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Circular Economy: A Bibliometric Analysis of Publications in the Web of Science

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ABSTRACT

The circular economy, which is considered an alternative to the linear economy, is one of the concepts explored within the scope of the sustainable development approach. With the worsening of resource usage and environmental challenges in recent years, research on the circular economy has grown dramatically. In its most basic form, the circular economy is based on the reduction of output and waste, as well as the recovery of waste.

This study aims to make a bibliometric analysis of the concept of circular economy, which is of great interest in the academic field. A quantitative approach for reviewing literature in any discipline is bibliometric analysis. In this regard, this study reviewed the literature and did a bibliometric analysis of the papers published in Web of Science between 2004 and 2022. The study examined 4182 studies titled 'circular economy' on the Web of Science. VOSviewer software was utilized in the study to conduct a systematic bibliometric analysis as well as a visual network analysis. As a result of the analysis, it has been revealed that the leading country in the circular economy is China, the institution is European Research Universities Association Leru, Journal is Sustainability and the researcher Patrizia Ghisellini.

Keywords: Circular Economy, Bibliometric Analysis, VOSviewer, Web of Science.

Döngüsel Ekonomi: Web of Science'daki Yayınların Bibliyometrik Bir Analizi

ÖZ

Sürdürülebilir kalkınma yaklaşımı ekseninde tartışılan kavramlardan birisi doğrusal ekonomiye alternatif olarak görülen döngüsel ekonomi olmuştur. Son yıllarda döngüsel ekonomi üzerine yapılan araştırmalar kaynak kullanımı ve çevresel sorunların derinleşmesiyle birlikte katlanarak hızla artmaktadır. Döngüsel ekonomi en temel ifade ile genellikle üretimin ve atık olarak düşünülen şeylerin minimize edilmesi ve oluşan atıkların geri kazanımı üzerine kurgulanmıştır.

Bu çalışma, akademik alanda oldukça ilgi gören döngüsel ekonomi kavramına yönelik bibliyometrik bir analiz yapmayı amaçlamaktadır. Bibliyometrik analiz, literatürde herhangi bir alanı gözden geçirmek için tercih edilen nicel bir yöntemdir. Buradan hareketle bu çalışma, konuyla ilgili literatürü gözden geçirerek Web of Science'ta 2004-2022 yılları arasında yayınlanan çalışmaların bibliyometrik analizini gerçekleştirmiştir. Çalışma ile Web of Science'ta yer alan 'döngüsel ekonomi' başlıklı 4182 çalışma analiz edilmiştir. Çalışmada sistematik bir bibliyometrik analizini yapmak ve görsel bir ağ analizi gerçekleştirmek için VOSviewer yazılımından yararlanılmıştır. Yapılan analizler sonucunda döngüsel ekonomi konusunda önde gelen ülkenin Çin, kurumun Avrupa Araştırma Üniversiteleri Birliği Leru, Journal is Sustainability ve araştırmacının Patrizia Ghisellini olduğu ortaya konulmuştur.

Anahtar Kelimeler: Döngüsel Ekonomi, Bibliyometrik Analiz, VOSviewer, Web of Science.

1. Introduction

The circular economy is one of the topics considered within the scope of the sustainable development approach. The global usage of materials has nearly tripled in the previous 107 years, from 7 billion tons in 1900 to 92 billion tons in 2018. The usage of materials in 2050 is expected to be between 170 and 184 billion (Circle Economy, 2021, p. 38). This means, humanity is currently using our planet's ecosystems 1.75 times faster than they can be regenerated, that is, almost a second world is needed in response to its production and consumption habits (WWF, 2019). In addition, by 2050, it is predicted that 2.8 more planets, almost a third world, will be needed (WWF, 2012, p. 56). Unfortunately, a remarkable part of the natural resources used are classified as waste due to the traditional linear economic model and cannot be brought back into the economy (OECD, 2011, p. 15). This situation has led to the questioning of the

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current linear economic structure, which sees natural resources as unlimited and cheap, and to the emergence of different paradigms within the concept of sustainable development. As a result of this questioning, and as a result of the transformation in the sustainability paradigm, the concept of circular economy has become popular and put into practice with the leadership of international organizations (European Commission, 2014; European Commission, 2020; OECD, 2021). European Environment Agency (2014, p. 11) claims that the circular economy focuses on the economy's physical and material resource components, such as recycling, limiting and reusing physical inputs to the economy, and treating garbage as a resource, resulting in decreased primary resource consumption.

The concept of circular economy, which emerged on the axis of sustainability, has become very popular today and has become a frequently discussed topic. Along with the discussions made within this framework, the circular economy issue has also been frequently discussed in the academic field and the number of studies on the subject has increased exponentially (Geissdoerfer et al., 2017; Reike et al., 2017, p. 249). Simultaneously, the rising academic literature on this issue makes it more difficult to understand the key areas of interest, the prominent institutions and authors, potential links across other countries and universities. For this reason, knowing the evolution of the studies on circular economy and classifying the studies in certain criteria not only provides convenience for researchers working on the subject, but also saves time. There are several bibliometric studies that highlight distinct facets of the circular economy. Such as "The Circular Economy A new sustainability paradigm?" prepared by Geissdoerfer et al., "Circular Economy: A Critical Literature Review of Concepts" by Beaulieu et al., "A Systematic Literature Review of Bio, Green and Circular Economy Trends in Publications in the Field of Economics and Business Management" by Ferreira Gregorio et al. and "Green, Circular, Bio Economy: A Comparative Analysis of Sustainability Avenues" by D. D'Amato (Geissdoerfer et al., 2017; Beaulieu et al., 2015; Ferreira et al., 2018; D'Amato et al., 2017). Although there are various biometric analysis studies on the topic of circular economy, most of the studies are not up-to-date and have not analyzed academic studies such as articles, book chapters, and proceedings papers in terms of scope.

Considering the studies and deficiencies in the literature, in this study, a bibliometric analysis of the concept of circular economy was carried out in an up-to-date and comprehensive manner. This study evaluated the studies on circular economy with bibliometric analysis, which is a quantitative technique used to review the literature in any field. In this context, 4182 studies titled 'circular economy' in the Web of Science (WoS) Core Collection database between 2004-2022 were analyzed. VOSviewer software was used to make a systematic bibliometric analysis of the circular economy and to perform a visual network analysis. As a result of the analyses, it was shown that the country that contributed the most to the circular economy was China, the institution was European Research Universities Association Leru, the Journal was Sustainability, and the researcher was Patrizia Ghisellini. Furthermore, the country with the highest connectivity is UK and the university with the highest connectivity is Delft Technical University.

2. Material and Method

WoS is a comprehensive database that contains and compiles academic studies. The emergence of scientific databases such as World of Science has made obtaining vast volumes of bibliometric data comparatively simpler (Kemeç & Tarakcıoglu Altınay, 2023). WoS's core collection is a hub of 21,100 high-quality, peer-reviewed publications that are widely accessed and distributed in over 250 disciplines, as well as access to over 53 million articles and 1.18 billion cited references. As a result, this database is valuable for exploring the literature on the circular economy. On the WoS database, the papers on the circular economy were assessed using the bibliometric analysis approach. A quantitative approach for reviewing literature in any discipline is bibliometric analysis. This strategy is efficient for quantitatively analyzing the most productive published literature and tracing the field's evolution over time (Hui et al., 2021; Iftikhar et al., 2019). In this article, studies on the circular economy are categorized by using VOSviewer software to perform a systematic bibliometric analysis and visual network analysis (see Figure 1 for VOSviewer terminology).

This study's information is based on the 'Core Collection Database of WoS,' which is a peer-reviewed, accessible, comprehensive, and multi-disciplinary database. 4182 papers from 2004 to 2022 (June 1, 2022) were downloaded in 'The Complete Record and Cited References' format from WoS. The search was

conducted on June 1, 2022. From 2004 until 2022, the string 'circular economy' was used to search titles, abstracts, and keywords. The data collection is made up of nine individual 'txt' files, as the WoS database only allows for 500 downloads in 'txt' format at a time. The VOSviewer tool, version 1.6.18, was used to evaluate the data. The scan includes all genres, including articles, conference materials, books, and book chapters.

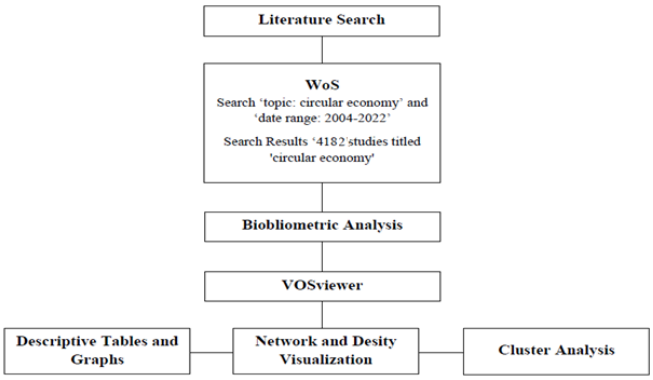

Figure 1. VOSviewer Terminology Diagram, Literature Search, and Bibliometric Analysis

3. Findings

In the study, 4182 studies that have been included in WoS so far have been examined. 4047 of the studies were published in English. A small number of different types of studies have been conducted in different languages such as German, Turkish and Spanish. As a result of the analysis, the studies were categorized according to years, keywords, countries and citations. In addition, the 10 most influential publications are shown in detail according to their publication types, fields of study, indexes, universities and journals.

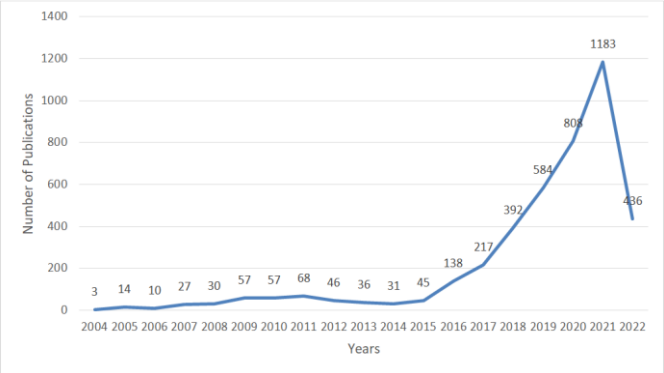

Figure 2. Distribution of Publications on Circular Economy by Years

As a result of the search made with the concept of circular economy, 4182 studies were found (The distribution of studies by years is shown in Figure 2). The first was published in 2004. While no serious change was observed in academic studies from 2004 to 2015, there has been a significant increase in the number of publications since 2016, and the number of publications on the 2021 circular economy reached the highest point by reaching 1183. It is thought that the reason for the rapid increase in the number of studies conducted after 2015 is due to the European Union's acceptance of the 'Circular Economy Package', which includes the 'EU Action Plan' and its annexes, for the circular economy covering the entire product life cycle, on 2 December 2015. Although it is seen that 436 studies were conducted in 2022 and there is a decrease in the studies, this is due to the fact that only half of 2022 has been completed.

Table 1. Most Influential Publication Types, Fields of Study, Indexes, Universities and Journals[1]

	Publication Types	Studying Places	Indexes	Universities	Journals
1	Articles (2695)	Environmental Sciences Ecology (1935)	SCI-EXPANDED (2379)	League of European Research Universities Leru (208)	Sustainability (382)
2	Proceedings Papers (799)	Engineering (1422)	SSCI (1483)	Delft University of Technology (50)	Journal of Cleaner Production (369)
3	Review Articles (434)	Science Technology (1286)	CPCI-S (581)	Technical University of Denmark (48)	Resources Conservation and Recycling (184)
4	Early Access (163)	Business Economics (814)	ESCI (526)	Indian Institute of Technology System Iit System (44)	Business Strategy and the Environment (85)
5	Book Chapters (124)	Energy Fuels (267)	CPCI-SSH (353)	Bucharest University of Economic Studies (42)	Sustainable Production and Consumption (61)
6	Book Reviews (11)	Materials Science (206)	BKCI-SSH (96)	University of Manchester (38)	Energies (57)
7	Books (9)	Computer Science (198)	BKCI-S (54)	Polytechnic University of Milan (36)	Science of the Total Environment (55)
8	Letters (6)	Operations Research Management Science (164)	A&HCI (19)	Royal Institute of Technology (34)	Journal of Industrial Ecology (49)
9	Retracted Publications (1)	Chemistry (180)		Utrecht University (33)	Waste Management (45)
10	Retractions (1)	Public Administration (134)		Norwegian University of Science Technology Ntnu (32)	Procedia Cirp (43)

Source: Created by the author

When Table 1 is examined, it is seen that 2695 of the studies made as a result of the search made in WoS with the concept of circular economy are Articles. This means Two-thirds of the studies are made up of article-type publications. When the studies on the circular economy are examined, it is seen that most of the publications are prepared in the field of Environmental Sciences Ecology. In terms of the number of studies carried out, Engineering, Science Technology and Business Economics come after Environmental Science. This shows that the ecological, engineering, technological and business aspects of the circular economy are mainly handled, and the subject is studied less frequently in terms of chemistry and public administration aspects. The most academic studies on the subject have been by the League of European Research Universities Leru. 208 of the 4182 studies carried out were carried out by this university. Looking at the top 10 journals that publish the most on the circular economy, Sustainability and Journal of Cleaner Production appear as the journals that contain the most publications on the circular economy. Approximately 28% of the articles in the top 10 journals were published by these two journals. 2379 of the publications on the circular economy on WoS are in the journals scanned within the scope of Science Citation Index Expanded (SCI-EXPANDED); 1483 of them were published in the indexes by the Social Sciences Citation Index (SSCI).

[1] Numerical differentiation has been observed in 'Publication Type', 'Studying Places', and 'Indexes' since a work on WoS can be in two or more categories.

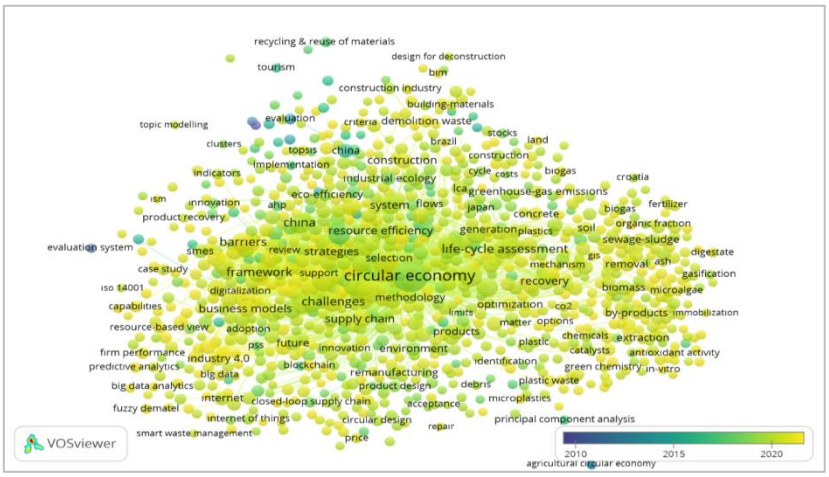

Figure 3. Keywords Frequency Distribution Overlay Map2

The data in the research was given a threshold value in order to construct more relevant maps from it. A keyword's minimum number of co-occurrences is set to at least 5. The threshold value was satisfied by 1013 out of 12444 terms in the keyword co-occurrence analysis. Each tag is represented by a colored circle in the network view. The circle of an object is defined by its frequency of use. The greater the tag on an object, the more frequently it is used. Furthermore, the thickness of the line connecting the circles shows the frequency of keyword co-occurrence in the network visualization map of high frequency keywords (Figure 3). Color shifts from blue to yellow boost the relevance of articles. In addition, the Circular economy keyword average is in the last quarter of 2018. In addition, the resource efficiency keyword average is the second quarter of 2019 and the life-cycle assessment keyword average is the last quarter of 2019.

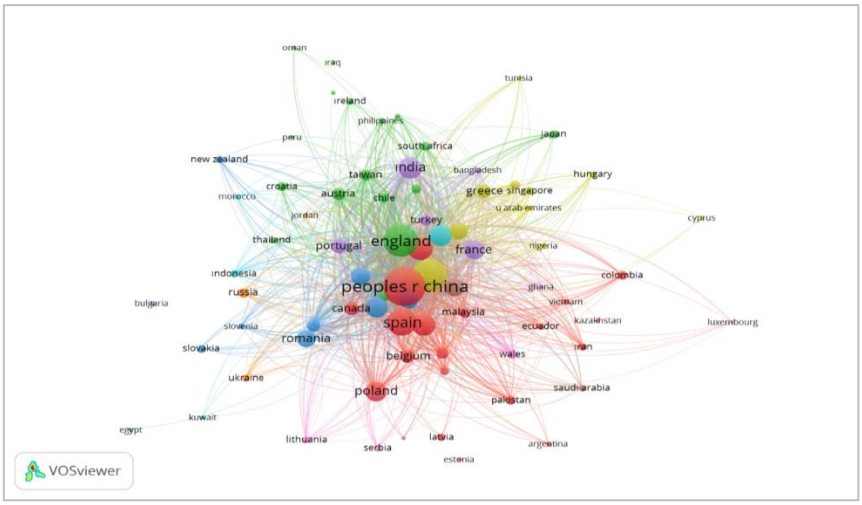

Figure 4. Network Map of Countries[3]

The minimum number of co-occurrence of a country is set to be at least 5. 76 thresholds from 110 countries were met. The UK is the country with the highest connection strength (14572 connections). The country with which British authors have the most partnerships (1353 connections) is Italy. Italy is

[2] The details of the frequency distribution (overlay) map of the keywords; Access is available online at https://app.vosviewer.com/?json=https://drive.google.com/uc?id=1Ccq0Dkpc00ja8aobc5Qrt0BPFwGXxov4

[3] To the details of the network map of the countries; Access is available online at https://app.vosviewer.com/?json=https://drive.google.com/uc?id=1tQo9RcJHQVn5C_XeZYD0J4jaZCpUhZic

followed by the Netherlands (1136) and China (1093), respectively. The WoS network map for countries is presented in Figure 4.

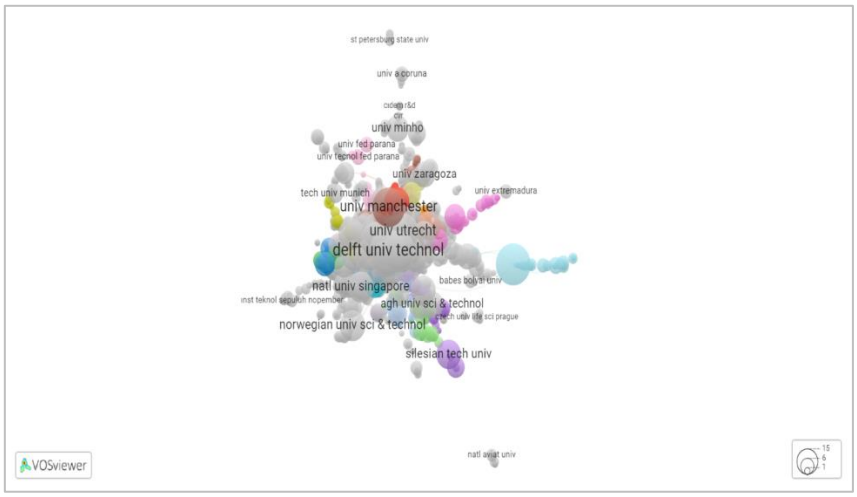

Figure 5. Network Map of Universities4

The WoS network map for universities is presented in Figure 5. In the context of co-authorship and connections, 3757 different organizations are represented in 18 different clusters. When institutions are ranked according to total connection strength, Delft University of Technology (108 connection strength) is in the first place. Manchester University ranks second with 74 connections, while "Montpellier Business School" ranks third with 65 connections. Delft University of Technology still ranks first in terms of the number of publications produced. In second place is Bucharest University of Economic Studies. Manchester University is in third place. These numbers show that the most active institution in the circular economy is Delft University of Technology. The institutions with which Delft University of Technology has the strongest connection are with Lund University and University of Cambridge in Sweden, respectively.

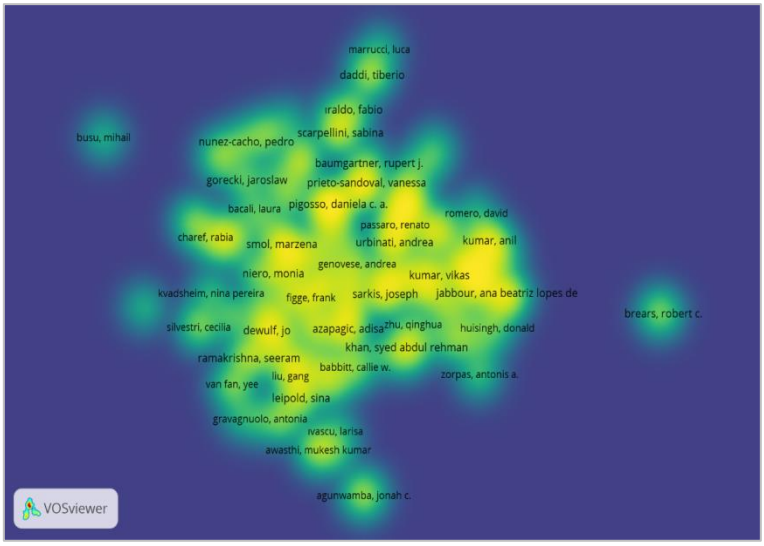

Figure 6. Density Map of the Authors5

[4] To the details of the network map of the countries; Access is available online at https://app.vosviewer.com/?json=https://drive.google.com/uc?id=1eW0ecVSb0TPntATdflYiWE8UwlTVgBDP

When the authors are ranked according to the number of citations (see Table 2), Patrizia Ghisellini et al. rank first with a total of 1709 citations from her studies on circular economy. Martin Geissdoerfer et al. are second with 1691 citations. Julian Kirchherr et al. are in third place with 1470 citations.

The most influential journal in terms of the number of citations is the Journal of Cleaner Production. Eight of the top twenty most cited studies have been published in this journal. The most effective studies on citation were made between 2006 and 2018. The low number of citations for the studies after 2018 is directly related to the spread of the publication processes of the studies over several years.

Table 2. The Most Influential Articles in Terms of Citations

Author	Title	Total Number of Citations	Publisher	Year
Patrizia Ghisellini et al.	A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems	1709	Journal of Cleaner Production	2016
Martin Geissdoerfer et al.	The Circular Economy A new sustainability paradigm?	1691	Journal of Cleaner Production	2017
Julian Kirchherr et al.	Conceptualizing the circular economy: An analysis of 114 definitions	1470	Resources Conservation And Recycing	2017
Jouni Korhonen et al.	Circular Economy: The Concept and its Limitations	893	Ecological Economics	2018
Nancy Bocken et al.	Product design and business model strategies for a circular economy	861	Journal of Industrial and Production Engineering	2016
Michael Lieder & Amir Rashid	Towards circular economy implementation: a comprehensive review in context of manufacturing industry	839	Journal of Cleaner Production	2016
Arnold Tukker	Product services for a resource-efficient and circular economy - a review	774	Journal of Cleaner Production	2015
Alan Murray et al.	The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context	745	Journal of Business Ethics	2017
Walter R. Stahel	Circular economy	665	Nature	2016
Biwei Su et al.	A review of the circular economy in China: moving from rhetoric to implementation	562	Journal of Cleaner Production	2013
Mateusz Lewandowski	Designing the Business Models for Circular Economy-Towards the Conceptual Framework	504	Sustainability	2016
Andrea Genovese et al.	Sustainable supply chain management and the transition towards a circular economy: Evidence and some applications	471	Omega-International Journal of Management Science	2017
Yuliya Kalmykova et al.	Circular economy - From review of theories and practices to development of implementation tools	422	Resources Conservation And Recycling	2018
Zengwei Yuan et al.	The circular economy - A new development strategy in China	416	Journal of Industrial Ecology	2006
Yong Geng et al.	Towards a national circular economy indicator system in China: an evaluation and critical analysis	406	Journal of Cleaner Production	2012
Jouni Korhonen et al.	Circular economy as an essentially contested concept	383	Journal of Cleaner Production	2018
Julian Kirchherr et al.	Barriers to the Circular Economy: Evidence From the European Union (EU)	382	Ecological Economics	2018
Sebastien Sauve et al.	Environmental sciences, sustainable development and circular economy: Alternative concepts for trans-disciplinary research	370	Environmental Development	2016
Roberto Merli et al.	How do scholars approach the circular economy? A systematic literature review	365	Journal of Cleaner Production	2018
Fenna Blomsma & Geraldine Brennan	The Emergence of Circular Economy A New Framing Around Prolonging Resource Productivity	346	Journal of Industrial Ecology	2017

Source: Created by the author

[5] The details of the density map of the authors; Access is available online at https://app.vosviewer.com/?json=https://drive.google.com/uc?id=1RBvkuxSUw_Uf3124qw3q94A3Spb4s9Ea

4. Discussions and Conclusion

The circular economy has been one of the prominent and frequently discussed issues in order to reduce the increase in resource use within the framework of the sustainable development approach. Along with these developments, the issue of circular economy has been discussed in the academic community with different dimensions recently. While the increase in the number of academic studies increases the knowledge about the subject; dimensions of literature, interests, connections, etc. made it difficult to detect. This study presented the literature on the circular economy with a biometric analysis.

According to the study results, it was determined that the leading country in circular economy studies is China, the institution was European Research Universities Association Leru, the Journal was Sustainability, and the researcher was Patrizia Ghisellini. In addition, the country with the highest connectivity is UK and the university with the highest connectivity is Delft Technical University.

To begin with, 4182 publications between 2004-2022 containing all types of studies were listed in the WoS database. Circular economy is a very current field of study. Since 2016, the topic of circular economy has often found a place in the literature. Between 2016 and 2021, 3322 studies were published. 79.3% of all publications were produced during this time period. Between the years 2004-2022, the most number of articles (2695) were produced.

Second, universities, which are built on collaboration and have a long history, stand out among institutions in studies in the circular economy. The League of European Research Universities, founded in 2002, is the most influential institution in the field of circular economy, with 208 publications. It is an association of 21 leading research-intensive universities that share the values of high quality teaching in an internationally competitive research environment. The largest and most comprehensive technical university in the Netherlands, Delft University of Technology, founded in 1842, comes second with 50 publications. Technical University of Denmark, established in 1829 in Copenhagen, Denmark's capital, ranks third with 48 publications.

Third, publications on the circular economy are dominated by the research areas of Environmental Sciences Ecology, Engineering, Science Technology, and Business Economics. Instead of being limited to a few fields, studies and collaborations in many fields will contribute more to the literature. As in research areas, several journals come to the fore in publisher organizations. A total of 935 studies were published in the journals Sustainability, Journal of Cleaner Production and Resources Conservation and Recycling. The share of these three journals among a total of 200 publishers is 22.3%.

Lastly, environmental concerns may affect the regional distribution of research intensity. For this reason, studies conducted in different countries offer clues to show the global trend. China, the UK and Italy are the most active countries in the circular economy. About 40% of all studies were conducted in these countries. When the countries are ranked according to their connections to do business together, the country with the most connections is England. The country with which English writers have the most partnerships is Italy.

In conclusion, this study has shown a clear picture of the evolution of circular economic research in general, including current and diverse publications. With the findings and evaluations of the study, it saves time and resources by compiling the literature holistically for local governments, governments, researchers, students and practitioners who are interested in circular economy.

In the future, this work can be extended by using different databases such as Scopus, Google Scholar. Considering the data presented in this study, qualitative analyzes on the circular economy can be carried out.

Araştırmacıların Katkı Oran Beyanı/ Contribution of Authors

Yazarların çalışmadaki katkı oranları Özkan YALÇIN %100 şeklindedir.
The authors' contribution rates in the study are Özkan YALÇIN %100 form.

Çıkar Çatışması Beyanı / Conflict of Interest

Çalışmada herhangi bir kurum veya kişi ile çıkar çatışması bulunmamaktadır.
There is no conflict of interest with any institution or person in the study.

İntihal Politikası Beyanı / Plagiarism Policy

Bu makale İntihal programlarında taranmış ve İntihal tespit edilmemiştir.
This article was scanned in Plagiarism programs and Plagiarism was not detected.

Bilimsel Araştırma ve Yayın Etiği Beyanı / Scientific Research and Publication Ethics Statement

Bu çalışmada Yükseköğretim Kurumları Bilimsel Araştırma ve Yayın Etiği Yönergesi kapsamında belirtilen kurallara uyulmuştur.
In this study, the rules specified within the scope of the Higher Education Institutions Scientific Research and Publication Ethics Directive were followed.

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