
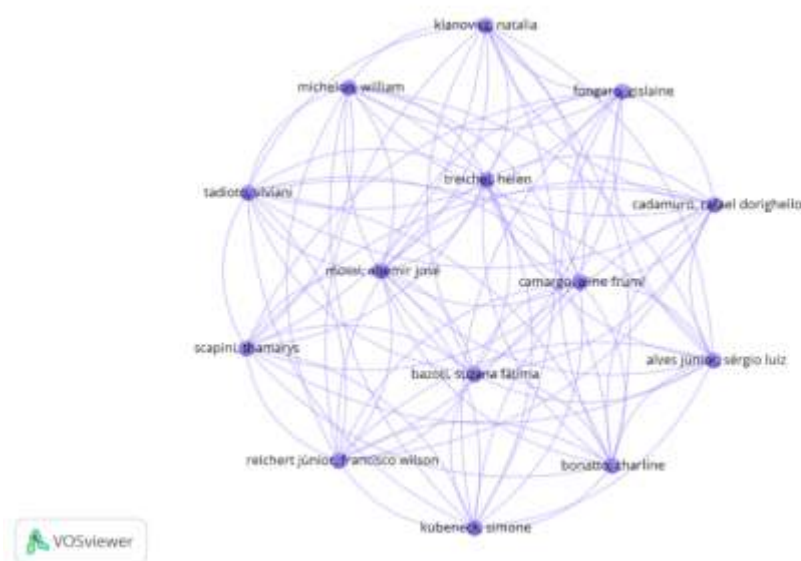
In this analysis, authors were selected as the unit to observe the collaboration networks and relationships between authors in academic publications. Furthermore, certain criteria were set for the authors to be considered in the analysis: An author must have at least one article and at least one citation. These criteria guarantee that the authors analyzed are active and their scientific impact has been recognized at least once.

There are 533 authors in 144 publications. The image shows a map representing the collaboration networks established between authors. Each dot represents an author, while the lines (links) between these dots symbolize the collaboration between authors. That is, there is a connection between authors working together on the same publication. The density and thickness of the lines indicate the frequency of collaboration. As can be seen, some authors (e.g. Helen Treichel, Aline Frum Camargo) are more centrally located and have more links than other authors. This indicates that these authors collaborate more intensively with other researchers. For example, Treichel Helen and Camargo Aline Frum Camargo play key roles in this network due to their central position.

The analysis identified a cluster. This cluster represents authors who concentrate on the same research area and frequently collaborate with each other. In VOSviewer analysis, clusters often allow for the identification of collaborations within a particular discipline or subject of study. Close relationships between authors in Cluster 1 may indicate that they are concentrated around a particular research theme or project.

The analysis identified 91 links. This represents the total number of collaborations between authors. That is, a total of 91 different collaborative relationships were established between these 14 authors. In addition, the most cited authors were Joel Carr, Davide Chiarelli, Paolo D'odorico, Kyle Frankel Davis and Jampel Dell'angelo. The high number of citations received by these authors shows that their work has had a significant impact and a wide resonance in the scientific world. In addition to scientific productivity, the number of citations also emphasizes the quality of the work and its importance in the field.

The most prolific authors are listed as Fabio Fava, Yufeng Wu, Cassamo U. Mussagy and Fiona Charnley. These names play an important role in the collaboration network and make significant contributions to the scientific literature. In the academic world, productivity is often measured by the number of articles published, so these authors have contributed extensively to the literature by conducting wide-ranging studies.
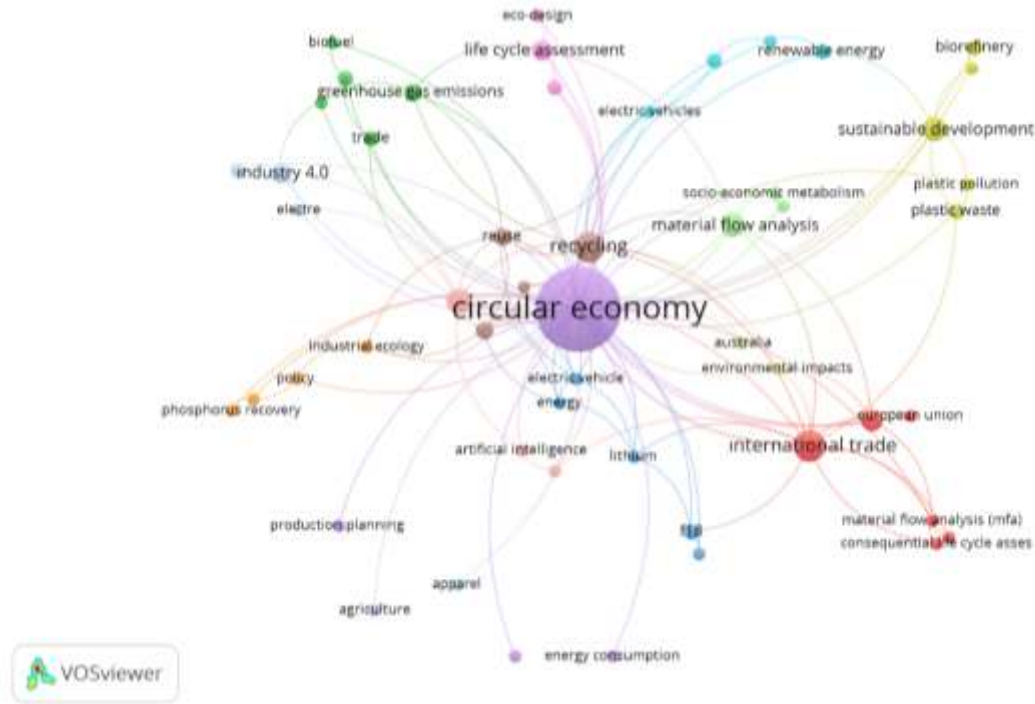
Citation of Authors
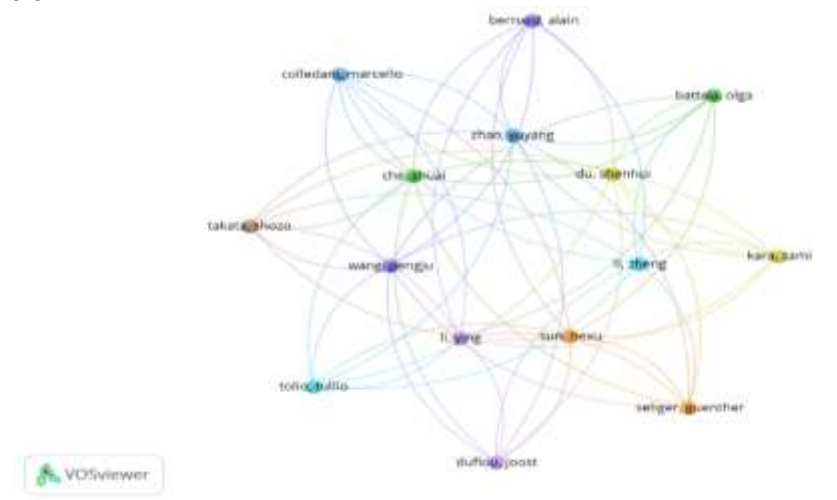
The figure shows an author citation analysis, based on each author having at least one text and one citation. The analysis presents a network visualizing the collaborations and citation relationships between authors. The figure shows 15 authors, 8 clusters and 56 links, indicating that researchers are closely related to each other and that certain groups have been formed. The analysis shows that authors working on the same or similar topics cite each other more frequently, thus forming specific clusters. For example, authors such as Zhao, Yuyang and Che, Shuai occupy a central position and are cited or collaborated with by many other researchers. This indicates that they are leading researchers in their fields.

The clusters are organized according to different research topics or approaches. Colored links represent citation relationships between authors. The density of these citation links reflects the collaboration and academic interdependence between authors. In sum, this author citation analysis reveals the network of relationships between authors in the international trade and circular economy literature and shows which authors contribute more to the literature.

**Co-occurence of Author Keywords**

The co-occurrence of author keywords analysis using VOSviewer above visualizes the relationships of keywords used in scientific studies in the field of circular economy. Such maps help to understand the key themes and topics in a particular research area. With 53 elements, 15 clusters and 131 links in the image, a total of 209 link strengths are noteworthy. The most frequently used keywords are Circular Economy, International Trade, Recycling, Sustainable Development and Material Flow Analysis. These keywords show that the concepts that frequently appear in the studies have crystallized and constitute the basic building blocks of circular economy studies. Moreover, the close relationship between these terms shows that research in these fields is complementary to each other.

Circular economy appears as the most used keyword in the center. International trade emerges as an important sub-theme within the framework of the circular economy. It is seen that the circular economy is included in studies in relation to many concepts; such as recycling, electric vehicles, reuse, industrial ecology. It is seen that the concept of international trade, which focuses on the circular economy, is frequently included together with the concepts of environmental impacts, the European Union, material flow and product life cycle. Material flow analysis stands out as an important method for the efficient use of resources and monitoring their movements within the economic cycle in circular economy studies.

The keyword recycling forms a separate cluster that points to its role as a central theme in circular economy studies. This sub-theme, which is closely linked to concepts such as waste, reuse and waste management, addresses critical environmental issues such as resource efficiency and waste management. The sustainable development cluster emphasizes the examination of the circular economy in the context of sustainability. The connection of this cluster with keywords such as renewable energy, plastic waste and biorefinery emphasizes the importance of renewable energy sources and waste management in terms of sustainable development.

Co-authorship of Countries
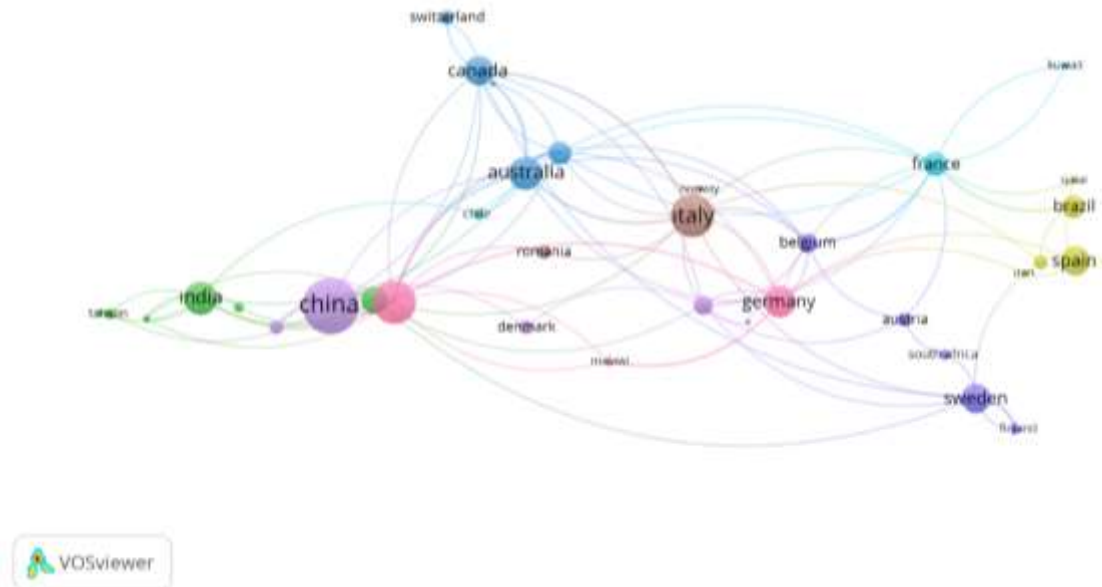
The image above depicts the co-authorship relationships between various countries in academic literature. It also highlights the dynamics of their collaborative efforts. The image visualizes collaborations between countries with a total of 42 items, 8 clusters, 99 links and 116 total link strengths. This analysis allows us to understand the scientific productivity of countries and the strength of their collaborations. In addition, metrics such as the number of publications and citations show how active countries are in the circular economy and related fields.

China is the leader in terms of the number of publications with 24 publications and appears as the largest cluster in the bibliometric map. It is observed that China is in close cooperation with many countries. The leadership in the number of publications shows that China is an important academic actor on topics such as circular economy and international trade. In second place was the United Kingdom with 16 publications. The country is particularly notable for its high number of citations per publication. This indicates that the quality and impact of its publications are high. The fact that the UK is not directly shown in the figure may indicate collaborations that are not included in the map, but given the number of citations, it is clear that it makes a significant scientific contribution. Italy (16) ranks third in terms of number of publications, but also plays a central role in scientific collaborations. The map shows that Italy has established particularly strong links with countries such as Germany, Belgium and France and has an important place in European research. Australia, with 11 publications, is involved in intense academic cooperation with China, Canada and other countries. Despite its geographical distance, Australia is active in international cooperation networks and its contribution to circular economy literature is evident in both the number of publications and citations it receives. With the same number of publications, India draws attention both in terms of the number of publications and the number of citations it receives. It is seen that India has a strong cooperation especially with China and its publications are highly cited and contribute to the literature.

When ranked in terms of number of citations, United Kingdom (1078 citations) proves its influence in the literature as the most cited country. The high number of citations indicates that the academic publications produced by the UK have a broad scientific impact. In addition to its strong collaborations with China, India also stands out for its high number of citations (799 citations). This shows that India's publications are not only quantitatively valuable, but also qualitatively valuable. India has made significant contributions to issues such as circular economy and sustainable development. Italy (789 citations)) stands out with its academic collaborations in the center of Europe, while at the same time reinforcing its influence in the literature with the number of citations it receives. Italy's strong collaborations and influential studies show that it maintains its leadership in circular economy literature. Australia (704 citations) occupies an important place in the circular economy literature thanks to its extensive collaborations with Asia and North America. It stands out as a strong academic actor in terms of both the number of publications

and citations. Although France (678 citations) is not in the top five in terms of the number of publications, it stands out with the number of citations it receives. France's collaborations, especially with Germany and Belgium, support the central role of these countries in European research.

The cross-country clustering observed in the bibliometric analysis may result from specific geographical or economic partnerships fostering research collaborations on international trade and circular economy issues. These clusters are particularly common among countries with regional trade agreements, economic cooperation and similar environmental priorities. For example, in unions with a strong cross-country economic and political structure, such as the European Union, circular economy and sustainable trade issues are supported in line with common policy objectives. In such regions, researchers often conduct joint research projects and funding opportunities support work aligned with regional priorities. On the other hand, for developing economies, the adoption of circular economy in different sectors is an important part of joint research with larger, developed countries, facilitating knowledge and technology transfer.

Furthermore, language similarities and cultural ties can also influence countries' propensity to cooperate; intensive collaborations between English-speaking countries can lead to clusters by facilitating access to knowledge and academic communication (Smith and Cramer, 2020). Such clusters support the concentration of common goals related to research policies and global sustainability goals in the areas of international trade and circular economy.

4. Conclusion

The relationship between circular economy and international trade has just begun to find a place in the literature. But this is an issue that needs more attention. Because a country cannot achieve the transition to circularity alone, countries that trade goods and services with each other need to work together on this issue as they will interact. The dynamic relationship between the circular economy and international trade plays a critical role in achieving sustainable development goals. The world is the home of all countries. And protecting this house can only be achieved through cooperation. The effects of the circular economy on international trade should be evaluated not only in terms of environmental sustainability, but also in terms of economic efficiency, competitiveness and global trade policies.

In order to understand the importance of this issue, important findings were obtained through bibliometric analysis regarding international trade and circular economy. The results of the analysis show that there has been a significant increase in the number of studies examining the impact of the circular economy on sustainable trade policies, and that research assessing the relationship between the circular economy and trade focuses particularly on issues such as environmental sustainability and resource management. International arrangements such as the Paris Climate Agreement and the European Union Green Deal have accelerated studies on the impacts of circular economy on international trade and increased the scientific influence of this field.

There is a strong increase in the publications that combine circular economy and international trade since 2019. This process is part of the growing importance attached to carbon neutrality objectives since the European Green Deal launched in 2019. It is also on a collision course with the global trade policies shaping the world market. As a result of bibliometric analysis, it is reached that China is the country with the most studies formulated in a way that integrates international trade and circular economy.

China began an influential role in the world economy in recent decades, hastening a shift from a commodity-driven economic paradigm to sustainable growth and green manufacturing. The circular economy has thus emerged as a strategic priority for China in this context. Posted in 2020, "China Carbon Summit and Carbon Neutrality Goal" shows an effort by China to indeed present these efforts as part of a larger global trade strategy that co-opts the circular economy model. To achieve this goal, China will pour significant investment into green technologies and environmentally friendly manufacturing. It also perceives these strategies as a new area where foreign trade can innovate. China's circular economy-based trade policies have become consistent with most regional economic organizations especially Europehere, the publication on China's circular economy continues to explode.

According to the analysis, the most frequently encountered word is reuse, recycling, industry 4.0, sustainable development, renewable energy in publications in which they interact circular economy practice and international trade. Resource efficiency and waste minimization are basic principles of the circular economy. In this sense, reuse and recycling are two of the key strategies of the circular economy. Through resource reuse, economic value is defined by utilizing fewer new materials in production processes and limiting waste. In contrast to this, the recycling

guarantees the sustainable management of material flows by recycling the waste materials and returning them to production processes. Being core principles of the ciracular economy model, both of these are put into the forefront of global supply chains of international trade, logistic processes and ecofriendly manufacturing methods.

Digitalization, automation, data analytics, AI and the Internet of Things — collectively referred to as Industry 4.0 — are creeping into production. This kind of technologies are critical to the proper application of the model of circular economy. Thus, Industry 4.0, as the fourth industrial revolution due to new science and technology paradigm, has the groundbreaking basic for improving circular economy practices and managing the production processes in a more intelligent and a more sustainable approach. IoT devices facilitate material flow monitoring, while data analysis can optimize waste management processes. Industry 4.0 also makes possible so-called "smart" production systems, which provide longer-lasting products and foster repair and reuse processes. Due to this, the related journals often discuss the concept of Industry 4.0 and circular economy integration.

Principle of "creating more value with fewer resources", the circular economy plays an important role in achieving sustainable development goals (Dabic et al., 2022). One of the main goals of global trade is to minimize the environmental impacts of trade and adopt sustainable production and consumption patterns. Circular economy helps to achieve these goals with smarter product use and production, the goal of extending the life of the product and its parts, and the beneficial use of materials at the final stage. If the production and distribution of products are planned in a circular manner while they are still in the idea stage, the main goal can be achieved. Countries, industries and companies shape their strategies and policies by incorporating sustainable development goals into their foreign trade processes. Therefore, the concept of sustainable development is also used as a publication in a way that is directly related to the circular economy. When it comes to efficient use of resources, the first concept that comes to mind is renewable energy. Renewable energy is one of the most important elements of sustainable energy production and consumption within the framework of the circular economy. Reducing dependence on fossil fuels, energy efficiency and minimizing the carbon footprint are among the main goals of circular economy applications. In this context, the use of renewable energy resources enables environmentally friendly production processes and increases the sustainability of international trade, so the concept of renewable energy is frequently encountered in publications on the circular economy and international trade. For example, in China's circular economy strategies and trade agreements, investments in renewable energy technologies appear as an important factor supporting the green transformation of international trade.

The increase in the number of academic publications that include the concepts of circular economy and international trade together is of great importance in terms of supporting sustainability and efficiency in trade. Global trade is being reshaped thanks to the principles of circular economy, which aim for efficient use of natural resources, minimizing waste and extending product life cycles. In order for supply chains to become more sustainable on a global scale, circular economy principles and supply chain processes need to be integrated with each other. Thanks to this integration, the material flow in the supply chain process can be optimized and waste can be reused and recycled. In addition, by switching to a circular economy, the energy consumption and carbon footprint in trade can be reduced and the negative effects of trade on the environment can be prevented. Therefore, global problems such as the depletion of natural resources and environmental pollution can be reduced with this approach. Based on this, academic studies in this field play a critical role in ensuring that international trade is environmentally friendly and in building a sustainable future. In addition, considering circular economy and international trade together and circularization of trade can strengthen global cooperation and policies and lay the foundations for a more efficient and sustainable economic system.

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