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The panorama of the circular economy in Brazil: a bibliometric study

O panorama da economia circular no Brasil: um estudo bibliométrico

El panorama de la economía circular en Brasil: un estudio bibliométrico

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Marcelo Miguel da Cruz
ORCID: https://orcid.org/0000-0001-6356-1196
Federal University of Rio de Janeiro, Brazil
E-mail: marcelo.cruz@pep.ufrj.br
Douglas Rosa Grillo
ORCID: https://orcid.org/0000-0003-4703-4892
Fluminense Federal University, Brazil
E-mail: douglasgrillo@id.uff.br
Daniel Pires da Luz Júnior
ORCID: https://orcid.org/0000-0001-8668-798X
Fluminense Federal University, Brazil
E-mail: daniel_pires@id.uff.br
Francisco Santos Sabbadini
ORCID: https://orcid.org/0000-0001-5303-9409
Rio de Janeiro State University, Brazil
E-mail: franciscosabbadini@gmail.com
Rodrigo Goyannes Gusmão Caiado
ORCID: https://orcid.org/0000-0002-3290-8385
Pontifical Catholic University of Rio de Janeiro, Brazil
E-mail: rodrigocaiado@puc-rio.br

Abstract
The circular economy is a new area of knowledge and has been gaining interest from researchers, government and industries due to the impact generated by the current consumption model that has been degrading the ecosystem in the face of the challenge generated by climate change. In this research, a bibliometric analysis was carried out in order to evaluate the trends and characteristics of scientific publications on the subject. Bibliometric data were obtained by consulting the scientific databases Scopus and Web of Science, which in turn were analyzed by the authors, and only articles that were related to the main research topic were considered. The results were compiled, analyzed and presented in the form of figures, graphs and tables – generated by using Microsoft Excel and VOSviewer software for the construction of some illustrations. Finally, the study allowed us to conclude that research on circular economy is incipient, in terms of scientific research, particularly in the Brazilian context, despite a slight growth in the number of publications related to the topic in recent years. Another aspect that can be seen was that the largest number of publications focuses on issues related to the technical cycle, with room for advances in biological cycle themes, especially in the Brazilian case, due to its biological biodiversity.
Keywords: Bibliometric analysis; Circular economy; Brazil; Scopus; Web of science; VOSviewer.

Resumo
A economia circular é uma nova área de conhecimento e vem ganhando interesse de pesquisadores, governo e indústrias devido ao impacto gerado pelo atual modelo de consumo que vem degradando o ecossistema diante do desafio gerado pelas mudanças climáticas. Nesta pesquisa, foi realizada uma análise bibliométrica a fim de avaliar as tendências e características das publicações científicas sobre o tema. Os dados bibliométricos foram obtidos por meio de consulta às bases de dados científicas Scopus e Web of Science, que por sua vez foram analisadas pelos autores, sendo considerados apenas artigos que estivessem relacionados ao tema principal da pesquisa. Os resultados foram compilados, analisados e apresentados em forma de figuras, gráficos e tabelas – gerados com o uso do software Microsoft Excel e VOSviewer para a construção de algumas ilustrações. Por fim, o estudo permitiu concluir que as pesquisas sobre economia circular são incipientes, em termos de pesquisa científica, principalmente no contexto brasileiro, apesar de um leve crescimento no número de publicações relacionadas ao tema nos últimos anos. Outro aspecto que pode ser observado foi que o maior número de publicações enfoca questões relacionadas ao ciclo técnico, havendo espaço para avanços nas temáticas do ciclo biológico, principalmente no caso brasileiro, devido à sua biodiversidade biológica.
Palavras-chave: Análise bibliométrica; Economia circular; Brasil; Scopus; Web of science; VOSviewer.

Resumen
La economía circular es una nueva área de conocimiento y ha ido ganando interés por parte de investigadores, gobierno e industrias debido al impacto generado por el actual modelo de consumo que ha ido degradando el ecosistema ante el desafío generado por el cambio climático. En esta investigación se realizó un análisis bibliométrico con el fin de evaluar las tendencias y características de las publicaciones científicas sobre el tema. Los datos bibliométricos se obtuvieron mediante la consulta de las bases de datos científicas Scopus y Web of Science, que a su vez fueron analizadas por los autores, y solo se consideraron los artículos que tuvieran relación con el tema principal de la investigación. Los resultados fueron recopilados, analizados y presentados en forma de figuras, gráficos y tablas, generados mediante el uso de Microsoft Excel y el software VOSviewer para la construcción de algunas ilustraciones. Finalmente, el estudio permitió concluir que la investigación sobre economía circular es incipiente, en términos de investigación científica, particularmente en el contexto brasileño, a pesar de un ligero crecimiento en el número de publicaciones relacionadas con el tema en los últimos años. Otro aspecto que se puede ver es que el mayor número de publicaciones se centra en temas relacionados con el ciclo técnico, con espacio para avances en temas de ciclo biológico, especialmente en el caso brasileño, debido a su biodiversidad biológica.
Palabras clave: Análisis bibliométrico; Economía circular; Brasil; Scopus; Web of science; VOSviewer.

1. Introduction

The impact of human consumption of materials and energy on the environment has gained greater relevance in recent decades, with pollution being an emergency to be resolved, since the generation of waste is one of its main factors (Barboza et al., 2019). One of the main themes about sustainability that has been worrying not only specialists, but humanity as a whole, is the search for alternatives to the linear model of production-consumption-disposal (Silva et al., 2021).

Today's linear "take, make, dispose" economic model, which relies on vast amounts of cheap and easily accessible materials and energy, has been at the heart of industrial development and has generated an unprecedented level of growth (EMF, 2015). From the business point of view, it is a model that is based solely on cost reduction, in the short term, and does not privilege the generation of differential values in the market, such as more durable and better quality services and products (CNI, 2018). Several factors indicate that the linear model is being increasingly challenged by the very context in which it operates, and that a deeper change in the operating system of our economy is needed (EMF, 2015).

In this context, according to EMF (2015), the circular model of growth, decoupled from the consumption of finite resources and capable of delivering resilient economic systems, is increasingly seen as the next wave of development, precisely because it has an unprecedented favorable alignment of technological and social factors that would make the transition to a circular economy possible at scale. According to CNI (2018), for this transition to actually occur, some changes in mindset (mental model) are necessary in the following elements: scope; premise; value offer; focus; personas; ethics and role.

The circular economy can be defined as a concept whose implementation requires the reduction of consumption of raw materials and energy, so that they can be easily reinserted into the production system, with the lowest possible entropy (Kuzma et al., 2020). Already according to Gregson et al. (2015), the circular economy emerges as a form of moral economy, with right and wrong ways to keep materials circulating around the planet and the economies of the world.

The pioneer in implementing the circular economy concept was Germany, in 1996, through the approval of a law on the management of toxic substances and closed-loop waste management (Sehnem & Pereira, 2019). In several countries, especially China, the United States and countries in the European Union, the mobilization and stimulus for the awakening of the circular economy produces visible effects of rationalization of production processes (Kuzma et al., 2020). In other words, the adoption of circularity measures, in addition to offering benefits to the environment, emerge as an attempt to improve and/or optimize the current production processes existing in the world.

In view of the above, the importance of compiling and analyzing the good practices implemented grows, as well as the opportunity to study the level of publication about them - identifying trends, the predominance of certain research areas, the sectors that have a greater number of studies and research on the circular economy.

For example, bibliometric studies on circular economy in the context of certain countries and regions of the world, such as the work of Kuzma et al. (2020), which quantitatively deals with the scientific contribution derived from publications on the subject. However, there is a lack of studies that consider Brazil as the main object of analysis.

According to Abdalla and Freire Sampaio (2018), in Brazil and South America, the concept of Circular Economy is still incipient and the incorporation by public policies in industrial production processes is moving slowly. Thus, in this scientific research, Brazil, for being a country with continental dimensions within South America, is highlighted as an object of study and analysis.

Thus, given this gap, this study seeks to answer the following central research question: What has been researched internationally in terms of the circular economy in the Brazilian context? The general objective is: to quantitatively identify, in the international literature (via searches of the Web of Science and Scopus scientific bases), the production of research related to the circular economy in the Brazilian context, in order to present an overview.

For the structuring of this research, bibliometrics was the method of analysis chosen, since the data regarding the scientific research found were treated in a predominantly quantitative way. Bibliometrics can help identify trends in knowledge growth in a given discipline, dispersion and obsolescence of scientific fields, more productive authors and institutions, and journals most used in the dissemination of research in a given area of knowledge (Soares et al., 2016).

In view of the above, this article is structured as follows. In section 1, the studied problem and the research objective are contextualized and introduced. In section 2, the theoretical form and the main issues involved with the central theme and object of study of this research are based. In section 3, the methodology used and the steps performed are described. Sections 4 and 5 present, respectively, the general and specific results (by cycles) of the bibliometric research, as well as the discussion about them based on the analyzed scientific production. Finally, section 6 presents the conclusions, final considerations and a list of suggestions/proposals for future research related to the topic.

2. Theoretical Foundation

In this section, the fundamentals related to the concepts of circular economy and their biological and technical cycles are presented, in order to conceptually support the research. Given the focus of this research, a description of the circular economy in Brazil will also be made.

2.1 Circular Economy

With the industrial revolution, the production processes were configured in a linear way, in which natural resources were extracted and from these a material good was produced, then, after use or consumption, they were incorrectly discarded in the environment (Maia et al., 2021).

Regardless of the origin of the term, the circular economy contains ideas from different schools of thought, and its roots can be traced back to the 18th century and the first economic theories that emerged in that period (Sehnem & Pereira, 2019). The concept of a circular economy has recently emerged as a policy objective in the context of rising resource prices and climate change (Gregson et al., 2015). However, the way of thinking in relation to circularity, refers to more remote times.

In an article, where 114 definitions of circular economy were analyzed, Kirchherr et al., 2017, p.229, concluded that conceptually the circular economy can be defined as:

> [...] an economic system that replaces the concept of "end of life" with reduction, alternative reuse, recycling and recovery of materials in production/distribution and consumption processes. It operates at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the

aim of achieving sustainable development while simultaneously creating environmental quality, prosperity and equity society for the benefit of current and future generations. It is enabled by new business models and responsible consumers.

A circular economy addresses the growing resource-related challenges for businesses and economies and can generate growth, create jobs and reduce environmental impacts, including carbon emissions (EMF, 2015). In other words, as the principles and ideas related to the circular economy are implemented, new business opportunities arise beyond the simple environmental appeal.

In its report, EMF (2021), cites that the circular economy contributes to the fulfillment of at least 12 (twelve) goals among the 17 (seventeen) Sustainable Development Goals (SDGs) listed by the United Nations (UN), the know: 1 – No poverty; 2 – Zero hunger; 3 – Good health and well-being; 4 – Quality education; 5 – Gender equality; 6 – Clean water and sanitation, 7 – Affordable and clean energy; 8 – Decent work and economic growth; 9 – Industry, innovation and infrastructure; 10 – Reduced inequalities; 11 – Sustainable cities and communities; 12 – Responsible consumption and production; 13 – Climate action; 14 – Life below water; 15 – Life on land; 16 – Peace, justice and Strong institutions; 17 – Partnerships for the goals.

The circular economy implies systemic and continuous change, and requires extensive cooperation between companies, the production chain, governments, universities and consumers (Kuzma et al., 2020). However, for the current concept of circular economy, each business model has one or more elements that, through the different stages of transformation, add value to their products sold and/or services provided, forming a supply chain.

The contemporary understanding of the Circular Economy and its practical applications in economic systems and industrial processes has evolved to incorporate different characteristics and contributions from a variety of concepts that share the idea of closed loops (Geissdoerfer et al., 2017).

Closing cycles in the production system reduces negative environmental externalities and increases positive environmental effects, such as reducing disposal activities through reuse of waste, recycling materials and components, and remanufacturing products (Kuzma et al., 2020). It should be noted that this must be valid for both the biological cycle and the technical cycle, since the circular economy must be considered in a systemic way.

2.1.1 Biological cycle and technical cycle

According to EMF (2015), a circular economy is one that is restorative and regenerative by design and aims to keep products, components and materials at their highest utility and value at all times, distinguishing between technical and biological cycles. That is, there is a division as to the characteristics and origins of the materials. The materials in the circular economy model are divided into technical and biological nutrients (Ribul et al., 2021).

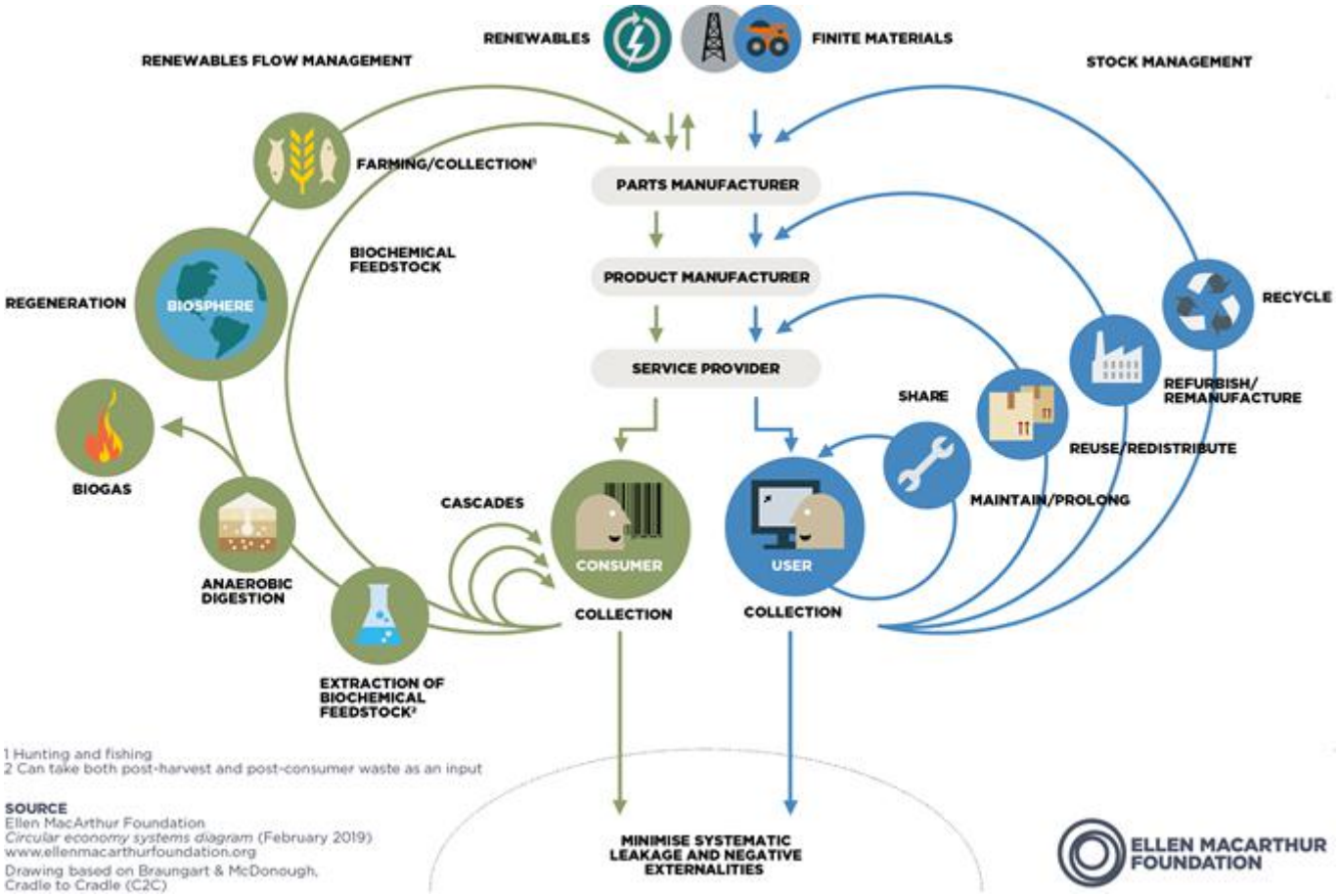
In view of this understanding, the existing differences in relation to the origins of the raw materials involved in the transformation stages are questioned, as well as the destination of waste generated along the various supply chains, as these can be of biological origin (through extraction of elements present in nature itself - renewable natural resources), or coming from other unlinked production chains (through the extraction of finite materials from nature or the acquisition of by-products from other production processes - extraction of natural resources / transformation industry). Thus, there is a need to distinguish these two cycles in different segments, one focusing on renewable natural resources and the other focusing on finite natural resources.

Thus, in this context, Navare et al. (2021) differentiate cycles as follows: while technical cycles involve the management of non-renewable stocks of abiotic resources and material flows that cannot be adequately returned to the

biosphere, cycles Biological resources contain the streams of renewable biotic resources that can safely circulate in and out of the biosphere.

These cycles are illustrated through the graphical representation called Systems Diagram of the Circular Economy (also known as “butterfly diagram”), as shown in Figure 1, below.

Figure 1 - Circular economy systems diagram (circular economy butterfly diagram).



Source: EMF (2022).

That is, on the one hand, there is a cycle with less human intervention, called the biological cycle. Whereas, biological cycles contain the flows of renewable biotic resources that can safely circulate in and out of the biosphere (Navare et al., 2021). And on the other hand, a cycle dependent on human intervention, the technical cycle. In which, according to Navare et al. (2021), abiotic resources are finite and therefore technical cycles are designed so that resources can be returned to the technosphere for as long as possible.

2.1.2 Circular economy and Brazil

The principles behind the circular economy are not completely new in Brazil and have started to emerge in pockets of activity in all regions of the country. Companies and other organizations see these principles as driving innovation factors with proven potential to create value and as an opportunity to differentiate themselves in the marketplace, even in times of economic turmoil and budgetary constraints (EMF, 2017).

In line with the global demands that define the circular economy as one of the ways to advance in sustainability, companies headquartered in Brazil have advanced in the development of initiatives that combine economic growth with the

efficient and rational use of resources (Silva et al., 2021). The relationship between sustainability and circular economy is intrinsically established by the socio-environmental and economic concern character shared by both areas (Kuzma et al., 2020).

In this way, it can be seen that Brazilian companies, as well as companies around the world, would not only be aiming at sustainability, but also a series of business opportunities. However, on the other hand, consumers are increasingly demanding in terms of product quality and the responsibility of these same companies regarding the management of waste generated by their production processes. These are two important aspects for companies to deal with more carefully, in case they are also engaged in raising their degree of differentiation from their competitors.

In today's economic environment, competition for new markets is increasingly fierce and consumers' perception of sustainable and affordable products is increasing rapidly (Do Amaral et al., 2018). Thus, given this scenario, initiatives, projects and solutions involving the circular economy have been drawing the attention of both the government and the Brazilian business community, becoming an object of interest. However, in Brazil, most initiatives aimed at adopting ideas of circularity come from Non-Governmental Organizations (NGOs) or institutes linked to the private sector. That is, the initiatives occur mostly in isolated ways.

However, according to Abdalla & Freire Sampaio (2018), there are records of the involvement of academic sectors in supporting research development and creating products incorporated into the biological cycle from renewable and biodegradable resources.

For EMF (2017), Brazil, due to its unique market and social characteristics and incomparable natural capital, is an attractive scenario for exploring opportunities that the circular economy could bring to the construction of economic, social and natural capital.

2.3 Bibliometrics

Bibliometrics has been used as a method of quantitative analysis for scientific research (Soares et al., 2016). According to Guedes & Borschiver (2005), bibliometrics is also a quantitative instrument, which allows minimizing the subjectivity inherent to the indexing and retrieval of information, producing knowledge in a given subject area.

Statistical data prepared through bibliometric studies measure the contribution of scientific knowledge derived from publications in certain areas (Soares et al., 2016); being a widely used tool for identifying research trends and/or identifying possible gaps on a given subject.

In this sense, bibliometrics makes it possible to observe the state of science and technology through all the scientific production recorded in a data repository (Soares et al., 2016). Ultimately, it contributes to decision making in information and knowledge management, as it helps in the organization and systematization of scientific and technological information (Guedes & Borschiver, 2005). In this way, bibliometrics, through the application of its techniques, allows the construction of a scientific panorama about what one wants to research or know in more depth.

3. Research Methodology

In this section, the methods used and the methodological approach used in carrying out this research will be described, including the following steps: definition of appropriate search terms in the scientific databases, the results obtained through searches in the Scopus and Web of Science scientific databases, the steps used to refine the research (filters applied and the data obtained at each advance) and finally, the list of questions and analysis criteria to which the data referring to the selected documents were submitted in the subsequent procedures of bibliometric analysis.

3.1 Search terms definition

The Scopus and Web of Science databases were chosen to carry out the searches for this research, as they bring together millions of scientific publications, because they are sources frequently consulted and cited by several researchers around the world and because they are aligned with the purpose of this research.

Based on the central question of the present work, initially, the following keywords were defined to carry out the searches: “circular economy”, “circular”, “economy”, “Brazil” e “Brasil”. Based on the combinations between the words, it was possible to arrive at the following search syntax (string) for carrying out searches in the Scopus (Elsevier) and Web of Science databases: (("circular economy" OR (circular* AND econom*)) AND (Brazil* OR Brasil*)).

Due to some particularities between the bases, in particular the difference between the initial search field in their home pages of the Web (worldwide network of computers), the following adjustments were made in the advanced search mode of both bases: while in the base Scopus was used the following search syntax, TITLE-ABS-KEY ((("circular economy" OR (circular* AND econom*)) AND (Brazil* OR Brasil*))), in the Web of Science database, the syntax, (TS=(("circular economy" OR (circular* AND econom*)) AND (Brazil* OR Brasil*))), in which the term 'TS' refers to what the base itself defines as ‘Topics’, which in turn covers the same topics that were searched in the Scopus database as ‘TITLE-ABS-KEY’ in your search algorithm.

The addition of the ‘*’ symbol was used at the end of the terms ‘circular’, ‘econom’, ‘Brazil’ and ‘Brasil’, in order to allow the search for words that were in the plural or that had suffix variations, such as for example: ‘circularity’, ‘economies’, ‘brazilian’ and ‘brasileiro’. And also to allow the search syntax to search for documents that understood these terms in both English and Portuguese, only considering this plural or suffix variation, by including the symbol ‘*’ at the end of the listed terms. These adjustments were made so that the searches were performed under the same conditions in terms of parameters and searched fields in both bases: titles (Title), abstracts (Abstract) and keywords (Keywords).

3.2 Initial search results

Using the search syntax described in the previous section, on October 11, 2021, a survey by titles, abstracts and keywords was carried out on the documents available in the Scopus and Web of Science databases, without restriction as to the year of publication, finding a total of 406 documents, as illustrated in Table 1.

Table 1 - Number of documents found in scientific databases

Scientific Database	Search Syntax	Qty. Documents
Scopus	*TITLE-ABS-KEY* (((“*circular economy” OR* (*circular** *AND econom**)) *AND* (*Brazil** OR Brasil*)))	224
Web of Science	(TS=((*“circular economy” OR* (*circular** *AND econom**)) *AND* (*Brazil** *OR* Brasil*)))	182
Total		406

Source: Authors.

Thus, in view of the initial results obtained and in order to meet the research objectives, advanced filters were then applied to both databases, in order to refine the research.

3.3 Research refinement

The filters and syntaxes used in the advanced search, in both bases, are described below, where the authors applied the

document type filter (document type), restricting themselves to only documents of the 'article' or 'conference paper' type, reaching the amount of 357 documents after this filtering. Additionally, documents were filtered, restricting them to only documents published in English or Portuguese, reaching a total of 356 documents (ie, 1 document was excluded).

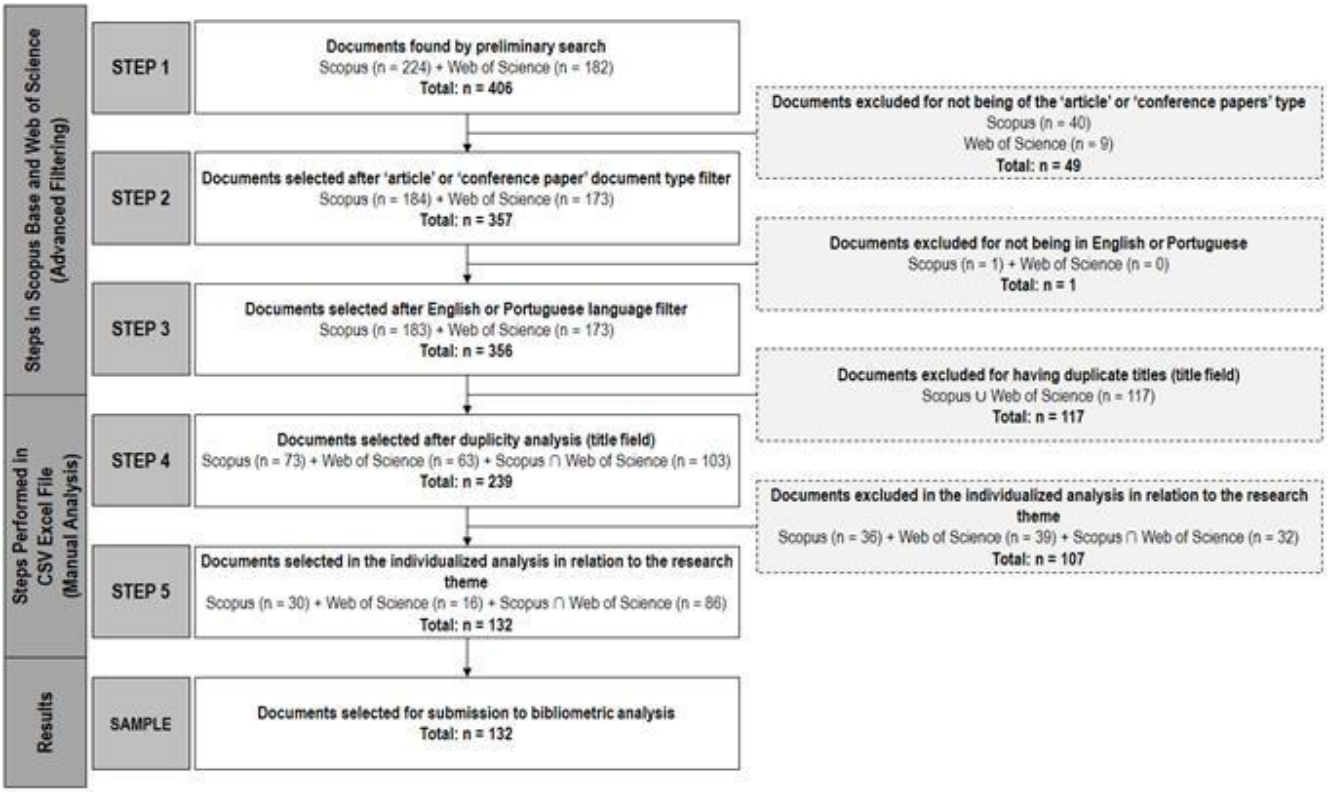
Thus, for the research phase of documents in the scientific bases, the following search syntaxes were arrived at: Scopus - TITLE-ABS-KEY ((("circular economy" OR (circular* AND econom*)) AND (brazil* OR brasil*))) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "cp")) AND (LIMIT-TO (LANGUAGE, "English") OR LIMIT-TO (LANGUAGE, "Portuguese")); Web of Science - (TS=((“circular economy” OR (circular* AND econom*)) AND (Brazil* OR Brasil*))) and Proceeding Paper or Article (Document Types) and English or Portuguese (Languages).

In a complementary way, in order to analyze only documents that were actually related to the research theme, data was extracted in an electronic spreadsheet in Microsoft Excel® format (.CSV) in the Scopus database and in a file in the notepad format (.TXT) in the Web of Science database – being then transferred and formatted in a Microsoft Excel® spreadsheet.

The unification of the data in a single worksheet allowed an individualized analysis of the publications, such as the identification of repeated documents, where 234 coincident lines were found, which in turn were eliminated, resulting in 117 coincident documents and 136 exclusive documents (73 documents from the Scopus database and 63 documents from the Web of Science database).

After creating the worksheet, an individual analysis of the articles was performed, verifying that each of the documents was related or not to the research theme ('circular economy' and 'Brazil') - where 107 documents were eliminated based on the analysis of the authors. In the end, after the filters were applied, it was possible to reach a total of 132 documents related to the research topic and enabled for bibliometric analysis. See Figure 2, below.

Figure 2 - Research strategy.



Source: Authors.

The documents excluded for not being adherent to the main theme of this research, were documents that discussed research on circular DNA, machines and industrial equipment of circular formats, biological areas, *Hevea brasiliensis* (rubber tree), mineral studies, social issues, domestic violence, geology, agriculture and health in general.

3.4 VOSviewer

The choice of a software for the treatment of bibliometric data was part of one of the steps of the methodology used. In order to make the processing and analysis of the data viable in a systematic way, as well as to make it possible to establish correlations between the data found via searches of the scientific bases, on which such research is based, the VOSviewer software was selected, because it has functionalities that facilitate the treatment of this data.

According to Van Eck & Waltman (2010), VOSviewer is a program developed for the construction and visualization of bibliometric maps, freely available to the research community (at www.vosviewer.com). It allows you to create maps for bibliometric network analysis based on data extracted from Scopus, PubMed, and Web of Science databases (Correa & Machado, 2018). Thus, due to these features, the software was selected for the construction of part of the graphs that illustrate the results obtained during the development of this research.

4. General Results

After carrying out the steps outlined in the previous section, it was identified that scientific research on the term circular economy in the Brazilian context is still at an early stage.

The following sections present the results of the compilations and analyzes carried out regarding: number of publications on the subject in recent years, main journals, main authors, economic sectors, research institutes and institutions, in addition to the countries most involved with the theme.

4.1 Distribution of documents published by scientific basis

When analyzing Table 2 and Figure 3, which show the number of articles found in the Scopus and Web of Science databases, it is highlighted that most of them, 65.15% (86 articles out of a total of 132) were found in both bases. See the intersection illustrated in the Venn diagram represented in Figure 3, below. In addition, 22.72% (30 articles out of a total of 132) were found only in the Scopus database and 12.12% (16 articles out of a total of 132) were found only in the Web of Science database.

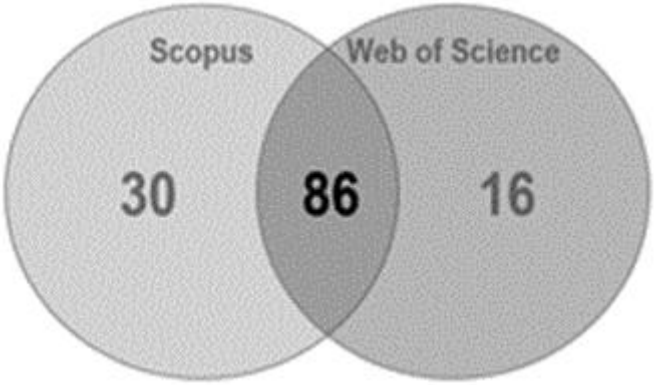
Table 2 - Distribution of the number of documents found in the scientific databases.

Distribution	***Scopus***	***Scopus ∩ Web of Science***	***Web of Science***
Qty. Documents by Basis	30	86	16
Total Documents		Σ = 132	

Source: Authors.

As previously mentioned, the intersection shown in Figure 3 refers to the articles found in both bases.

Figure 3 - Distribution of documents found in the scientific bases researched.

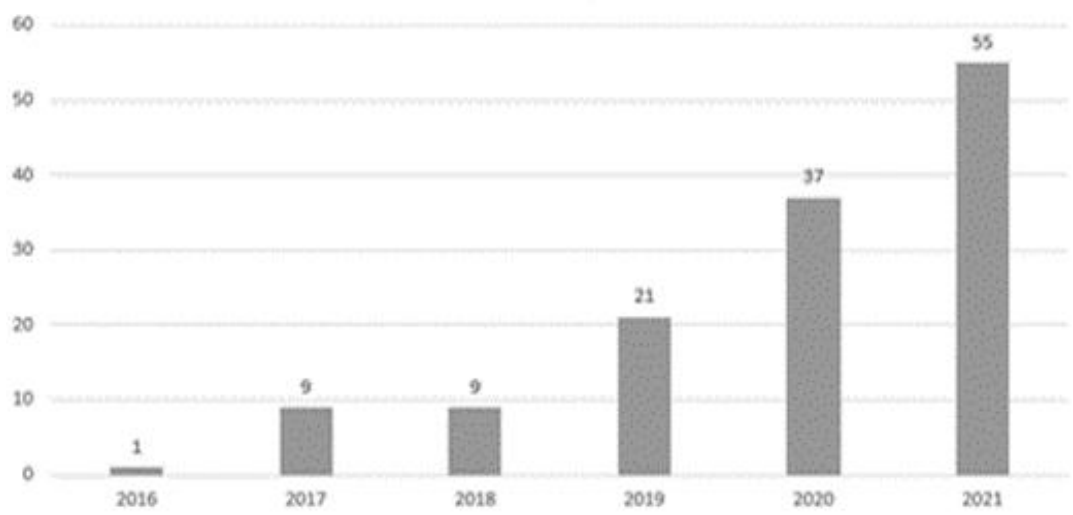


Source: Authors.

4.2 Distribution of published documents per year

When analyzing Figure 4, below, it is observed that the number of publications in 2020 reached a number of publications close to twice the number achieved in the previous year (2019). Another point that draws attention is the worldwide growth in the number of publications between 2019 and 2021, revealing the increase in attention devoted to the subject "Circular Economy and Brazil" over the period.

Figure 4 - Distribution of published documents per year.

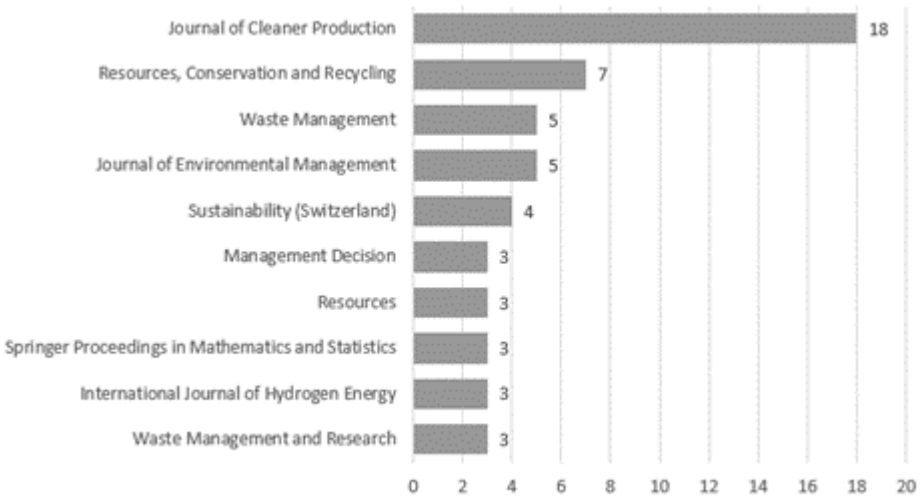


Source: Authors.

4.3 Journals / Conference Proceedings with the highest number of publications

It was found that 13.63% (18 documents) of the research found are present in the 'Journal of Cleaner Production', while the journal 'Resource, Conservation and Recycling' presents about 5.30% (7 documents) of the publications. The other journals listed among the 10 (ten) with more than 2 (two) published documents, together hold an index of 21.97% (29 documents) of publications on the subject. In other words, the 10 (ten) journals that have the most published studies on the subject hold approximately 40.90% of the total publications found in the present study, see Figure 5, below.

Figure 5 - Distribution of documents published by Journal or Conference Proceedings.



Source: Authors.

4.4 Most cited articles

Another analysis carried out was that of the articles that contributed most to the scientific production of the circular economy area in the Brazilian context. Table 3 brings the ten most cited articles in descending order.

Table 3 - List of most cited articles (TOP 10).

Ord.	Citations	Title	Authors	Year	Journal
1	146	Scientific literature analysis on big data and internet of things applications on circular economy: a bibliometric study	Nobre G.C., Tavares E.	2017	Scientometrics
2	98	Multi-product biorefineries from lignocelluloses: A pathway to revitalisation of the sugar industry?	Farzad S., Mandegari M.A., Guo M., Haigh K.F., Shah N., Görgens J.F.	2017	Biotechnology for Biofuels
3	47	Does material circularity rhyme with environmental efficiency? Case studies on used tires	Lonca G., Muggéo R., Imbeault-Tétreault H., Bernard S., Margni M.	2018	Journal of Cleaner Production
4	44	The potential use of oyster shell waste in new value-added by-product	Silva T.H., Mesquita-Guimarães J., Henriques B., Silva F.S., Fredel M.C.	2019	Resources
5	39	Trends of natural resource footprints in the BRIC (Brazil, Russia, India and China) countries	Wu R., Geng Y., Liu W.	2017	Journal of Cleaner Production
6	37	Stakeholders, innovative business models for the circular economy and sustainable performance of firms in an emerging economy facing institutional voids	Chiappetta Jabbour C.J., Seuring S., Lopes de Sousa Jabbour A.B., Jugend D., De Camargo Fiorini P., Latan H., Izeppi W.C.	2020	Journal of Environmental Management
7	34	Improving sustainable supply chains performance through operational excellence: circular economy approach	Sehnem S., Chiappetta Jabbour C.J., Farias Pereira S.C., de Sousa Jabbour A.B.L.	2019	Resources, Conservation and Recycling
8	33	Circular economy indicators for organizations considering sustainability and business models: Plastic, textile and electro-electronic cases	Rossi E., Bertassini A.C., Ferreira C.D.S., Neves do Amaral W.A., Ometto A.R.	2020	Journal of Cleaner Production
9	31	First-mover firms in the transition towards the sharing economy in metallic natural resource-intensive industries: Implications for the circular economy and emerging industry 4.0 technologies	Chiappetta Jabbour C.J., De Camargo Fiorini P., Wong C.W.Y., Jugend D., Lopes De Sousa Jabbour A.B., Roman Pais Seles B.M., Paula Pinheiro M.A., Ribeiro da Silva H.M.	2020	Resources Policy
10	30	Remanufacturing for the circular economy: Study and evaluation of critical factors	Singhal D., Tripathy S., Jena S.K.	2020	Resources, Conservation and Recycling

Source: Authors.

Among the 10 (ten) listed publications, the works by Nobre e Tavares (2017) and by Farzad et al. (2017), published in the same year, which deal with a bibliometric analysis regarding research related to big data and the internet of things

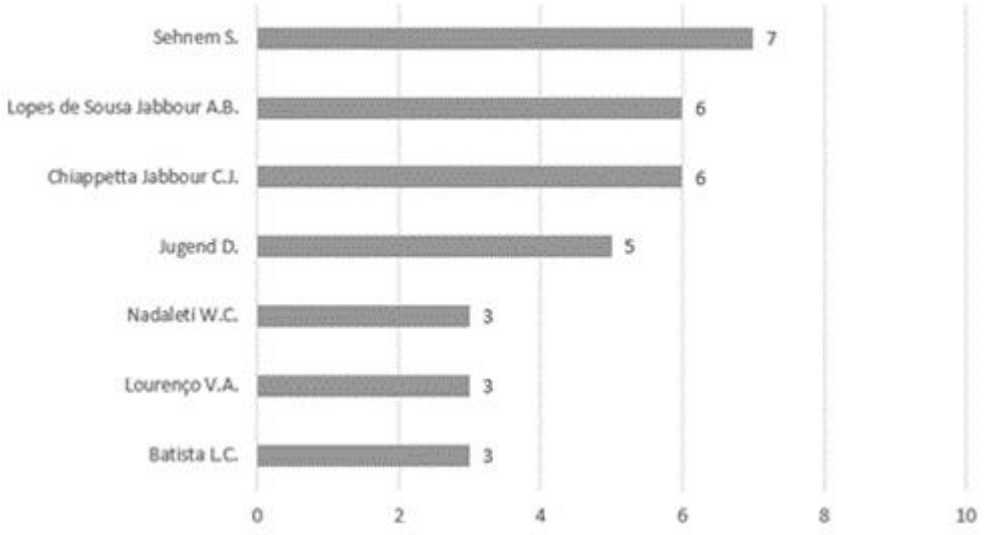
applications in the scope of the circular economy, and to multi-product biorefineries from lignocelluloses in the scope of the sugar industry, respectively.

Another important point to be highlighted in this topic is the dilution of publications in different areas (industry, technology, plastics, textiles, tires, etc.), under different methodological approaches (bibliometry, case study, framework/indicator, etc.) and the registration of 6 (six) publications with Brazilians involved in the authorship.

4.5 Authors with the highest number of publications

Regarding the authors with the highest number of publications, Figure 6, below, shows the authors with at least 3 (three) publications related to the topic.

Figure 6 - Distribution of published documents by authors.



Source: Authors.

On the other hand, when compared to Table 3, which lists the most cited publications, presented in the previous item, Figure 6, above, does not present any of the 2 (two) authors who previously stood out the most in terms of the number of citations.

However, other authors such as: Sehnem S., Lopes De Sousa Jabbour A.B., Chiappetta Jabbour C.J. and Jugend D., appear in both analyses, through the construction of joint/partnership research (in group), which can characterize a possible formation of emerging research groups, focused on the area in question.

4.6 Authors' institutions of origin (Affiliations)

Based on the institutions of origin (affiliations) of the 7 (seven) authors with the largest number of publications in the area, Table 4 was prepared below.

Table 4 - Affiliations of authors with the highest number of publications (Institutions of Origin).

Ord.	Authors	Institutions of Origin (Affiliations)
1	Sehnem S.	UNOESC - Universidade do Oestes de Santa Catarina (Chapecó, Brazil)
		UNISUL - Universidade do Sul de Santa Catarina (Florianópolis, Brazil)
2	Lopes de Sousa Jabbour A.B.	Montpellier Business School (Montpellier, France)
		University of Lincoln / LIBS - Lincoln International Business School (Lincoln, United Kingdom)
		EM Normandie Business School (Paris, France)
3	Chiappetta Jabbour C.J.	Emlyon Business School (Ecully, France)
		University of Lincoln / LIBS - Lincoln International Business School (Lincoln, United Kingdom)
		Montpellier Business School (Montpellier, France)
4	Jugend D.	UNESP - Universidade Estadual Paulista - Portal (Bauru, Brazil)
5	Nadaleti W.C.	UFPel - Universidade Federal de Pelotas (Pelotas, Brazil)
6	Lourenço V.A.	USP - Universidade de São Paulo (São Paulo, Brazil)
		UFPel - Universidade Federal de Pelotas (Pelotas, Brazil)
7	Batista L.C.	Aston University / Aston Business School (Birminghan, United Kingdom)

Source: Authors.

Once again, the presence of the names of the following authors is identified: Sehnem S., Lopes De Sousa Jabbour A.B., Chiappetta Jabbour C.J. e Jugend D.

Another point that draws attention is the presence of institutions located in different geographic regions, both in terms of different regions within Brazil itself (South Region and Southeast Region), and in terms of other countries (France and the United Kingdom). The Southern Region of Brazil is highlighted, through UFPel, located in the city of Pelotas (with two related affiliations) and the Montpellier Business School, located in the city of Montpellier in France (with two related affiliations).

4.7 Main economic sectors surveyed

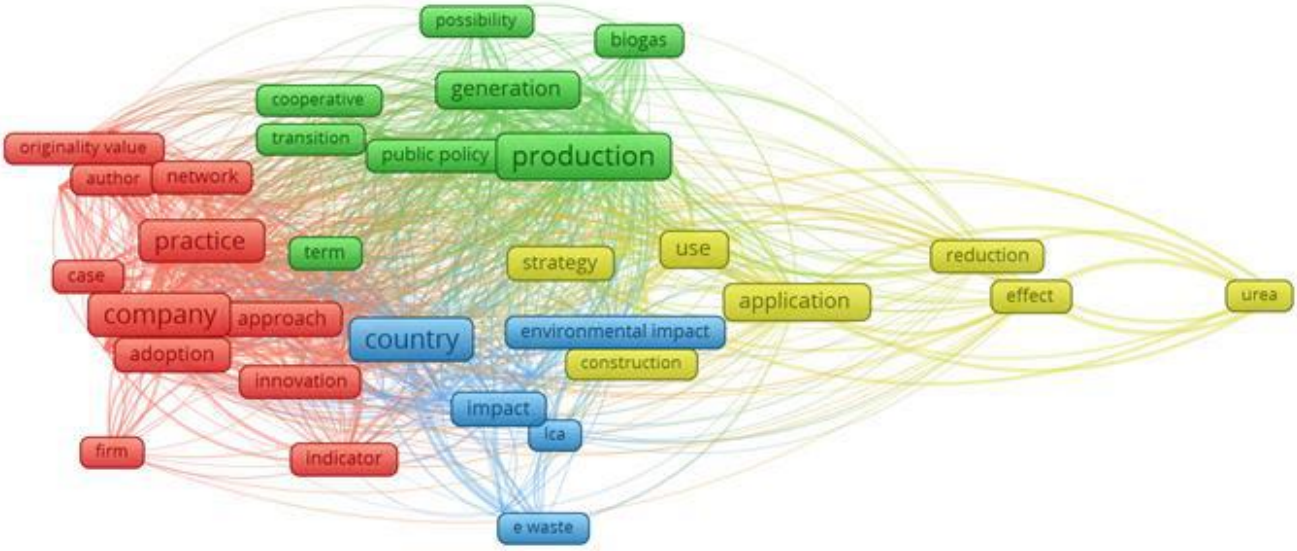
Based on the word cloud shown in Figure 7, below, elaborated through the frequency with which the terms were registered in the sectorial filter, performed by the authors during the article selection stage, based on the content analysis of the 132 selected works, it can be observed that some topics stand out. Among them: energy, cities, countries, solid waste, multi-sector and water. This suggests that the sectors that would be in vogue at the moment are these, at least in terms of related scientific research.

Figure 7 - Main sectors involving the Circular Economy.

Source: Prepared by the authors via the WordArt website.

For the construction of the map represented in Figure 8, below, a search was carried out for terms that occurred at least 10 (ten) times among the abstracts of the listed articles, where they were submitted to analysis via VOSviewer software.

Figure 8 - Terms with at least ten occurrences in the abstracts of the articles.



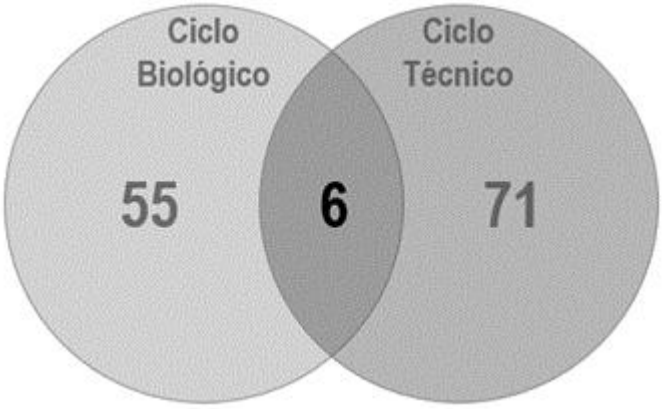
Source: Prepared by the authors via VOSviewer.

The terms were organized into 4 (four) clusters. The largest of them, represented in red, is composed of a total of 11 (eleven) terms. Analyzing Figure 8, it can be understood that this cluster contains terms related to the way of approaching the theme of the circular economy in the listed studies, as it contains terms that refer to it, such as: “approach”, “case”, “indicator” and “company”. While the second largest cluster, represented in green, is composed of a total of 9 (nine) topics, which tend to be terms related to the applicability of the area in which the studies were prepared, as it contains terms such as: “cooperative”, “generation”, “biogas”, “production” and “public policy”.

4.8 Distribution of publications by cycle

Another analysis carried out, with a view to identifying the trend of publications between the two cycles, biological and technical, was regarding the individual analysis of the articles, carried out by the authors, pointing out the affinity of each article with each of these two cycles of the circular economy. The Venn diagram, represented in Figure 9 below, shows the distribution of articles according to their affinity with each of the cycles, see below.

Figure 9 - Distribution of publications by cycle.



Source: Authors.

There is a relative concentration of the number of publications for the technical cycle, with 71 articles (about 53.79% of the total), while the biological cycle exclusively records a total of 55 articles (about 41.67% of the total). Despite this quantitative difference in articles between the two cycles, the 6 articles (about 4.54% of the total) that address both cycles must be taken into account.

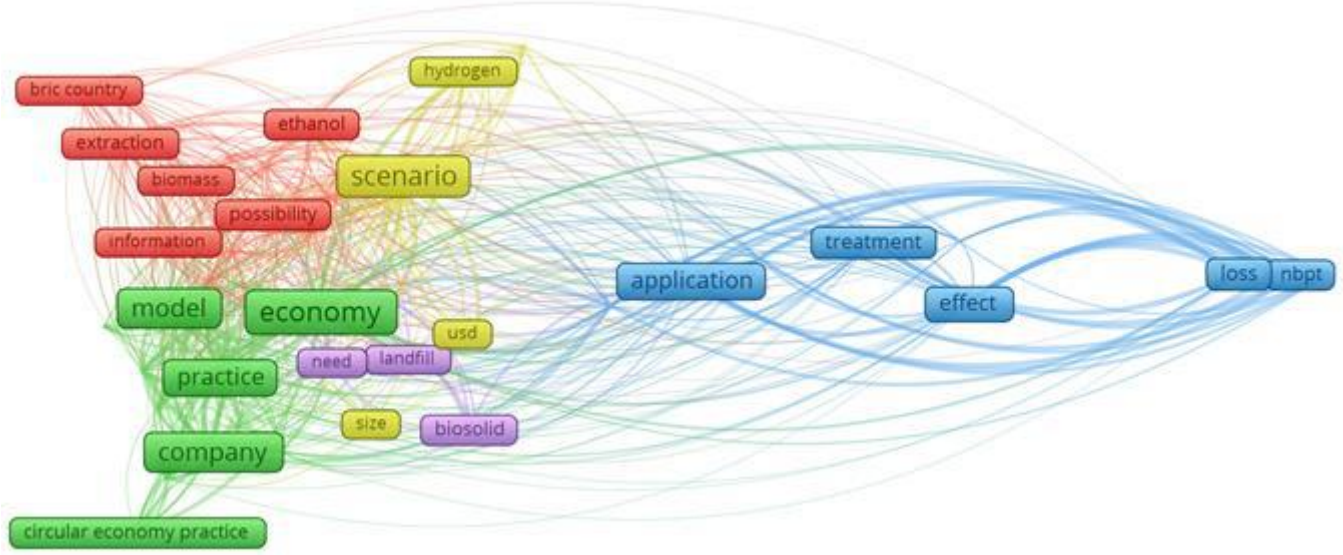
5. Specific results (by cycles)

In addition to the results presented, in this section the analyzes carried out on each of the cycles of the circular economy are presented separately, bringing their due specificities.

5.1 Occurrences of biological cycle terms

In order to obtain an overview of the topics most frequently addressed within the biological cycle, a cluster map was prepared, based on terms that occurred at least 5 (five) times in the texts of the abstracts of the listed articles, but identified by the authors as being of the biological cycle. See Figure 10.

Figure 10 - Occurrences of terms in the abstract - Biological Cycle.



Source: Prepared by the authors via VOSviewer.

It is observed in Figure 10, the term “economy”, highlighted, as being the central term of the links between the clusters. Corroborating one of the spelling elements of the term “circular economy”.

As for the formation of clusters, Figure 10 shows 5 (five) different clusters. The largest of them, formed by 6 (six) elements represented in red. This cluster presents concepts related to possible forms of energy, referencing terms such as: “ethanol”, “biomass”, “extraction” and “possibility”. While the second largest cluster, represented in green, is composed of 5 (five) items that would supposedly address concepts related to circular economy practices in organizations, since they mention the terms: “company”, “practice”, “model”, “practice” and “circular economy practice”. Another group that is evident on the map and represented in purple refers to concepts related to biosolids with the terms: “biosolid” and “landfill”.

With the most recurrent terms in the keywords of the articles classified as being from the biological cycle, a cloud of words was built excluding the term “Circular Economy”, from which some terms stood out, such as: “sustainability”, “biogas”, “Brazil”, “waste management”, “bioeconomy”, “biofuels”, “bioethanol”, “biorefinery”, “hydrogen” and “circularity” as can be seen in Figure 11.

Figure 11 - Occurrences of terms in keywords - Biological Cycle.

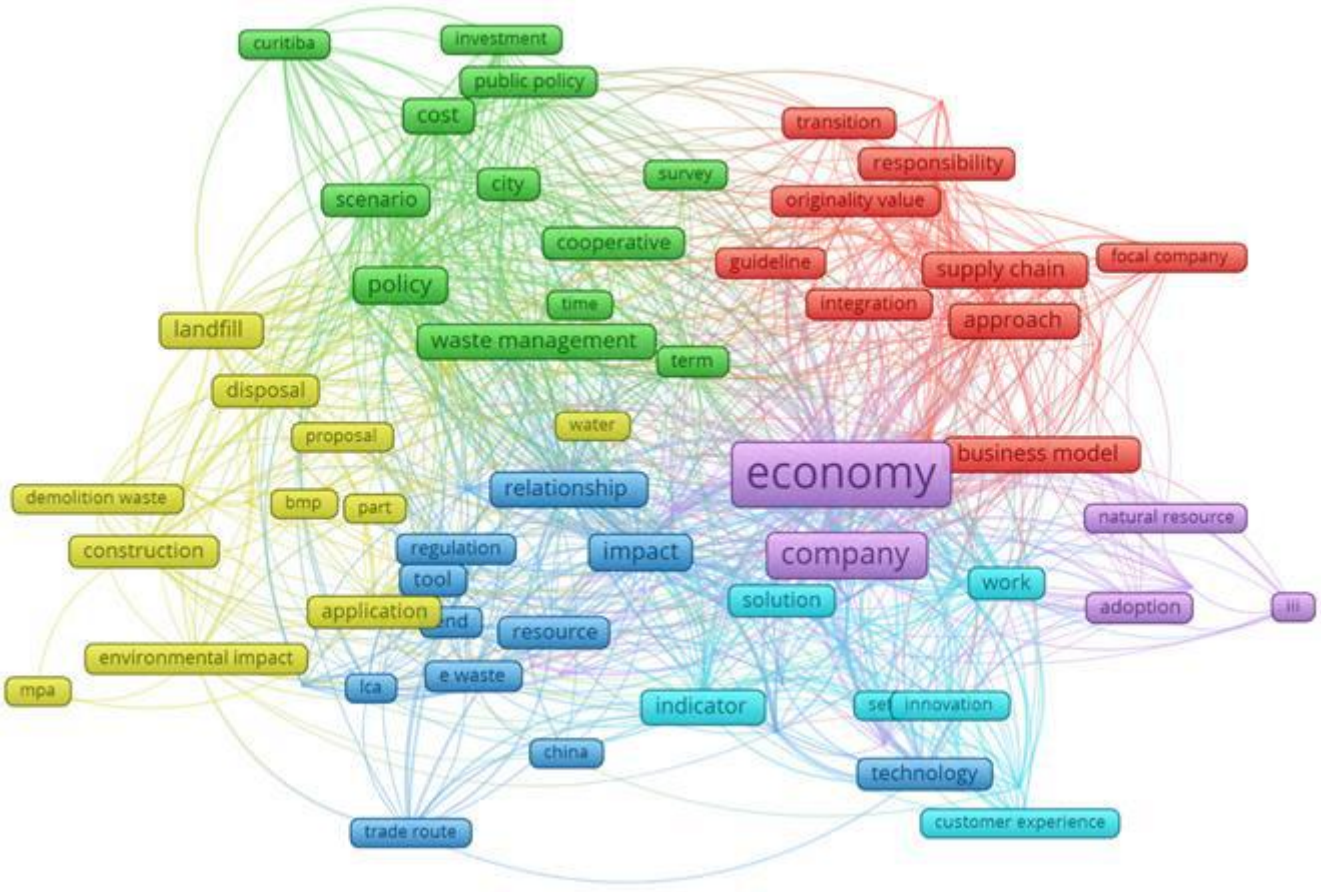
Source: Prepared by the authors via the WordArt website.

In short, through Figure 11, it is verified through the highlighted terms, for the biological cycle, that there are links related to some forms/sources of obtaining energy (such as: biogas, biofuels, hydrogen, biodiesel, bioethanol and biorefinery), which may indicate a trend of future research related to these topics.

5.2 Occurrences of terms of the technical cycle

Similarly, to the analysis carried out in the previous topic for the biological cycle, a cluster map was created, represented in Figure 12, which brings the most recurrent terms, with at least 5 (five) occurrences in the abstracts of articles classified as being from the technical cycle.

Figure 12 - Occurrences of terms in the abstract - Technical Cycle.



Source: Prepared by the authors via VOSviewer.

As in the construction of the cluster map built for the biological cycle, the central term that was also highlighted was the term: “economy”, in addition to other terms such as: “waste management”, “supply chain”, “relationship”, “construction”, “indicator” and “company”. VOSviewer organized the map elements into clusters, the largest of which is displayed in green and consists of 12 items. This cluster brings terms such as “waste management”, “public policy”, “city”, “cooperative” and “city”. Among the terms that appear in Figure 12, it is evident that some refer to concepts related to the areas of waste management, supply chain, environmental impact and construction.

With the most recurrent terms in the keywords of the articles classified as being from the technical cycle, a cloud of words was constructed, excluding the term “Circular Economy”. Some of the most prominent terms were: “sustainability”, “recycling”, “Brazil”, “E-Waste”, “waste management”, “waste pickers”, “reverse logistics”, “packaging”, “reuse” e “industry 4.0” as seen in Figure 13.

Figure 13 - Occurrences of terms in keywords - Technical Cycle.

Source: Prepared by the authors via the WordArt website.

Finally, the terms highlighted in Figure 13 indicate that the technical cycle tends to address research related to waste management and reverse logistics. In other words, solutions related to these topics may be addressed by specialists and researchers in future studies.

6. Conclusions and Final Remarks

The present research aimed to identify what has been researched internationally in terms of the circular economy in the Brazilian context, in a quantitative way, from the Web of Science and Scopus bases, establishing an overview on this topic. Thus, in view of the chosen method of analysis (bibliometrics), it was possible to answer the central question of this research, as well as to reach its general objective.

Through bibliometric and systematized analysis of the data extracted from the scientific bases consulted, the main information related to: distribution of documents published by scientific basis were discussed and presented, in the form of graphs, figures and tables; distribution of documents published per year; journals / congresses / proceedings with the highest number of publications; most cited articles; authors with the highest number of publications; authors' home institutions (affiliations); main economic sectors researched; distribution of publications by cycle; specific results (by cycles); occurrences of terms of the biological cycle; and occurrences of terms of the technical cycle.

In summary, when analyzing the bibliometric data about the scientific production related to the circular economy in the Brazilian context, it was possible to identify the current research trends, for both cycles (biological and technical), drawing an overview on the subject.

With this, it is concluded that research related to "circular economy" and "Brazil" are still few, being considered as a relatively emerging subject, at least in terms of scientific research. Since the publications found in the researched scientific bases, involving the terms “circular economy” and “Brazil”, date from the year 2016. This fact points to a delay, at least in the Brazilian context, in the face of such an important and debated theme by specialists in the area (who seek solutions that involve

sustainable options in several areas, including circularity).

Among the fields of activity found during the research, most of the analyzed studies cover topics related to energy, civil construction, solid waste, agriculture, cities, plastics, biofuels and waste management.

Another research finding was the identification that the analyzed works are equally distributed among the economic sectors impacted by them (primary, secondary and tertiary) of the economy, which demonstrates a diversification of the application of the circular economy in terms of Brazil.

As for cycles, it was identified that in the biological cycle, concepts related to energy and fuels stand out, such as: biogas, bioeconomy, biofuels and hydrogen. While in the technical cycle, concepts related to reverse logistics and waste management stand out, such as: recycling, waste pickers, return of materials and packaging.

As suggestions and proposals for the elaboration of future research, it is suggested: a) the application of other tools to evaluate the panorama of the circular economy in Brazil; b) carrying out more research focused on biological cycles; c) the extension of the study carried out in this research using other search filters; and d) replicate the steps of this research to analyze other regions (eg countries or continents).

Finally, after the results presented throughout the research and the discussions carried out, it is concluded that Brazil is still at an early stage of research in relation to solutions related to the circular economy, and as an opportunity, some joint actions between universities, organizations and government can be the starting point for the dissemination of circular thinking and the consequent increase in its practice in the country.

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