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Circular Economy. A Review and Bibliometric Analysis

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Abstract: The aim of the study is mapping the thematic structure of the circular economy research by mapping research outputs related to it. The methodology consists of developing a bibliometric study based on data obtained from the Web of Science and the Scimago Journal & Country Rank from 2016 to 2019. Some descriptive and bibliographic maps and strategic diagrams are shown; they are generated by SciMAT and VOSViewer. In addition, there is also a bibliometric analysis using alternative metrics. The analysis highlights a new perspective on the subject, analysing the concept from the business administration perspective and not only from the traditional viewpoint of the environmental sciences and industrial production. Finally, the analysis identifies future implications of the circular economy linked to the field of business management.

Keywords: circular economy; bibliometric analysis; scientific production; WoS; Scopus

1. Introduction

Business development has an impact not only on a territory's economic system but also directly on the immediate environment. There is now a global debate that seeks to converge business interests with global sustainability, rendering both businesses and societies sustainable. Thus, there is a clear commitment to reversing the contributions of Milton Friedman, when he wrote, not without controversy, on 13 September 1970, in The New York Times that "a company's social responsibility is to generate profits". In this sense, the lobby Business Roundtable [1] from the U.S. has changed its position to transform its traditional discourse on Milton Friedman's theories into a new conception of the company that, at the same time as being competitive, is committed to both internal and external stakeholders.

The debate over the last forty years over the confrontation between economic (growth and profitability) and social (occupation and well-being) and environmental objectives (preservation of the environment for future generations) has been gradually lost in favour of the necessary integration of all terms [2]. Entering the scene of the so-called "circular economy" comes precisely to defending the viability of developing together economics and environmental well-being.

The concept of the circular economy was perhaps established in 1976 by two researchers from the Batelle Institute Geneva (https://www.battelle.org/), Walter R. Stahel and Geneviave Reday, who conducted a report for the Directorate-General for Labour and Social Affairs of the European Union, in which, under the title "The Potential for Substituting Manpower for Energy", they explored a new productive and economic system that allows for the creation of jobs and the saving of resources: the circular economy [3–5].

However, circular economics began to be widely discussed from 1990 with the work of David W. Pearce, Kathleen Segerson and R. Kerry Turner: "Economics of natural resources and the environment" [6]. For these authors, the circular economy pivots around the three basic elements of an economic system—resource suppliers, waste assimilators and sources of utility—and advocates for

cyclical use of resources for the creation, supply and use of products generated for companies. It is about extending the shelf life of the products that are generated in the production system to render them more profitable and more sustainable over time.

From the point of view of the practical and academic implementation of the circular economy, the first significant studies occurred in the early 2000s. Thus, there are different trends in how to approach this new commitment to the economic and productive system. A new way of building and producing that eliminates products with negative impact sand reduces the harmful impacts of production through efficiency in the design of products and systems is proposed [7]. Moreover, it is suggested a so-called natural capitalism [8], which seeks to transform a system that reduces natural resources use and invests resources from the economic system in the environment, while others [9] called for industrial ecology. The primary idea of the circular economy has evolved into new conceptions, with different studies emerging regarding its scope and definition [10,11].

Recently, the number of publications on the circular economy has proliferated. Its importance and scientific topicality could be seen in a recent study [12]. There have also been relevant studies of the application of the circular economy to the improvement of business management and administration [13,14], as well as highlighting the opportunities presented by the circular economy in companies with a high tendency towards innovation and entrepreneurship [15]. Nevertheless, it is also important to identify the application of the circular economy in specific sectors, such as companies that provide services and that have a clearly technological component [16].

In addition to these academic approaches, there is also a clear trend at the governmental level of promoting the circular economy. Today, a global initiative on promoting the circular economy is the Ellen Macarthur Foundation, which aims to promote the transition to the circular economy. This think thank works hard to make its goals possible and does so by collaborating with academia and governments [17].

At the European level, there is an official strategy for moving towards this concept. It is entitled "Close the Circle: an EU Action Plan for the Circular Economy", presented in 2015 [18] and reinforced with a new, concrete feature in 2019 [19]. At the Spanish level, there is a proposal aligned with this strategy, which has been presented as Spain Circular 2030 [20] which has been analysed to concretize its application to the those challenges pointed out by European Community institutions [21].

For this reason, it is considered of high interest to know the evolution of studies related to the circular economy; as a result, this bibliometric study allows for identifying the main trends in scientific production in a particular field of study. In the case of the circular economy, there are different bibliometric studies that emphasize different aspects. In 2016 an exploratory bibliometric analysis of the circular economy was performed [22], while in 2017, others studied how to apply technology to the circular economy in practice [23]. Furthermore, more researchers [24] analysed the relationship of the circular economy and the environment. In this context, the objective of this research is to identify, through a bibliometric study, the main trends in scientific production of the circular economy, identifying the main authors, lines of research and most commonly used terms in scientific production. More specifically, it intends to present, as much as possible, which trends could constitute the future scenario of this discipline, which analyses not the only monetary and economic value but also the social and environmental value of business development and emphasizes what could be the scientific development in the coming years in the field of the circular economy.

Thus, we performed a bibliometric analysis, as detailed in the next section. Next, the results obtained in this research are presented in relation to the countries and languages of publication, the annual evolution of the number of publications, the most influential journals and authors and the main areas of knowledge in which the publications are framed. The work ends with the conclusions and implications of the study.

By reading this paper, readers will get an up to date tvision of the circular economy, pointing out which are the most significant authors, publications and also the thematic structure output related to circular economy.

2. Methodology

To study the evolution of the circular economy, we conduct a bibliometric analysis of scientific publications. It has been conducted using traditional techniques, but doing it not only in the Web of Science, but also Scimago Journal and Country Rank, which are currently the most widely used and recognized databases for bibliometric studies. Once the query was conducted in Web of Science, we conducted it again in Scimago Journal and Country Rank, in order to obtain a global vision of this subject. This approach as also consolidated by conducting the same query in Google Scholar, which uses Google Scholar Metrics to describe the scientific output of researchers and the numbers of citations that each of their publications has received.

Currently, we attempt to spread out new measures to identify the use and impact of scientific publications, which are known as alternative metrics. They are gaining relevance [25] and could complement the traditional metrics described above. These new measures consider the use of articles in social networks and count, for instance, the Tweets that an article receives (in the case of Twitter) or the use of documents in resources, such as bibliographic reference managers [26]. In terms of importance, it is considered that Mendeley "is the source of altimetric data that includes a higher volume of scientific production" [27] (p. 353) due to most items from Web of Science and Scopus having been integrated into Mendeley's user accounts. Instruments used to measure these alternative metrics are PlumX Metrics (https://plumanalytics.com/), Altlmetric.com (https://www.altmetric.com/) and Impactstory.org (https://profiles.impactstory.org/).

In this study, data collection was performed using Web of Science (WoS) and Scopus, as well as Google Scholar Metrics (GM) as a contextual element. The analysis is performed for the period of 2016–2019 and used as a search term "Circular economy" because it has been identified as a specific term used in several articles identified in the literature review performed for this study. Furthermore, in previous bibliometric studies [22,24], this term has also been used. Finally, after analysing several bibliometric studies and considering the various types of documents that appear in the databases (especially in the case of WoS), the types of documents to be analysed are restricted to articles and reviews. This decision is based on these two types of documents containing relevant and up-to-date information on a topic and being the results of research processes.

Data were collected during the period from 30 March to 3 April 2020, with the following distribution (according to Table 1):

Table 1. Data collected.

Database Name	Resulting Values
Web of Science	3391 records
Scopus	1901 records
Google Scholar Metrics	36,300 records

Data collection was performed for each database separately but using the same methodological criteria. First, the results obtained on the Web of Science are presented and then those of Scopus. Finally, these extracted results are contrasted with those that appear in Google Metrics. After the search was performed in each database, the results were curated to ensure the consistency of the records that will be part of the analysis that is performed.

For the analysis of the data obtained, we perform a bibliometric analysis using VOSViewer and SciMAT. In addition, we contrast these results with another study based on alternative metrics that analyse the current impacts of articles by measuring their direct use from elements, such as additions to bibliographic reference managers or Tweets.

3. Results

3.1. Presentation of Results

3.1.1. Web of Science

In 2016–2019, a total of 3391 records were published that analysed and were related to the circular economy, obtaining the following results.

Most important articles: To measure this element, we considered the number of citations that these publications received, presenting the ten most cited in Table 2.

Table 2. Items with the highest relevance in Web of Science (WoS).

Number	Item Title	Authors	Year of Publication	Citations Received
1	A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems	Ulgiati, S.; Ghisellini, P.; Cialani, C.	2016	642
2	The Circular Economy—A new sustainability paradigm?	Bocken, N.M.P.; Geissdoerfer, M.; Hultink, E.J.; Savaget, P.	2017	483
3	Sustainability and on situ monitoring in battery development	Grey, C.P.; Tarascon, J.M.	2017	365
4	Towards circular economy implementation: a comprehensive review in context of manufacturing industry	Lieder, M.; Rashid, A.	2016	333
5	Conceptualizing the circular economy: An analysis of 114 definitions	Reike, D.; Kirchherr, J.; Hekkert, M.	2017	307
6	Product design and business model strategies for a circular economy	Bocken, N.M.P.; Bakker, C.; de Pauw, I.; van der Grinten, B.	2016	268
7	The Circular economy: an interdisciplinary exploration of the concept and application in a global context	Murray, A.; Skene, K.; Haynes, K.	2017	236
8	The E factor 25 years on: the rise of green chemistry and sustainability	Sheldon, R.A.	2017	232
9	Circular economy	Stahel, W.R.	2016	229
10	Recovery and recycling of lithium: A review	Swain, B.	2017	219

Most significant authors: Twelve authors with higher production on the subject under consideration are shown in Table 3.

Table 3. Authors with a higher production in WoS.

Number	Author	Papers Published
1	Geng, Y.	22
2	Lundstrom, M.	13
3	Purnell, P.	11
4	Irabien, A.	11
5	Charnley, F.	11
6	Niero, M.	11
7	Qi, J.	11
8	Zhao, J.	11
9	Li, W.	11
10	Peng, X.	11
11	Wu, B.	11
12	Wang, H.	11

Journals with more papers published: Regarding the number of documents published on the subject and indexed, in Table 4 we present the ten journals that have published the largest numbers of papers on the subject.

Table 4. Journals with higher production in WoS.

Number	Journal Title	Number of Documents Published
1	Journal of cleaner production	438
2	Sustainability	259
3	Resources conservation and recycling	163
4	Waste management	96
5	Journal of industrial ecology	58
6	Science of the total environment	52
7	Waste management & research	48
8	Journal of environmental management	40
9	Energies	34
10	Bioresource technology	34

Years: In Table 5 we present numbers of papers published on the circular economy.

Table 5. Scientific publication on the subject during the years related to the study carried out in WoS.

Year	Number of Items	Percentage	Growth
2016	294	9%	0%
2017	576	17%	8%
2018	987	29%	12%
2019	1534	45%	16%
Total	3391	100%	N/A

In addition to the absolute values, the percentage represented by the published journals each year compared to the total publications for the period of 2016–2019 is also shown, as well as the percentage growth occurred yearly since 2017.

3.1.2. Scopus

During the period of 2016–2019, 1901 records were published concerning aspects related to the circular economy.

Most important papers: To measure this item, we considered the number of appointments received by these papers. In Table 6, shown are the ten most cited.

Table 6. Items with the greatest relevance according to Scopus.

Number	Item Title	Authors	Year of Publication	Citations Received
1	A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems	Ulgiati, S.; Ghisellini, P.; Cialani, C.	2016	821
2	The Circular Economy—A new sustainability paradigm?	Bocken, N.M.P.; Geissdoerfer, M.; Hultink, E.J.; Savaget, P.	2017	619
3	Towards circular economy implementation: A comprehensive review in context of manufacturing industry	Lieder, M.; Rashid, A.	2016	431
4	Conceptualizing the circular economy: An analysis of 114 definitions	Kirchherr, J.; Reike, D.; Hekkert, M.	2017	424
5	The Circular economy: an interdisciplinary exploration of the concept and application in a global context	Murray, A.; Skene, K.; Haynes, K.	2017	342
6	Product design and business model strategies for a circular economy	Bakker, C.; Bocken, N.M.P.; de Pauw, I.; van der Grinten, B.	2016	341
7	Circular economy: The concept and its limitations	Korhonen, J.; Honkasalo, A.; Sepp., J.	2018	263
8	Sustainable supply chain management and the transition towards a circular economy: evidence and some applications	Genovese, A.; Acquaye, A.A.; Koh, S.C.L.; Figueroa, A.	2017	226
9	Designing the business models for circular economy-towards the conceptual framework	Lewandowski, M.	2016	221
10	Environmental sciences, sustainable development and circular economy: alternative concepts for trans-disciplinary research	Bernard, S.; Sauvé, S.; Sloan, P.	2016	178

Most significant authors: Authors with higher production on the subject, highlighting, in Table 7, the 12 most productive.

Table 7. Authors with higher production Scopus.

Number	Author	Articles Published
1	Lundstrom, M.	15
2	Liu, Y.	9
3	Charnley, F.	9
4	Molina-Moreno, V.	9
5	McAloone, T.C.	8
6	Wilson, B.P.	8
7	Wang, Y.	8
8	Prieto-Sandoval, V.	8
9	Kulczycka, J.	8
10	Astrup, T.F.	8
11	Purnell, P.	8
12	Geng, Y.	8

Journals with more published articles: In Table 8, we present the numbers of documents published are related to the ten journals with the greatest numbers of publications.

Table 8. Titles of journals with a higher production according to Scopus.

Number	Journal Title	Number of Documents Published
1	Journal of Cleaner Production	280
2	Sustainability (Switzerland)	183
3	Resources, Conservation and Recycling	109
4	Waste Management	60
5	Journal of Industrial Ecology	43
6	Science of the Total Environment	31
7	Came environmental science, engineering and management	30
8	Journal of Environmental Management	23
9	Waste Management and Research	20
10	Bioresource Technology	18

Years: In Table 9 we present number of articles that have been published on the circular economy and that have been indexed in selected databases.

Table 9. Scientific publication on the subject during the years related to the study carried out according to Scopus. Source: Scopus.

Year	Number of Items	Percentage	Growth
2016	132	7%	0%
2017	311	16%	9%
2018	575	30%	14%
2019	883	46%	16%
Total	1901	100%	N/

In addition to the absolute values, we also show the percentages represented by the published papers in each year compared to the total number of publications for the period of 2016–2019, as well as the percentage growth that occurred between the years since 2017.

3.1.3. Google Metrics

Once we obtained the data from the two primary databases, we proceed to contrast the information with what appeared in Google Metrics. In this case, the query was not as accurate as in WoS or Scopus.

Searching for records is not as consistent and can only be filtered by publication interval. In addition, it must be considered that the log indexing does not run as it does in the previous databases and that, in this case, it is more general. Moreover, filters for authorship related to the subject from the results obtained cannot be added, nor can those with greater numbers of publications or years of editing on the subject.

A total of 36,300 results were retrieved with the search.

Most important articles: To measure this element, we use the specific order of importance (relevance) set by the search engine. The top 10 are presented in Table 10.

Table 10. Items with the greatest relevance according to Google Metrics.

Number	Item Title	Authors	Year of Publication	Citations Received
1	Conceptualizing the circular economy: An analysis of 114 definitions	Kirchherr, J.; Reike, D.; Hekkert, M.	2017	764
2	The Circular Economy—A new sustainability paradigm?	Bocken, N.M.P.; Geissdoerfer, M.; Hultink, E.J.; Savaget, P.	2017	1187
3	Product design and business model strategies for a circular economy	Bakker, C.; Bocken, N.M.P.; de Pauw, I.; van der Grinten, B.	2016	727
4	Circular economy: the concept and its limitations	Korhonen, J.; Honkasalo, A.; Sepp. l., J.	2018	526
5	Circular economy rebound	Zink, T; Geyer, R.	2017	203
6	Towards circular economy implementation: a comprehensive review in context of manufacturing industry	Lieder, M.; Rashid, A.	2016	431
7	The Circular economy: an interdisciplinary exploration of the concept and application in a global context	Murray, A.; Skene, K.; Haynes, K.	2017	342
8	Designing the business models for circular economy-towards the conceptual framework	Lewandowski, M.	2016	221
9	A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems	Ulgiati, S.; Ghisellini, P.; Cialani, C.	2016	821
10	Circular economy as an essentially contested concept	Korhonen, J.; Nuur, C.; Feldmann, A.; Birkie, S.E.	2018	207

3.2. Analysis of the Results

The analysis of the results collected evidence for the relevance of publications that have been collected in WoS and Scopus. In addition, and as an element to finish consolidating the importance of the results obtained in these two resources, the existence of these publications and their importance on Google Metrics have also been identified. It is considered that these publications appeared both in WoS and in Scopus, indicating their relevance at international level. To present these aggregated results, an individual analysis of the results has previously been performed in each database used, confirming that, in general terms, the results that have been collected are similar in the WoS and Scopus, as well as those listed in Google Metrics.

Data analysis is performed at four levels. First, we show the publications that have a greater relevance on citations received. Second, these results are studied using bibliometric maps using VosViewer, and third, strategic diagrams are presented using SciMat. Fourth, we compare these bibliometric results with the results of the analysis of the same publications using tools linked to alternative metrics.

In addition, the data analyses consider elements such as the titles of articles and journals, authors and their affiliations, and the conceptual scope of publications.

3.2.1. Results by Citations Received

In analysing the results obtained, we can see that the data collected by the two reference databases are very similar.

Regarding the 10 articles that initially have the most importance at the international level in WoS and Scopus, considering the number of citations received, 6 articles of these top 10 appeared in both databases, allowing us to point out that they are the most influential globally in analysing aspects of the circular economy.

These six titles are the following in Table 11.

Table 11. Items with the highest influential globally.

Number	Item Title	Authors	Journal Title	Year
1	A review where to circulate economy: the expected transition tone a balanced interplay of environmental and economic systems	Ulgiati, S.; Ghisellini, P.; Cialani, C.	Journal of Cleaner Production Vol. 114, pp. 11–32	2016
2	The Circular economy—A new sustainability paradigm?	Bocken, N.M.P.; Geissdoerfer, M.; Hultink, E.J.; Savaget, P.	Journal of Cleaner Production Vol. 143, pp. 757–768	2017
3	Towards circular economy implementation: a comprehensive review in context of manufacturing industry	Lieder, M.; Rashid, A.	Journal of Cleaner Production Vol. 115, pp. 36–51	2016
4	Conceptualizing the circular economy: an analysis of 114 definitions	Reike, D.; Kirchherr, J.; Hekkert, M.	Resources Conservation and Recycling Vol. 127, pp. 221–232	2017
5	Product design and business model strategies for a circular economy	Bocken, N.M.P.; Bakker, C.; de Pauw, I.; van der Grinten, B.	Journal of Industrial and Production Engineering Vol. 33, No. 5, pp. 308–320	2016
6	The Circular economy: an interdisciplinary exploration of the concept and application in a global context	Murray, A.; Skene, K.; Haynes, K.	Journal of Business Ethics Vol. 140, No. 3, pp. 369–380	2017

Derived from this fact, in Table 12, we present the affiliations of the most relevant authors because their papers have been the most cited worldwide according to the two databases used to perform this study.

Table 12. Affiliations of authors who have published the most relevant articles worldwide.

Author	Affiliation	Country
Ghisellini, P.	Università de Bologna, Alma mater Studiorum, Department of Agricultural, Food Science & Technology	Italy
Cialani, C.	Dalarna University, School of Technology & Business Studies, Econ Unido, S-79188 Falun, Sweden	Sweden
Ulgiati, S.	Parthenope University Naples, Department of Science & Technology, Y-80143 Naples, Italy Beijing Normal University, School of Environment, Beijing, Peoples R China	Italy China
Geissdoerfer, M.	Univeristy of Cambridge, Department of Engineering, Institute for Manufacturing, Cambridge CB3 0FS, England Delft University of Technology, Industrial Design Engineering, Landbergstr 15, NL-2628 CE Delft, Netherlands	United Kingdom Netherlands
Savaget, P.	Univeristy of Cambridge, Department of Engineering, Institute for Manufacturing, Cambridge CB3 0FS, England Delft University of Technology, Industrial Design Engineering, Landbergstr 15, NL-2628 CE Delft, Netherlands	United Kingdom Netherlands
Bocken, N.M.P.	Univeristy of Cambridge, Department of Engineering, Institute for Manufacturing, Cambridge CB3 0FS, England Delft University of Technology, Industrial Design Engineering, Landbergstr 15, NL-2628 CE Delft, Netherlands	United Kingdom Netherlands
Hultink, E.J.	Delft University of Technology, Industrial Design Engineering, Landbergstr 15, NL-2628 CE Delft, Netherlands	Netherlands
Lieder, M.	KTH Royal Institute of Technology, Department of Production Engineering, Brinellvagen 68, SE-10044 Stockholm, Sweden.	Sweden
Rashid, A.	KTH Royal Institute of Technology, Department of Production Engineering, Brinellvagen 68, SE-10044 Stockholm, Sweden.	Sweden
Kirchherr, J.	Utrecht University, Copernicus Institute for Sustainable Development, Innovation Studies Group, Heidelberglaan 2, NL-3584 CS Utrecht, Netherlands	Netherlands
Reike, D.	Utrecht University, Copernicus Institute for Sustainable Development, Innovation Studies Group, Heidelberglaan 2, NL-3584 CS Utrecht, Netherlands	Netherlands
Hekkert, M.	Utrecht University, Copernicus Institute for Sustainable Development, Innovation Studies Group, Heidelberglaan 2, NL-3584 CS Utrecht, Netherlands	Netherlands
by Pauw, I.	IDEAL & Co Desing and Explore, Amsterdam, Netherlands	Netherlands
Bakker, C.	Delft University of Technology, Industrial Design Engineering, Landbergstr 15, NL-2628 CE Delft, Netherlands	Netherlands
van der Grinten, B.	IDEAL & Co Desing and Explore, Amsterdam, Netherlands	Netherlands
Murray, A.	Kings School Winchester, Hoare Chair Responsible Management, Romsey Rd, Winchester SOUND22 5HT, Hants, England	United Kingdom
Skene, K.	Biosphere Research Institute London, England	United Kingdom
Haynes, K.	Newcastle University, School Business, Northern Zoco Chair Accounting & Finance, 5 Barrack Rd, Newcastle Upon Tyne NE1 4SE, Tyne & Wear, England	United Kingdom

The six most significant papers are analysed because they coincided with the two bibliometric indices used.

We observe that the majority of the most cited international researchers on aspects related to the circular economy have some affiliation with the Netherlands (43%). Next are affiliations linked to the United Kingdom (29%) and Sweden (14%). By observing nodes of collaboration from bibliometrics maps, we observe that there are relations between countries and institutions in promoting research on circular economy.

The journals in which the most relevant papers have been published are the following in Table 13.

Table 13. Journals in which the most relevant articles have been published worldwide.

Journal of cleaner production
Resources conservation and recycling
Journal of Business Ethics

A more detailed analysis of these publications shows the following in Table 14.

Table 14. Journals in which the most relevant articles have been published worldwide with editorial and bibliometric characteristics.

Title	Country of Editing	Publishing	JCR Category	Category Scopus
Journal of cleaner production	Netherlands	Elsevier	Environmental Sciences Engineering, Environmental Green and Sustainable Science and Technology	Environmental Science: General environmental Science Business, Management and Accounting: Strategy and Management Engineering: Industrial and Manufacturing Engineering Energy: Renewable Energy, Sustainability and the Environment
Resources conservation and recycling	Netherlands	Elsevier	Environmental Sciences Engineering, Environmental	Economics, Econometrics and Financial: Economics and Econometrics Environmental Science: Waste Management and Disposal
Journal of Business Ethics	Netherlands	Springer	Business Ethics	Social Sciences: Law Arts and Humanities: Arts and Humanities (miscellaneous) Business, Management and Accounting: General Business, Management and Accounting

It seems clear that the most relevant journals in this area, if we focus on the most important papers for the citations that were received, were published by two major international scientific editors: Elsevier and Springer, located in the Netherlands. Examining the thematic areas to which publications are linked, there has been an important effort in the field of environmental sciences, as well as in economics and ethics.

3.2.2. Bibliometric Maps of the Results

We present bibliometric data below that identify the most relevant elements of the relationships among the most prominent authors, topics and publications on the circular economy during the period of 2016–2019. We use VOSViewer bibliometric software, and it runs with the records obtained from the Web of Science and Scopus. The results are presented in a different chart for the data of each database; they cannot be run together because the system does not allow joint representation due to the formed

source of the records being different and not supported. The study of the results of Google Metrics was not performed because it cannot obtain a system-compatible file to be able to perform the query.

To create the maps, a minimum of five repetitions are established in the case of keywords and citations received by the analysed articles to generate an element visible on the map in question. This process displays the records that have the greatest direct impact and is able to identify more clearly the thematic affinity relationships established from these elements. First, we present the bibliometric maps of the authors who have appeared to identify which researchers are most relevant in terms of the number of publications generated around the circular economy. Second, we show the keywords that are related to the research topics currently being considered in the world of the circular economy. Then, we introduce the organizations that are linking to research on the subject at the international level and the countries with the greatest involvement. Finally, we add the most relevant authors who stand out due to the influence that their publications have had on the international scientific group, analysing in this case only the WoS records.

Bibliometric Map of Authors

Regarding Web of Science, in order of importance, examining the central nodes of these relationships, the most prominent author is Yong Gen, from which other relationships are established, grouped into four nodes (Figure 1).

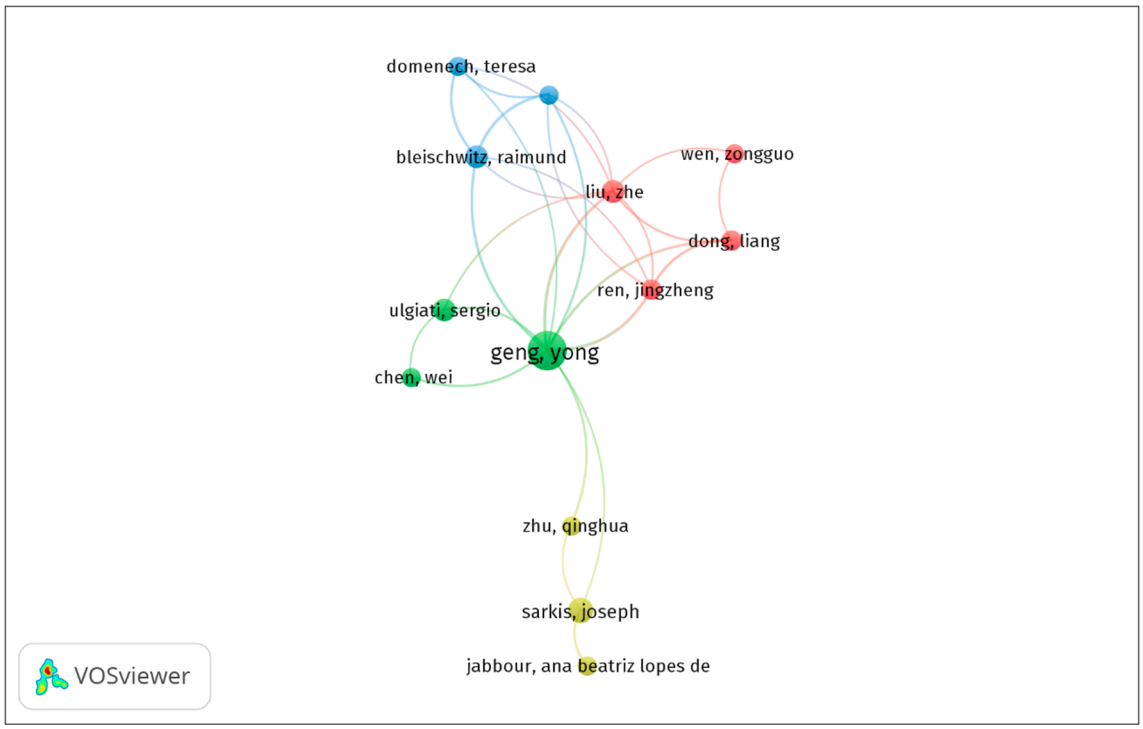

Figure 1. Bibliometric maps of WoS authors.

Pointing out authors, according to the records of Scopus, it is observed that the main relationship is between Li Jing and T.C. McAloone, grouped into four main areas of work (Figure 2).

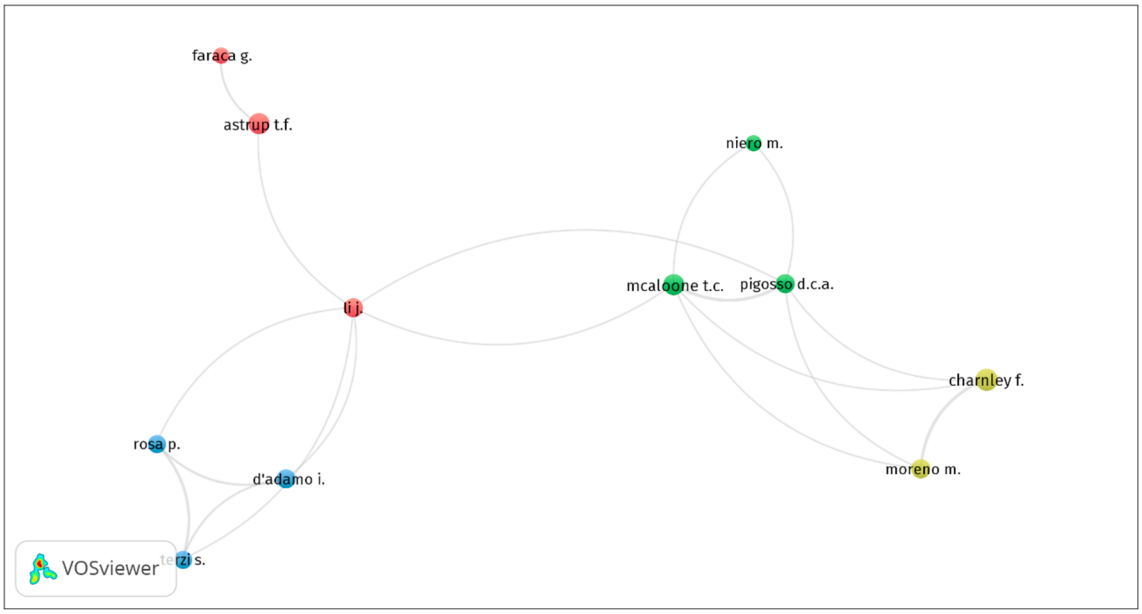

Figure 2. Bibliometric maps of Scopus authors.

Bibliometric Keyword Map

According to records of WoS, we observe that the main node around which research in the field of knowledge is grouped is circular economy, and other nodes are highlighted as recycling (Figure 3).

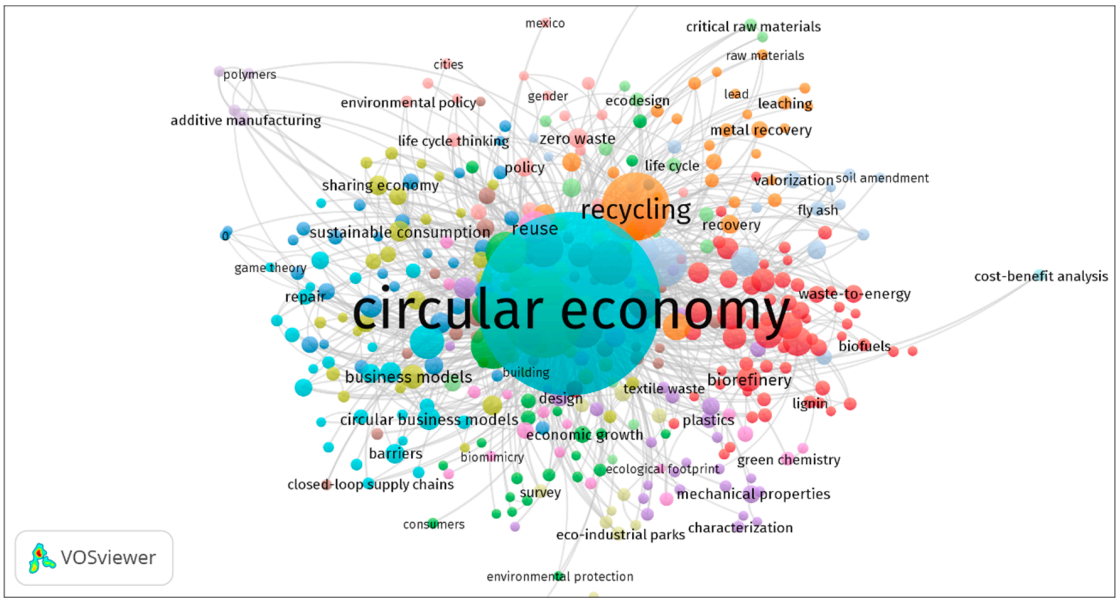

Figure 3. Bibliometric map of keywords *WoS*.

In Scopus, we observe a similar behaviour as that in WoS, but a new node appears around remanufacturing. There are new concepts that have a considerable volume of iterations, such as recycling and industrial symbiosis (Figure 4).

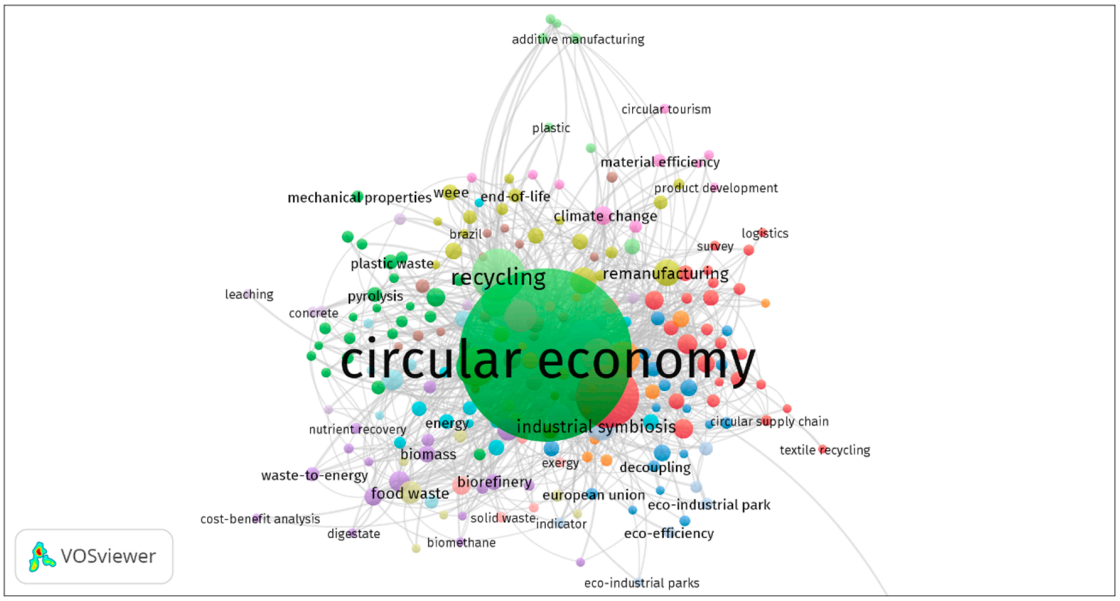

Figure 4. Bibliometric map of Scopus keyword.

Bibliometric Map of Publishing Organizations

From the analysis of the information that appears in WoS, we observe that the organizations leading scientific publications are Delft University (Netherlands) and Aalto University (Finland) (Figure 5).

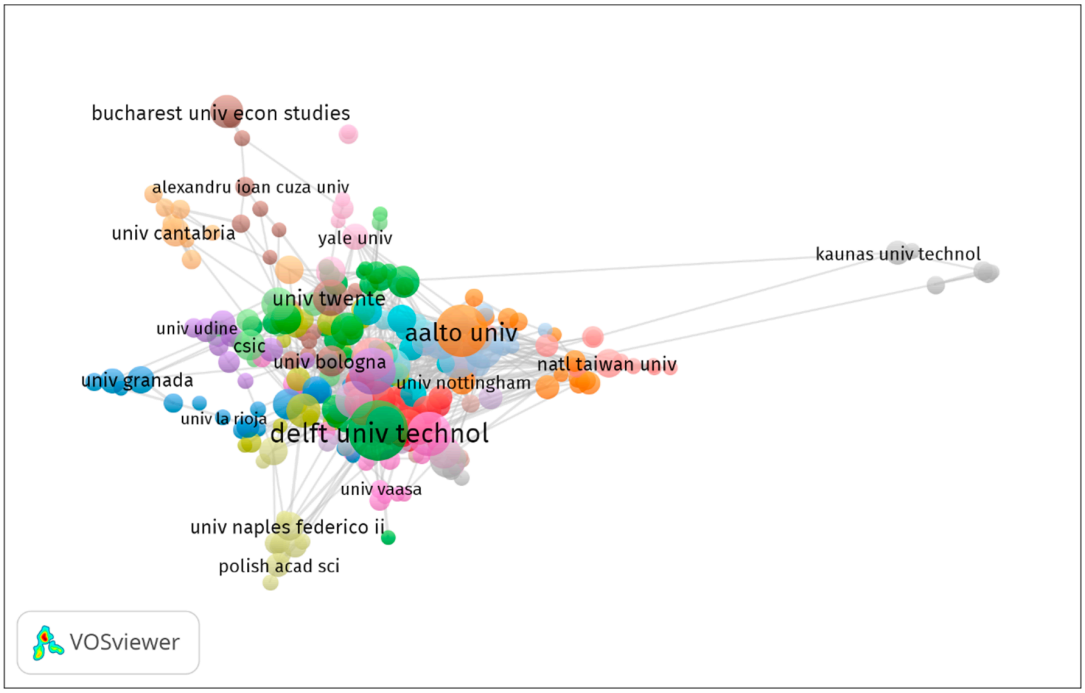

Figure 5. Bibliometric map of publishing organizations *WoS*.

With the information from Scopus, we observe that the main nodes are built around Chinese institutions (including the Shanghai School of Environmental Sciences) and the Faculty of Economics and Social Sciences of the Heidelberg University of Germany (Figure 6).

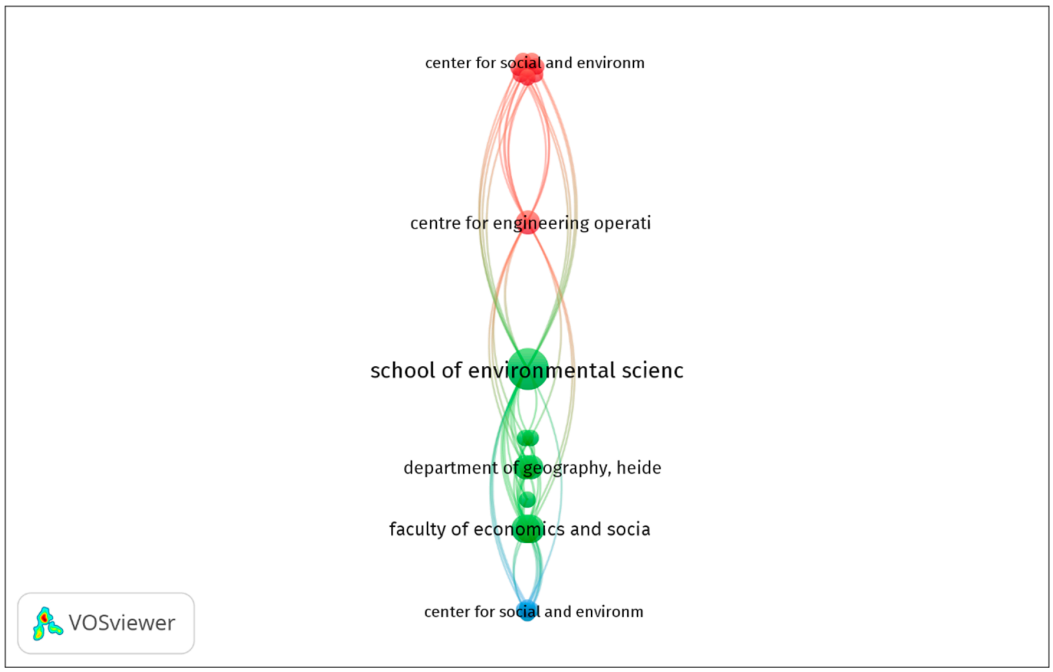

Figure 6. Bibliometric map of publishing organizations according to Scopus.

Bibliometric Map of Countries

Using WoS, we observe that the countries that are most relevant in terms of publication are the United Kingdom, China and Italy, from which other secondary nodes are derived. It is noted from this map that European countries play a leading role in this issue, perhaps in line with community legislative provisions on disciplines. In addition, it can also be considered that more developed countries, grouped around institutions such as the G7, provide a boost to the subject, with the exception of the United States and Canada (Figure 7).

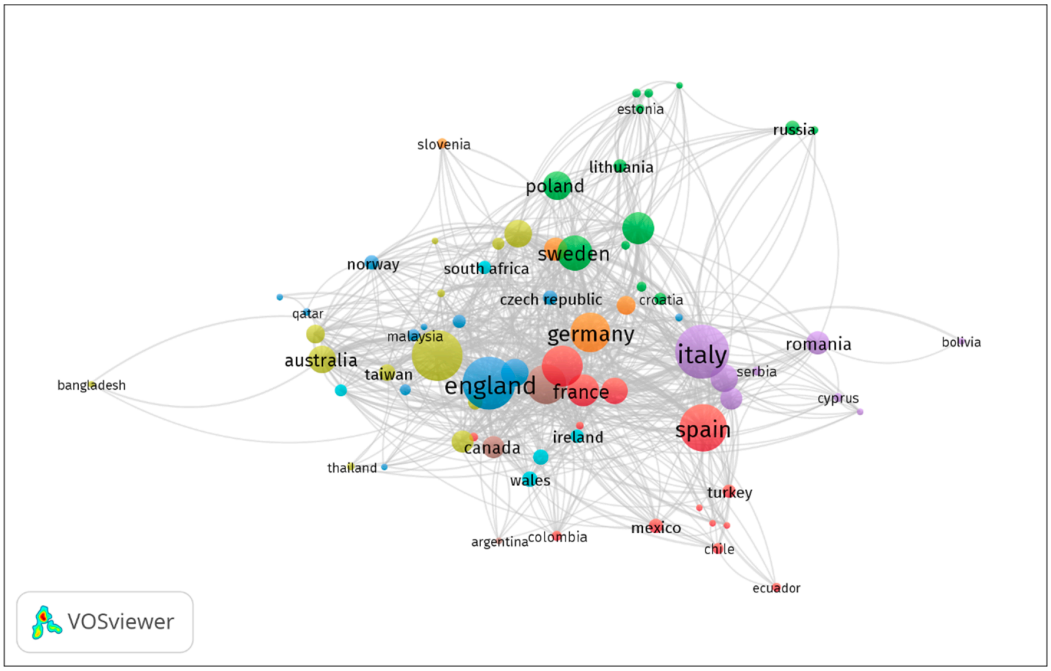

Figure 7. Bibliometric map of countries where seconds is published WoS.

According to data from Scopus, behaviour similar to that previously observed is displayed (Figure 8).

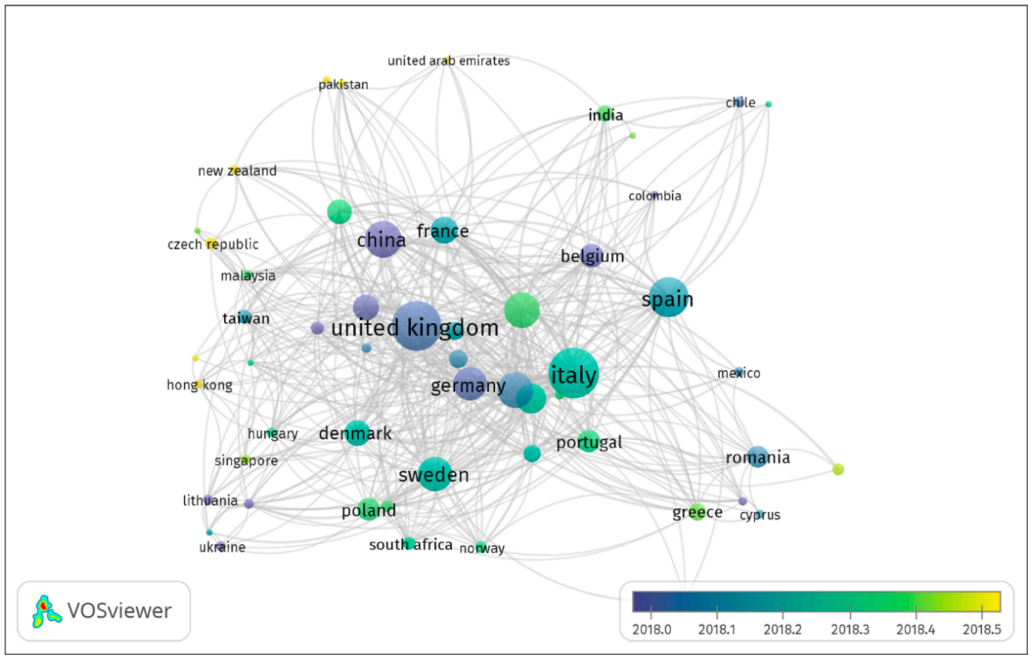

Figure 8. Bibliometric maps of countries where it is published according to Scopus.

Bibliometric Map of Quotes Received by Authors

Only available for WoS, it highlights the prominent role of Patricia Ghisellini, who is the first author of the paper identified as the most relevant on the subject, as it is shown in Figure 9. Thus, this author, together with the other collaborators with whom she has published the most relevant paper, could be considered the central core of the discipline in the period studied. From this article, we see other relationships between authors.

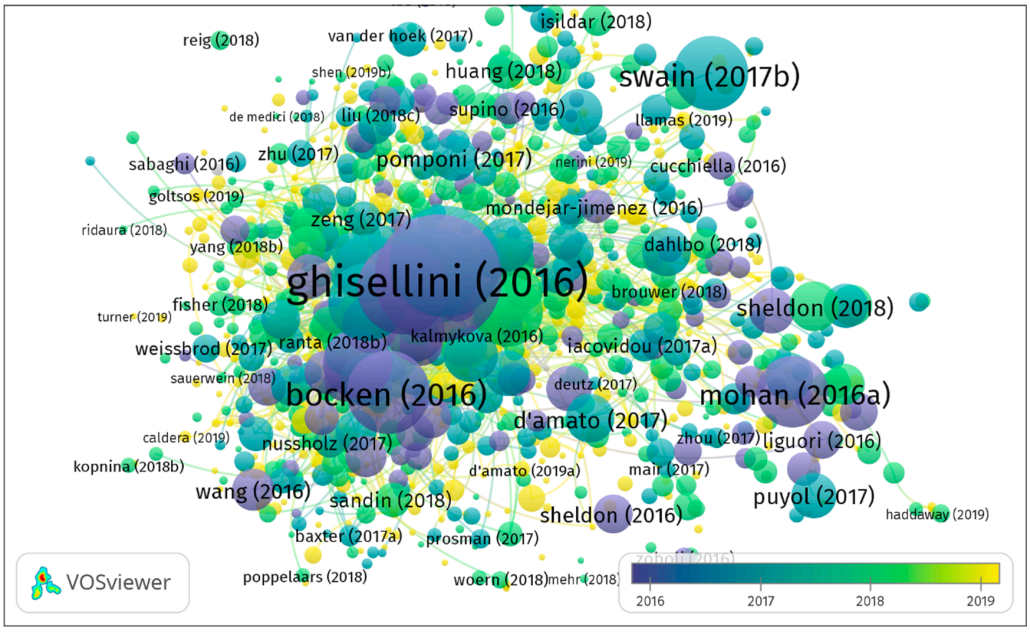

Figure 9. Bibliometric maps of most cited authors seconds WoS.

3.2.3. Strategic Diagrams

Using the SciMAT tool, we created a conceptual map of the thematic evolution of the central research topics and aspects linked to the circular economy. This diagram represents the major themes, which are those that concentrate on the higher density of publications and centrality of research, as well as those that are developing according to a slower evolution.

This analysis is carried out for the four years that have been studied. It is considered for this analysis that the most relevant articles are determined using the h index that they have received. This index is considered more stable than quotes directly received because it "measures both the productivity and impact of a set of publications, relating the number of articles and quotes received fear the same" [28] (p.9). This analysis was only possible on articles obtained with WoS. However, as it has been pointed out previously, most of the retrieved records also matched those in Scopus and Google Metrics.

From this strategic diagram (Figure 10), we can observe another concentration of research related to the circular economy. This element has occupied over the four years of study a high level of centrality and density in relation to the object of study, but over time, it has coexisted with the emergence of other research nodes.

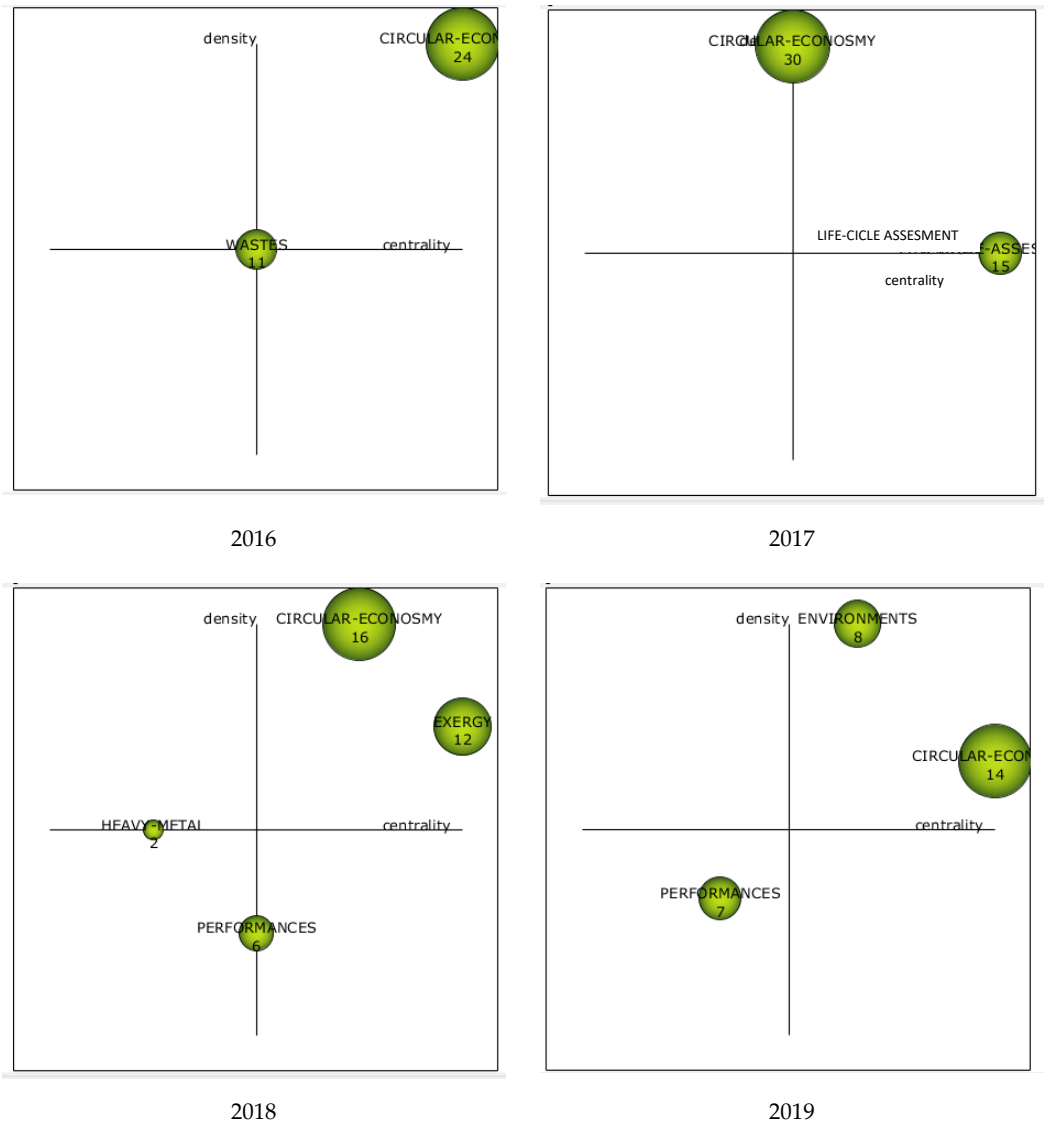

Figure 10. Strategic diagram on the subject from WoS.

Today, despite the continuing leadership of the concept of the circular economy, it has lost centrality and density, and other issues appear, such as those grouped under the concept of performances which could be related to the practical applications of the circular economy.

A second level shows what relationships exist among the various primary thematic concepts, which nodes are most significant, and which nodes relate to what. This analysis is performed for the entire global period and not year by year since; in this way, one can obtain a more global view of it (Figure 11).

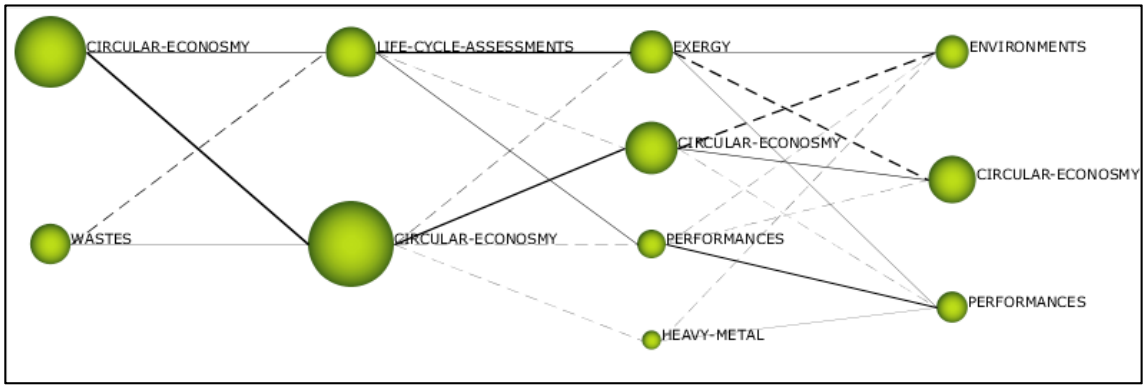

Figure 11. Strategic diagram of thematic relationships from WoS.

We can see the importance of research on the circular economy, as well as that other investigations are initiated with different approaches that can feed each other.

3.2.4. Analysis of Alternative Metrics

In the field of scientific literature, an incipient trend is initiated to use alternative metrics that analyse the real influence of articles by measuring their direct use from elements such as additions to bibliographic reference managers or Tweets. First, in Table 15, we analyse the use that has been made by Mendeley, a manager of bibliographic references, of the six articles identified as the most cited.

This table shows that the most commonly used article according to Mendeley is the second most important according to the traditional bibliometric data used by WoS and Scopus. However, there is little difference between what would be the use of the most cited article in the first place, compared to the most used for Mendeley's purposes.

In all cases, we observe that the uses of the articles are much greater than the quotes received. It appears that its use is greater than its incorporation into other works and therefore in making appointments on the origins of the articles in question.

Table 15. Users who have added the most important items to their Mendeley accounts.

Number	Item Title	Authors	Incorporated into Your Mendeley	Citations Received at WoS	Citations Received on Scopus
1	A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems	Ulgiati, S.; Ghisellini, P.; Cialani, C.	2816	642	821
2	The Circular economy: a new sustainability paradigm?	Bocken, N.M.P.; Geissdoerfer, M.; Hultink, E.J.; Savaget, P.	2930	483	619
3	Towards circular economy implementation: a comprehensive review in context of manufacturing industry	Lieder, M.; Rashid, A.	1603	333	431
4	Conceptualizing the circular economy: an analysis of 114 definitions	Reike, D.; Kirchherr, J.; Hekkert, M.	2153	307	424
5	Product design and business model strategies for a circular economy	Bocken, N.M.P.; Bakker, C.; de Pauw, I.; van der Grinten, B.	1636	268	341
6	The Circular economy: an interdisciplinary exploration of the concept and application in a global context	Murray, A.; Skene, K.; Haynes, K.	1497	236	342
Total readers who have added the articles to their Mendeley			12,635		

In Table 16, below, is a second analysis that discusses the thematic linkage of the users of the papers according to the data of the bibliographic reference manager Mendeley.

Table 16. Thematic linking of users of articles according to Mendeley.

	Papers Users by Area of Knowledge According to Mendeley					
Item Title	Business Sciences	Environmental Sciences	Engineering	Social Sciences	Design	Economy
A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems	28%	30%	30%	12%	-	-
The Circular economy: a new sustainability paradigm?	32%	27%	30%	11%	-	-
Towards circular economy implementation: a comprehensive review in context of manufacturing industry	31%	26%	35%	-	-	9%
Conceptualizing the circular economy: an analysis of 114 definitions	30%	30%	28%	-	-	12%
Product design and business model strategies for a circular economy	35%	22%	30%	-	13%	-
The Circular economy: an interdisciplinary exploration of the concept and application in a global context	39%	26%	21%	14%	-	-

With this fact, the thematic linkage is emphasized of the researchers who have used each of the most relevant papers. It can be seen that, in four of the six papers, the users who have worked the most with the publications have thematic linkages to business sciences, a fact that again justifies the

importance of the circular economy from the viewpoint of business administration. In the two cases in which this outcome has not appeared in this sense, i.e., when the main consumers have different linkages than business sciences, there is very little difference with readers of business administration because there is little distance to the first ones.

Finally, we present an analysis of the data of alternative metrics obtained from PlumX Metrics, with other information rather than the uses according to Mendeley. In Table 17, we provide new information, such as blogs or posts generated in Wikipedia, and we also highlight the use made of articles on social networks [29].

First, the paper that stands out by far as the most used in social network is that occupying the fourth place in the ranking of the most important papers according to classic bibliometry. It has a prominent position with respect to the rest of the papers by the number of Tweets measured and the numbers of mentions on blogs and on Facebook. The paper that occupies the second position in terms of the relevance on social networks is the one that has this position also according to classical bibliometry. This article has appeared more times in the press and has more entries on Wikipedia than the rest of the articles.

Thus, considering the most used papers according to the alternative metrics regarding its relevance on social networks, there is a significant difference with the classic measures.

Table 17. Alternative metrics according to PlumX Metrics.

		PlumX Metrics				
Item Title	**Uses**	**Mentions to Blogs**	**Press**	**Facebook**	**Wikipedia**	**Tweets Made**
A review where to circulate economy: the expected transition tone a balanced interplay of environmental and economic systems	2520	4	1	1		2
The Circular economy: a new sustainability paradigm?	1961	2	13	3	4	6
Towards circular economy implementation: a comprehensive review in context of manufacturing industry	1370	3		2		5
Conceptualizing the circular economy: an analysis of 114 definitions	760	11	4	58	1	76
Product design and business model strategies for a circular economy	1217	2	1		1	0
The Circular economy: an interdisciplinary exploration of the concept and application in a global context	4640	2	1	2	2	26
Total	12,468	24	20	66	8	115

4. Discussion and Conclusions

First, we can highlight the importance of the circular economy as a research area due to the number of publications that have been indexed in the most important bibliometric databases. This importance can be justified by comparing the results obtained with other bibliometric analyses. For example, in other similar and recent studies [30], there has been evidence of a production of 734 items during the period of 2014–2019 in the thematic field of "Urban extension"; this value is much lower than the records published on the subject of study of this work. At the same time, in other studies [31], we can observe a number of data similar to those obtained in this work. Specifically, in the area

called "Business Intelligence", during the period from 2013 to 2017, there considered 3191 documents, a number very similar to the 3391 obtained in WoS on the circular economy.

This paper offers a contemporaneous review of circular economy, by identifying the most significant authors, publications and thematic structure output related to circular economy.

Regarding the main trends of the circular economy, the study has identified a double evolution. First, we note that, in the beginning, the circular economy focused on productive aspects, but today, we observe a shift towards the importance of considering aspects of business organization and their impacts on organizational structures. This idea is based on evidence such as the most relevant publications on the subject also being currently linked to concepts of business administration, as well as the most prominent authors also having affiliations with business schools and measures linked to alternative metrics. Moreover, it is also important to point out that, within the thematic classification of WoS and Scopus publications in the field of social sciences and the organization of companies, there are several papers indexed. Second, there is a diversification of the application of the circular economy to several areas. If we analyse the strategic diagrams, we can visualize this trend towards decentralization with the emergence of new areas of interest not only focused on the initial meanings of the circular economy.

Furthermore, the authors who have published the largest numbers of documents related to the circular economy are Yong Geng, Mari Lundstrom, Phil Purnell and Fiona Charnley. The first is Chinese, the second is Finnish, and the last two are British. With the exception of the last author, with an affiliation to an institution that focuses on business management, the others are linked to the field of environmental sciences. Therefore, there is still a tendency to focus on the circular economy from the most environmental aspect and the impact of industrial production on the environment. However, it is evident that a new scientific approach can lead to a new practical application of the concepts developed from this new research. If we consider the most prolific author on the subject and not the most relevant considering the citations received, we highlight especially Yong Geng, an author from Shanghai linked to the Shanghai Jiao Tong University and specifically to the School of Environmental Science and Engineering.

With regard to the terms most used in scientific production in the field of the circular economy, there is still a certain concentration of publications around the general concept of the "circular economy", although it can be observed that, in the last years studied, there is a tendency to diversify the concepts through which research is performed. In fact, the strategic diagram of thematic relationships indicates that there is a new diversified approach to the subject. These new thematic conceptions include terms such as "Performance", "waste" and "environment", diversifying the concepts with which this published literature is identified. This trend towards diversification can also be seen from the analysis of the evolution of the thematic concentration from the strategic diagrams created for each of the years studied in the period covered in the work performed.

These elements are presented with a very significant distribution regarding the importance of the subject in Europe and China. These two environments lead scientific production on the subject. While in the European environment, the leadership of institutions that have enacted legislative provisions to encourage their development might be of some importance, in the case of China, it could also be a determined gamble to achieve higher productive performance of their business organizations. Indeed, for China, as an economy growing constantly in recent years, betting on these concepts could be based on a more focused conception towards the environmental impact of production and not only business administration. The Asian authors identified in this study have links that justify this view of the facts, if we consider their affiliation to the department of environmental science of universities (in the case of Yong Geng) or the orientation of their works to production systems in the case of Jingxing Zhao.

Some of the articles studied, especially the most relevant ones in terms of the number of citations received, have seen the government involvement of European countries and EU programmes, as well as the Chinese government, in promoting these investigations. Therefore, it seems that one of the possible explanations for this outstanding leadership is the political commitment underlying these economic

endowments that allow these studies to be performed. These commitments include international academic collaboration programmes, such as the one that enabled one of the authors of the most cited article, with an Italian affiliation, to collaborate with the Beijing Normal University (China).

Similarly, it is important to demonstrate the lack of apparent commitment of the United States of America and Canada, countries considered economic powers and members of major intergovernmental organizations, such as the G7 and G20, among others. Without the complicity of these two countries, the circular economy will barely be able to have an impact globally. It is also important to point out the lack of presence of other emerging countries, including Latin American and African countries. Therefore, it seems that greater global awareness is needed to have a global impact.

In addition, the work carried out shows that the results obtained are similar between the two databases used and that the most relevant authors are similar in the two resources consulted.

Additionally, from the thematic nodes that have been identified, we can analyse the research trends on the circular economy. Therefore, this study reveals the importance of the concentration of articles that seek to provide an overview of the circular economy and, second, an environmental view of the concept, including recycling and reuse. However, it is significant that we can observe nodes linked to more organizational and business management aspects, such as business models, and those specific to the circular economy, as well as more specific aspects, such as supply chains and production or consumer behaviour.

Performing a more accurate analysis of the most cited papers [11,15,32–35], it is noted that there are elements that indicate this transition of the importance of the circular economy from the point of view of purely environmental aspects to those more specific to organization and administration. It is relevant that the most relevant paper according to this study presents a comprehensive review of the origin and impact of the circular economy. This finding could be explained by this paper being considered as having a good origin and being a consistent and fulfilled source of information, fostering the true spread of to the concept and its implications at a more particular level.

Moreover, the definition of the scope of work is committed to provide a broader view over time on the bibliometric impact of the circular economy. Specifically, this work complements other previous bibliometric studies [22,24]. The analysis conducted in this research is broader in time and more complete methodologically speaking, both in terms of the databases used to obtain the data and in the analytic techniques used, which also include an approximation on the impact of the most relevant publications through alternative metrics. From the point of view of the evolution of the most important publications on the subject, in [22] were identified the most relevant journals: Journal of Cleaner Production and Resources, Conservation and Recycling. This study adds a new publication: Journal of Business Ethics. This finding is very important since it is noted that the circular economy is being approached from the point of view of business and business administration, opening the approach to the discipline by researchers, and it is no longer only studied from the fields of environmental and natural sciences but also from business management.

Based on a historical reading of the complementarity between the study carried out and previous ones [22,24], China continues to play a prominent role as a country that has worked in this area of knowledge by editing documents on the subject, but now other geographical places are also added that have relevance. This change highlights the relevant roles of the Netherlands, Italy, the United Kingdom and Sweden, confirming the importance of the discipline at the European level.

Classic and alternative metrics have been used in the analysis of the data. Differences can be seen between the two metrics used, which alter the order of importance of the most important papers with respect to the uses and their relevance in terms of social networks.

On the one hand, this study highlights the importance of the circular economy as an area of knowledge and, on the other hand, provides evidence that this discipline is evolving from scientific application to practice. In this context, and considering the revision of the papers that have been highlighted in this study as the most important, we observe different future trends of the circular

economy linked to business management can be pointed out, in addition to the scientific and political implications.

In the field of practical implementation in business organizations, it is important to encourage the transformation of production systems that are currently poor in considering ecological aspects and the circular economy in their ordinary functioning. The public sector and administration should play an important role in promoting this commitment. Moreover, it is also important to highlight the connection of the circular economy and the so-called sharing economy with innovation in companies to render the impact positive and to improve the benefits to organizations. In addition, to articulate this implementation of the circular economy it is necessary that, in companies, all stakeholders commit to their impulses and allow for increases in their operational efficiency. It will be important to determine the practical implications in companies for the adoption of the circular economy in their business models and to analyse how this commitment impacts the management of resources (productive, human and technological) and the companies' own structures to continue to be viable for both owners and shareholders and for the environment in which they operate. However, each application will have to be particular to each particular company or industry.

In the scientific field, an effort must be undertaken to guide a transformation that emphasizes the impacts of the circular economy on businesses and consumer models—not only on the sale of products, but also on a more global and holistic vision focused on the sale of services. It also highlights the need to promote research on the circular economy and to achieve greater dissemination of it. It is also important to build a consistent theoretical corpus on the practical implications of the circular economy for business administration.

In the political-administrative sphere, it is urgent to increase the commitment to the circular economy of Europe's producers and consumers, with the aim of replicating this impact on European public policies. As a result of these elements, an effort must be undertaken to promote more rational consumption among consumers and to know more about how they consume. In addition, a significant effort is needed to promote regulatory and legislative frameworks that ensure the expansion of the circular economy by rendering companies competitive and profiting from their activity, but with an overall vision of community benefit.

With regard to the limitations of the study performed, the study highlights the dynamics of accounting for the bibliometric importance of the articles using traditional metrics. Bibliometric indices always perform analyses retrospectively, so to provide an approximation of the relevance of the most recent publications, we must wait for the publication of new indices, in which the citations of the articles that have been published today are collected.

In the future, this study could be extended by including a previous and later time period with that considered in this research. It could also be complemented by a qualitative approach to the circular economy through an expert panel composed of relevant people on the subject, identified from this bibliometric analysis.

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