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Circular economy: A brief literature review (2015–2020)

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ABSTRACT

Hitherto implemented economic mechanisms and development processes have led the planet to face numerous environmental and ecological depletion challenges. In light of this, Circular Economy emerges as an effective tool for triggering a sustainable development process. This article aims to present different perspectives and concepts of circular economy. To that end, a qualitative study was conducted and the methodology of systematic literature review was applied, so as to obtain solid knowledge about the theme, using the most recent and relevant articles. Scielo, Science Direct and Google Scholar database were the source of the articles that met the defined criteria, described in six steps: search key words; only scientific articles considered; publication between 2015 and 2020; in English; with 100 or more citations; relevant content to the theme. As a result, an extract of the researched articles and a comparison between the scientific literature on this subject is presented, showing some evolution of the aspects of the Circular Economy, such as designing of new products, emerging of new legislation and adoption by industry. Although the study was not conclusive on how the evolution of Circular Economy will take place, authors suggest future studies to assess the transition towards an economic circularity. Also, it is recommended that future studies consider case studies as a model for assessing Ciruclar Economy progress in the light of legislation and economic interests.

1. Introduction

Circular Economy (CE) emerged in the 1970s from the idea of reducing the consumption of inputs for industrial production, but it proves to be potentially applicable to any resource [23]. Through the possibility of making human activity more resilient, using the natural cycle model, CE proposes a change in the "extraction-production-disposal" paradigm of linear economy (LE), currently applied on a large scale in the industrial environment [19]. This concept has gained acceptance to address the issue of sustainability in public policies in governments such as those of the European Union (House of Commons, 2014) and has been implemented as a national development strategy in China [10].

Driven by the estimated population growth for 9 billion people by 2050 [3], severe anthropological and environmental impacts are taking place, such as the decrease in biodiversity, which worsens the ecological imbalance on a large scale [4], and the scarcity of raw materials due to the demand extraction by millions of inhabitants, which causes fluctuations in market prices and instability in the world economic system [7,19,20].

By and large, CE is based on: design of manufactured products with added value and maximum use in longer life cycles; creation of versatile products with different uses, in different periods of their useful life, thus guaranteeing the reuse of a single good; restitution of solid waste to the industrial sector in an orderly manner, where the cost of secondary raw materials from recycling is competitive in the market; as well as a systemic approach to supply chain management, evaluating the interconnections between the energy produced, the extracted material, and the natural environment [19].

However, there is a lack of consensus on the definitions and terminologies of CE in the scientific community [13] and a deformed and dissipated relationship with other concepts in the area of sustainability [9] — such as green economy, clean production or industrial ecology [18].

Among the reasons for this study is that the systematic review will provide a background to properly position new research activities [14]. In view of this, the present work aims to establish a clear relationship among the different approaches to circular economics, through an overview of the most up-to-date and relevant scientific publications on the topic, with the specific objective of a systematic literature review. To

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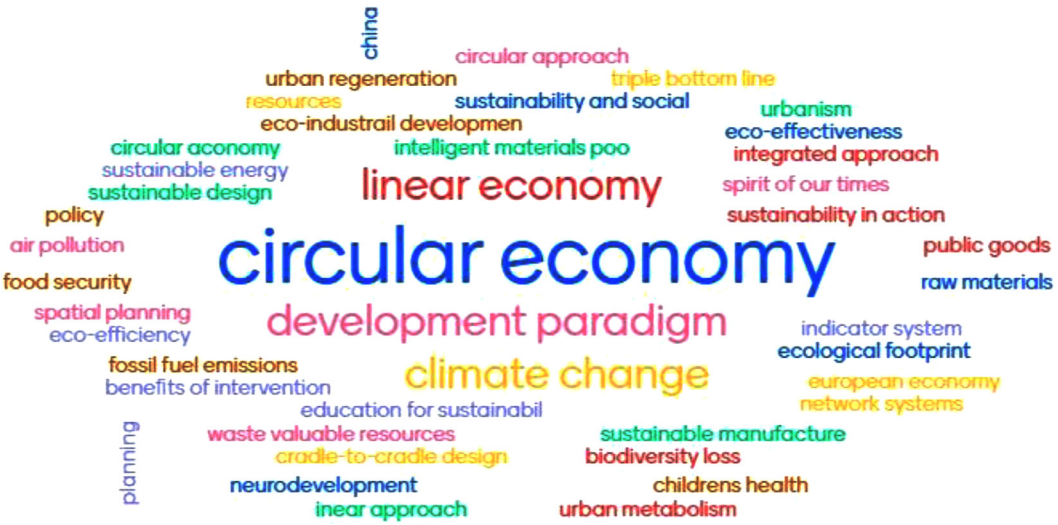


Fig. 1. Word Cloud used for selection of the literature
https://www.mentimeter.com> Accessed in June 2020,12:58.
Source: Authors (2020).

achieve the presented objectives, the methodology used is the systematic literature review, through an adaptation of Creswell [5] and Sampaio and Mancini [22], as it enables the sharing of data and evidence found in journals and bibliographic databases, and has the potential to expand these studies, thereby adding solidity to concepts already known.

2. Methodology

When an explicit and systematized method is applied to a literature review, it is possible to investigate the evidence related to some areas, topics or therapeutics in a summarized way, thus allowing comparing the results obtained by the main authors, in order to identify similarities, differences, or even gaps that will make future research possible, becoming an extremely useful tool for researchers [22].

To achieve the goals proposed by this article, a qualitative study was conducted, employing a systematic literature review, so as to obtain solid knowledge about the theme, using the most recent and relevant articles, as suggested by authors Creswell [5], and Sampaio and Mancini [22].

In analyzing the way many academics capture, evaluate and summarize the literature, Creswell [5] stated that there is not only one way of systematizing research. Following his recommendation, six steps were taken in this study.

In the first stage, to define the key words that would be used to locate the literature, it was used the formation of a word cloud through the software available on the metimeter website. All keywords found in the preliminary literature were inserted into the software. The repetition of words forms the cloud, highlighting those that are repeated most. The words in evidence were then used for a more objective selection of the literature that will be considered in this study. There was a greater incidence of the following: *Circular Economy, Development Paradigm, Linear Economy, and Climate Change*, as shown in Fig. 1.

In the second step, after creating the keyword database, the Google Scholar website was chosen – as proposed by Creswell [5]—, as well as Scielo and Science Direct, which among the options offered are those that allow the best application of filters and viewing data item by item. By applying the keywords, a total of 5491 journals were obtained.

In the third stage, journals were selected using date filters (January 2015 to January 2020), language (English only), type of bibliography (only citable scientific articles) and number of citations in other scientific articles. The minimum of 100 citations was chosen, as per Brandau, Monteiro and Braile [24], recognizes the value of the research. The said criteria was perfomed to obtain only the most recent and academically relevant articles, thus preventing any future counterpoint in the research and obtaining 46 journals in total.

The fourth step sought to characterize the list of the main themes of each article derived from the search with the theme “definition of characteristics of the concept of circular economy”, thus ensuring that each journal evaluated could contribute to the central theme, thereby avoiding the flight from the principles established at the beginning of this study, resulting in a total of 12 articles. This process is exemplified in Fig. 2.

For the fifth stage, a table was built with the titles, authors and publication date of each selected article, which provides an overview of the origin of the data obtained, as shown in Table 1.

For the sixth stage, a summary of each of the 12 selected articles was written to formulate a brief review of the main elements in the texts, which are shown in Section 3 (Results) of this article. In this stage, the formulation of the abstracts was designed in such a way that the relevant concepts on the topic be evident and amenable to comparison, in order to understand the point of view and approach of each author’s work for a global understanding of CE within the academic scenario.

3. Results and discussion

A summary is a brief review of the literature covered that allows the reader to expand on the fundamental aspects of the article [5]. By selecting the most important components, informing about the data collection method and presenting the main results obtained from each study evaluated in this paper, we could build an overview of the academy’s perspective on the circular economy. The present paper now brings the synthesis of the articles selected, organized in alphabetical order by article title:

a) *The circular economy, design thinking and education for sustainability* [1]. The author states that national production is directly associated with the industrial development arising from industrial revolutions, causing the wealth of nations to increase according to the development of technologies such as mechanization, and currently digitization, due to the process that is followed in the extraction-production-disposal principle of the linear economy. In being so, Therefore, industrial designers aim to produce aesthetically pleasing and functional objects. After the global economic collapse, product durability became a financial problem for companies, so programmed obso-

Table 1
List of evaluated articles and their main elements.

Author / Publication date	Title of article	General comparative aspects about the theme
Andrews. D, 2015	The circular economy, design thinking and education for sustainability	It incorporates the concept of biomimetics - "an approach to innovation that seeks sustainable solutions to human challenges, emulating the patterns and strategies tested by nature's time" - to EC through a parallel with bio-geochemical cycles.
[17]	Towards circular economy implementation: a comprehensive review in context of manufacturing industry	It divides academic works on CE into three different perspectives according to the motivation of the publication: scarcity of resources (energy and material consumption); environmental impact (solid waste, landfills, emissions or pollution); and economic benefits (financial aspects, such as cost reduction, increased revenue or gross domestic product.
[2]	The emergence of circular economy: a new framing around prolonging resource productivity	It defines CE as an umbrella concept, which encompasses other concepts based on resource life-extension strategies.
[6]	Green, circular, bio economy: A comparative analysis of sustainability avenues	It presents CE, the green economy and bioeconomy as concepts derived from the principles of sustainability; CE stands out for its concern with urban development and inter-governmental relations in supply chains.
[8]	Measuring Circular Economy Strategies Though index Methods: A Critical Analysis	It explains that, under a view of applicability, the metrics for evaluating processes that use the concept of CE must be specific, taking into account mainly the scope of the case.
[9]	The circular economy – A new sustainability paradigm?	It brings the element of the holistic view, where circular economy is incorporated into sustainability; makes a parallel between the two concepts, with sustainability being the basic concept and CE the practical application.
[11]	Sustainable supply chain management and the transition towards a circular economy: Evidence and some applications.	It features a case study that illustrates the benefits of applying CE in the supply chain; affirms the need to structure from top to bottom for the transition from the economic paradigm to happen.
[15]	Circular Economy: The Concept and its Limitations	It presents CE within the a perspective based on three dimensions of development, classifying it as a "collaborative economy".
[12]	A systematic review on drivers, barriers, and practices towards circular economy: a supply chain perspective	It points to the use of CE principles in urban development. The path proposed with the best potential for effectiveness is top-down implementation; highlights the legislative participation of public administrations in circularity processes.
[13]	The circular economy umbrella: Trends and gaps on integrating pathways	It exemplifies the application of CE as a mandatory regulation in China; shows the way in which the CE impacts the supply chains, prioritizing inter-organizational relations. The development of communication among government agencies is crucial to the transition process.
[16]	Circular economy as an essentially contested concept	It emphasizes that in order to understand the strict definition of CE, it is necessary to understand the holistic aspect applied to man-nature relations as the main element. The other aspects that make up the concept are derived from several areas of knowledge. It considers the application of CE flexible, according to the case and objective of the researcher.
[21]	The circular economy: new or refurbished as CE 3.0? - exploring controversies in the conceptualization of the circular economy through a focus on history and resource value retention options	It presents the roots of the CE concept, which develop from the first concerns of industrial production about the residues of its processes.

Source: authors (2020).
Table 1: List of evaluated articles and their main elements.

lescence design was proposed, making consumer goods quickly replaceable. However, this industrial application made the supply of resources very high. Over the decades, mineral, fluvial and energy resources have been extracted more and more voraciously, generating associated emissions of pollutants in the air, soil and water. Due to the facts presented, the author shows CE as a strategy to overcome the modern obstacles of sustainable development. The article proposed that industrial design is the determining factor for the transition to a more circular economy, insofar as, just as consumption, waste is a matter of influence. It is a collaborative process that uses sensibility and designer methods to reach a viable commercial strategy, thus converting need into demand, named by the author as Design Thinking, which can be achieved with the impulse for legislative changes and through incentives. The role of the proposed designers also demands the preparation of professionals in the design area, so the author also posited that education on sustainability be incorporated in the design curricula since the first year as a crucial measure.

b) *Towards circular economy implementation: a comprehensive review in context of manufacturing industry* [17]. The authors proposed a systemic review of the research efforts that cover the main aspects of CE and, based on this search, formulated a strategy for simultaneous implementation involving national efforts (top-down) and individual efforts of private companies (bottom- up).

For the systematic review of the literature, the search of the web of Science platform was initiated, where 136 articles were identified, which incorporated selective criteria, such as language, type of literature, divided into three different perspectives according to the motivation of the publication, namely: resource scarcity (energy and material consumption), environmental impact (solid waste, landfills, emissions or pollution) and economic benefits (financial aspects, such as cost reduction, increased revenue or gross domestic product).

The study concluded that the business and economy aspects have been neglected, thus presenting the risk of inhibiting the application of CE as an industrial advantage. Therefore, an efficient implementa-

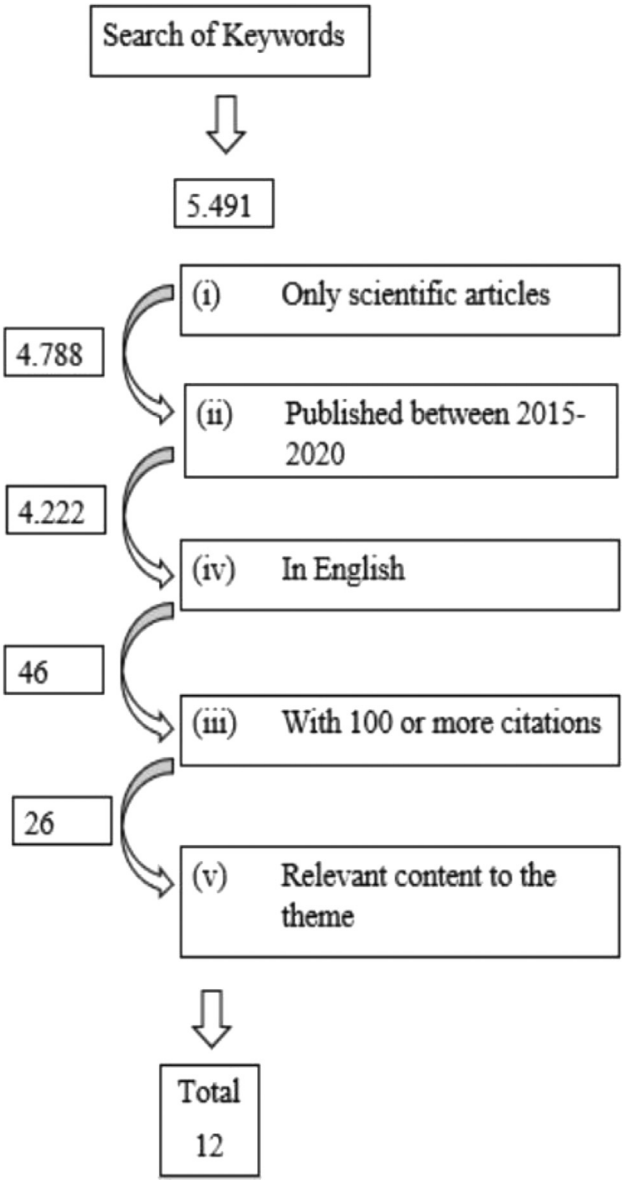


Fig. 2. Structure of the systematization process for choosing articles, using filters
Source: authors (2020).

tion must combine the three main aspects of CE, in order to provide a systemic view, threby avoiding biased interpretations. The authors proposed as continuity of their study the more extensive works in the area of social awareness and new business models, with the use of integrative tools for the transition process.

c) *The emergence of circular economy: a new framing around prolonging resource productivity* [2]. In order to determine the role that CE can play in the debate about waste and resource management, the authors use the umbrella concept proposed by Hirsch and Levin (1999) as an analytical lens, insofar as CE offers a new view of various strategies grouped under this banner, calling attention to prolonging the use of resources in the industrial environment. Umbrella concepts are ideas used freely to encompass and explain a set of diverse phenomena, generally arising when a field or discipline lacks guiding theories or a development paradigm, having the function of composing the debate on a given theme, filling the knowledge gap, creating a new comprehensive cognitive unit.

The authors propose that CE fits the umbrella perspective due to its circular structures around activities that prolong resource productivitys. These activities are described as resource life-extending strategies (RLESs). By reproducing only the basal concept, it can fit into different organizational forms, such as frameworks, think tanks (group of experts on specific political or economic problems), legislative and consultative bodies, academic or business models.

To describe the development of the concept of CE, the authors proposed a gradual line that presents the main mutation points in the idea of RLESs in a schematic way, within the following periods: preamble period (1960–1985), excitation period (1985–2013), and validity challenge period (2013-present). The division of periods occurs gradually, since there is no event that marks the point of change from one unit to another. Finally, the article posited that the CE reformulation shows the role of RLESs more clearly in waste and resource management. Thanks to the inclusion and promotion of the CE concept by the Ellen MacArthur Foundation and the World Economic Forum, it has been possible to start a conversation, as well as to accumulate and compile knowledge in a systematic way. Specifically, the authors stated that it is necessary to reinvigorate and expand the social sciences aspects of industrial economics both in theory and in implementation.

d) *Green, circular, bio economy: a comparative analysis of sustainability avenues* [6]; The authors noted three main concepts in the academia and public policies, namely: circular economy (CE), green economy (GE), and bioeconomy (BE). The article proposed a comprehensive comparison among the three concepts presented, through a systematic literature review. In a literature search on the three topics, with the publication date of the articles between the years 1990 and 2017, on the Web of Science website, a body of articles was formed and subsequently processed using the R-Core software, thus obtaining a sample range of 864 articles for CE 615 for GE, and 464 for BE totaling 1943 publications.

In order to establish a baseline for comparison, the authors used two definitions of sustainability already pre-defined by other authors. The first consists of six narratives that describe sustainability and its dimensions, whereas the second covers the social and economic development dimensions, thus applying the keywords and topics emerging from bibliometric analysis, identifying the alignment of the concepts CE, GE and BE.

Their analysis concluded that the platforms where each concept was studied vary greatly and reflect the intra and interdiversity. The main differences observed around CE were: focus on urban ecological performance, formation of recycling and industrial symbiosis policies, development of techniques and products in supply chains. The GE concept is presented as being more comprehensive, including the other two concepts analyzed, and addressing the following elements: sustainable development, investment and development of public policies aimed at green tourism, environmental education and the production of renewable energy, as well as recycling, reuse and reduction of resources. Among the concepts presented, BE has a greater focus on specific principles that differ from others, such as: energy sustainability through biomass, development of rural policies, application of the biological concept in health (natural medicine) and in the use of biodegradable materials, as well as biodiversity security, especially for vegetation.

Therefore, despite the various differences among the EC, GE and BE concepts, it is possible to identify that they are all articulated by the common ideal of balanced economic, social and environmental development and that the use of each one by the authors, according to the objectives of their studies, adds diversity to their original idea. The final proposal of the study was to investigate the application of each concept within different political and regional contexts.

e) *Measuring circular economy strategies through index methods: A critical analysis* [8]. The authors posited that the EC paradigm introduces a new perspective through its consolidated foundations in environ-

mental sciences and sustainable development; however, the amount of literature focused on how to effectively measure the level of "circularity" of a product or service chain is scarce. The study proposed a monitoring structure for a CE strategy, carefully evaluating the main methodologies for comparing indexes, and building a system for the most appropriate selection for each case. Initially, to facilitate the circularity monitoring process, a conceptual framework was proposed, in which the analysis of different literature documents established four levels to measure the adoption of circularity in a process: monitoring of material input and product design, production, consumption, and end-of-life resource management.

In this sense, the actions involved, encompassing the production design, the business model, the reverse chain and cross-cycle and cross-sectoral collaboration have to be measured. From a European Union EEA 2016 document, five other categories also musthad be measured: a) reduction of waste and the use of natural resources, b) reduction of emission levels, c) reduction of loss of valuable materials, d) increase in the share of renewable and recyclable resources, e) increase in the value duarability of product; and, finally, the levels of implementation of the paradigm. In this way it is also possible to measure political intervention and regulatory frameworks on CE.

Using literature that reviews the main environmental assessment methodologies, the authors classified those based on indexes to measure the adoption of the CE paradigm. The proposed taxonomy is based on two factors: typology, where the methodology can be based on a single indicator or multiple indicators, and four categories of parameters: material and energy flow, land use and consumption, and other life cycle bases. The study concluded that there are fourteen methodologies for the environmental assessment of products, services or processes, which were presented with their main strengths and weaknesses, thus facilitating the choice, although not all meet the requirements presented in the framework. For better visualization, a table with the scope of each evaluated method was presented, making its limitations and applicability visible. Finally, the authors stated that, in the general framework, the evaluation of methodologies for the transition from CE is in its first steps, mainly at the micro level and that further studies are needed to bridge the gap between circular economy theory and the practice of economic transition.

f) *The Circular Economy – A new sustainability paradigm?* [9].The authors address the theme of CE by synthesizing its relationships with sustainability, by means of a bibliometric analysis. As a research problem, the authors define the following questions to be answered: What are the main similarities and conceptual differences between sustainability and Circular Economy? How does Circular Economy conceptually relate to sustainability?

First, they carried out bibliometric research, an established form of meta-analytical research of the literature. The data were collected from the Web of Science in January 2016, searching for the keywords "circular economy", "sustainability" and "circular economy and sustainability", showing by means of a graphic representation the number of articles published by the related themes, by date and place of publication.

To exemplify the main differences and similarities between the two concepts, the authors established discussion factors assembled into a comparative table containing the term's origins, goals and main motivation, and answering the questions: Which system is prioritized? For whose benefit?

How did they become institutionalized (widespread)? Who do they influence? Whom should they influence? What is the time for changes? It also assesses perceptions of responsibilities, commitments, goals and interests behind the use of the term. Through these criteria it was possible to identify the characteristic elements for CE and for Sustainability.

The main similarity observed, according to the authors, is that both notions, multidisciplinary or interdisciplinary, emphasize intra and intergenerational commitments motivated by environmental risks and multiple paths for development. In addition to these similarities, the concepts are mainly used in different contexts and for different purposes.

Sustainability is rooted in early sustainable development, while CE is broader, addressing institutional commitments and development opportunities. A characteristic observed in relation to CE, when looking at the content of publications from different countries, is that there are different political projections, according to the economic situation of each country, such as industrial interventions with more environmental emphasis in rich countries like Sweden, and greater social emphasis in developing countries like Zambia. The study concluded with the suggestion of carrying out new studies with methodologies that have randomized representativeness, in order to eliminate the selection bias.

g) *Sustainable supply chain management and the transition towards a circular economy: Evidence and some applications*. [11]. The authors compared two case studies from the chemical and food processing sectors, focusing on the performance of traditional and circular production systems and applying various indicators. They depart from the premise that CE enables the creation of a self-sustainable production system and the correct use of the environment and that which is obtained from it.

To compare the case studies, the authors established two industrial processes for each sector (chemical and food): each presented a traditional (linear) chain without post-production responsibilities and correct disposal, and a circular supply chain, which takes a broader view of the entire production system.

For the first case study, the comparison of chemicals in the water treatment sector took into account a supply chain using a by-product (the acid waste) of titanium dioxide, ferrous sulfate (FeSO4), as raw material and a ferric chloride (FeCl3) supply chain, which is produced in a linear fashion, based on empirical data collected from real sources from UK companies and supplemented with secondary data from Ecoinvent.

The second case study, related to the food industry, presented both a linear chain based on a production system where virgin cooking oil is used as raw material for biodiesel, and a circular chain based on the recovery of cooking oil used in biodiesel production, based exclusively on secondary data collected from Ecoinvent.

Based on the multi-regional input-output (MRIO) hybrid framework, the implications of carbon emissions from the implementation of a circular supply chain were examined in relation to supply chains. A table constructed for the best visualization of each supply chain enabled the following classifications for carbon emissions: very high (inputs with emissions greater than 10% of the total emissions of the life cycle); high (5–10%); medium (1–5%); and low (less than 1%). Using the hybrid life-cycle assessment (LCA) framework, the study also calculated the direct impacts of carbon emissions, indicated as "indirect inputs", in 18 sectors: agriculture, forestry, fishing, mining, food, textiles, wood and paper, fuels, chemicals, minerals, metals, equipment, utilities, construction, commerce, transport and communication, commercial services and personal services.

Based on data comparison, in the first case (chemical industry) the use of ferrous sulphate produced by this circular process not only generated less emission than the linear production system of the ferric chloride supply chain (about three times less), but also avoided the occurrence of emissions generated by the disposal of metallurgy residues from titanium oxide. It could also be observed that the direct and indirect carbon emissions of $FeSO_4$ were lower than those of $FeCl_3$ demonstrating the environmental efficiency of the circular process.

For the second case, the carbon emission rate in the circular supply chain was lower than in the linear chain, but the main factor for reducing carbon emissions in the circular supply chain was the fact that used cooking oil was employed, which before it was considered waste and discarded.

In conclusion, the article showed the clear environmental benefits from using circular supply chains. Bottom-up initiatives at the supply chain level may need to be encouraged through some form of government support from above downwards (as in the case of the biodiesel supply chain). The study also proposed that studies should be carried out to expand the empirical evidence.

h) *Circular economy: the concept and its limitations* [15]. The authors claimed that the concept of CE is based on a fragmented collection of ideas, which derive from semi-scientific concepts such as industrial ecology, industrial ecosystems, cleaner production, eco-efficiency, and cradle-to-cradle design. Although the concepts are of scientific importance for sustainability, their connection with the CE is not clear, but unorganized and superficial. The highly idealized view according to the authors is that in the CE concept the economic and natural systems are integrated into a single system, with a 100% dependence on renewable energy; however only 25% of the energy on the planet is produced by renewable sources and although that reuse is the main point for other materials, for energy it is virtually impossible, due to thermodynamic limitations, besides having organizational and cultural limits.

Using this problem, the article proposed two objectives: to build a definition of CE within the perspective of sustainable development, by defining three-dimensional sustainable development and planetary limits; and identifying six challenges to be overcome for the CE's global contribution. As a construction of the definition of CE within the perspective of sustainable development, the authors described that CE is a collaborative economy, formed by a social system of production and consumption, maximizing service through a nature-society-nature flow and a production flow of energy through cyclical materials, and cascading energy sources.

The six challenges presented are: 1) *the thermodynamic boundary,* since even cyclical systems create waste and consume energy; 2) *the spatial and temporal boundary*, where the problem extends throughout the material's useful life, insofar as prolonging it can create economic and organizational structures that risk long-term sustainability; 3) *physical economic growth*, which consists of the rebound and the boomerang effects; 4) *path dependencies and imprisonment*, which is the phenomenon described when an economic innovation gains better acceptance in the market because it was first presented; 5) *inter-organizational strategies and management as opposed to intra-organizational ones*, consisting of the coordination of collaborative networks between companies that generate waste, and companies that use it as raw material for remanufacturing (business between companies); 6) *the definition of physical flows,* which addresses the difficulty of officially standardizing policies for CE activities, due to the way the definition will always be variable and dynamic because of historical or cultural issues in each part of society.

Through the information presented, the authors concluded that the creation of the concept of CE, although accepted by several governments in the world, occurred mainly through professionals in the business community and among policy makers. Their article was presented as the first attempt to build a base with critical criteria.

i) *A systematic review on drivers, barriers, and practices towards circular economy: a supply chain perspective.* [12]. Because of the lack of concise literature on the factors, barriers and cutting edge practices that are relevant to the application of CE, the authors proposed an in-depth exploration of current practices, in order to improve the importance of this topic and help analyze its level current implementation. To achieve this objective, the article presented a multi-perspective systematic review, applying a search on the keyword "circular economy" as both title of the article and presence in the abstract, on the Web of Science and Scopus websites. The following criteria were used to select the journals: only formal literature, English-language peer-reviewed articles on the topic of "circular economy", publication date between 2000 and 2016, only reviewed articles, in press or editorial material. As a result of this search, 173 articles were filtered, removing those that did not meet the criteria in both databases. To cover possible outflows of relevant articles, a manual search was deployed using the search term "circular economy in the supply chain". In the circular economy, the following keywords were used: "drivers", "practices", "barriers" and "closed loop", to be found in summaries. Keywords such as remanufacturing, reduce, reuse and recycle were also included in the manual collection, thus obtaining 22 additional articles, totaling 60 articles included for scope formation.

The study identified thirteen motivators for the implementation of CE, which were grouped into the five following comprehensive clusters: *politics and economics* —referring to legislative resolutions related to the production chain and economic growth; *health* — including improvements in public and animal health; *environmental protection*—addressing at this point climate change and the quality of production and care of natural resources; *society* — where population growth, urbanization, job creation, and consumer awareness were addressed; and *product development* —proposing efficiency in the use of energy and increasing the value of processed raw materials.

Within the perspective of top-down practices the article proposed the following eight clusters: *governance initiatives*—in this aspect the creation of laws and policies, pilot projects, performance indicators, among others, are present; *economic initiatives* — proposing to disassociate economic development from environmental impacts through the development of financial instruments; *cleaner production* —addressing the increase in eco-efficiency in production, with awareness of consumption, business cooperation and reverse logistics; *product development*— referring to durable design; *management support* —in the aspect of directing the transition to CE; i*nfrastructure* —in the sense of proposing a shared information system at the regional level; *knowledge* —at this point addressing the development of research and scientific dissemination around the subject; *society and culture* —referring to the change in the attitude of the whole society towards remanufactured products, creating acceptance in the market and simplifying the means of consumption.

The authors also indicated as the main barriers to the transition process, governmental, economic and technological issues; problems of knowledge, skill and management; the very structure of CE; culture and social issues, as well as to market issues.

As a conclusion, it was proposed that the measures observed as mechanisms and practices dialogue with the identification of the presented barriers, and as further work it was suggested to test the proposal and produce more case studies from different sectors involving the circular economy.

j) *The circular economy umbrella: Trends and gaps on integrating pathways* [13]. Due to the lack of academic knowledge about CE in different epistemological fields, the authors proposed to investigate trends and gaps in the convergence of literature paths on the topic, using a combination of semantic, bibliometric analysis, networks and content analysis in a systematic review of literature. To guide the study, the authors asked three questions: What are the main research flows, the main topics, authors and journals? What is the definition of circular economy? What is most up to date in terms of thinking, trends and gaps in the literature?

The study considered the research in the Web of Knowledge, Web of Science Core Collection and Scopus databases, applying only a single filter of "type of documents", choosing only "articles", "reviews" and "articles in press", using the search string for "circular economy" applied as a topic in the Web of Science, and in the Scopus database for article title, abstract and keywords. The removal of articles was done by selecting the article according to the relevant content for the questions initially proposed, thus obtaining a sample range of 327 studies.

The result of the study demonstrated the existence of three main clusters: ecoparks, industrial symbiosis and supply chain. Much of

the literature involved comes from China, due to mandatory regulation (2009), where the focus of research is concentrated on the symbiosis and ecoparks clusters. Regarding the supply chain cluster, the article showed a need for understanding between internal or external partners for the implementation of the supply chain, and that the context of this cluster is related to the organizational exchange of by-products and waste output.

It emphasized the need for better interactions between government agencies, policy makers, communities and manufacturing industries. In order to continue the research, the authors proposed that studies be carried out using confirmatory approaches and applying a triple-bottom-line approach, since the economic-environmental has been the most used so far.

k) *Circular economy as an essentially contested concept* [16]. To better understand the principles of CE, which is only an emerging concept in the scientific sphere, the authors defined two objectives: first, to identify, discuss and develop the various definitions provided by the emerging literature; and second, to suggest an initial research approach under which CE research can be conducted.

To that end, they divided the literature review into two parts: the first ascertained the main conceptual academic bodies that constitute the speech on CE of the Ellen MacArthur Foundation (EMAF), and the second obtained articles through the search for the keyword "circular economy" in titles, abstracts and keywords over the 2000–2017 period, seeking only English texts, applied on the Web of Science platform, with an additional filter of five or more academic citations. Subsequently, a manual selection was made on the articles found, seeking to identify definitions, descriptions or conceptual debates on the theme, resulting in 40 articles.

The authors verified that EC is loosely based on a fragmented collection of sustainability ideas, compiled from various areas of knowledge. Among the observed concepts were: industrial ecosystems and industrial symbiosis, cleaner production, product-service systems, eco-efficiency, cradle-to-cradle design, biomimicry, resilience of socio-ecological systems and performance savings, natural capitalism, and the zero emissions concept.

In order to achieve the first objective, regarding the various definitions present in the literature, the authors stated the need to adopt a working definition of the concept, according to the application determined by each researcher who will use CE in some sustainability structure, but to maintain it as the main conceptual mechanism, with its present holistic aspect, aligned with the current academic, political and sector consensus. As a conduction mechanism for research on CE, it was proposed that firstly an organizational level be established and, secondly, the stage the research is taking place be defined, be it in the formation of a paradigm or in the practical application of the concept.

l) *The circular economy: New or refurbished as CE 3.0? - Exploring controversies in the conceptualization of the circular economy through a focus on history and resource value* retention options [21]. The article, in line with other scientific productions, observed the lack of conciseness about CE, since several other concepts of sustainability seem to integrate the philosophical body of the concept of economic circularity. Thus, a brief history of the development of CE and value retention options (ROs) was proposed.

To achieve their objectives, the authors carried out two distinct literature reviews, one focused on providing paradigmatic clarity for the conceptualization of CE, and the other focused on the search for a principle of operationalization. The searches took place on the Google Scholar and the Scopus databases, performed manually by searching for the keyword "circular economy", operated as a Title-Summary-Keyword search, and obtaining a total of 69 academic articles, which were analyzed.

In tracking the research undertaken about CE, three important phases were noted in the history of this concept: from 1970 to 1990, dealing with waste, where the first concerns of the industry about the waste generated in the production processes were addressed; from 1990 to 2010, connecting input and output strategies for eco-efficiency, characterized by the evolution of waste output metrics, and waste-reducing strategies; from 2010 onwards, maximizing value retention in the age of resource depletion, marked by worse global impacts, and high demand for raw materials. In conclusion, the authors proposed that more research using mixed methods be done on CE in order to better understand the practical mechanisms of its application in industrial production processes.

Considering the articles analyzed as a sample of how the concept of CE evolved over time, it was possible to make the following considerations:

- From 2015 to 2016, with the appearance of the production design aspect, this becomes an issue of economic clash, as linearity aggregates several mechanisms that generate greater profit for producers, while demanding a greater amount of natural resources. At this stage, it is also observed that economic mechanisms cannot be neglected. This divergence of interests makes it difficult to apply a systematization of the production vision based on CE.
- In 2017, it was observed a greater number of scientific publications on the subject of EC and also contrasted with the previous two years in the researched material. For example, in the 2015–2016 phase, studies discussed how the resources applied to production can be exhausted quickly; on the other hand, the new studies (2017) began to indicate ways and strategies for extending the useful life for everyday products, reducing the use of resources for new products, even though they observe that such practices needed incentive.

  It is also at this stage that EC is shown as a participant in a larger set of ecological concepts, mainly associated with urban and industrial relations. It also shows the systemic relationship of the industries with the environment in which they operate, indicating profitable and sustainable ways for the development of the industry, the generation of local jobs and the reuse of resources initially applied in the production chain, thus recovering part of the financial investment in purchase of resources that can be reused.

  The creation of public policies also appears to be fundamental so that the CE takes space and starts to be considered as a practice. Case studies are more frequent, showing how CE is applied in companies' daily lives and how it gains space in legislation and in organizational discussions.
- The evolution towards the application of EC on a large scale appears in the studies of 2018, still in the form of an outline, since economic models need more evidence in the studies presented.

The publications carried out in the years 2019–2020 did not meet the inclusion criteria in this study, which may indicate little attention to the theme, or even lack of time for the pre-established citation criteria to have been met. Understood as a limitation of this study, it is suggested that further research should be carried out, thus observing the evolution of CE in the academic field for the cited years and upcoming periods.

4. Conclusion

Drawing on the results presented in Section 3, the present work concludes that there is an association between the deficiency of the CE concept and the fact that neither the formulators are from the scientific community, nor has the issue been effectively addressed in the academic sphere. Our main findings conclude that: for the CE concept to reach circularity, strategies to extend the useful life of resources must be applied [16]; CE is a condition for sustainability, with the main actors in the transition process being private companies [9]; to assess a circularity process, one must measure which actions are taken by the object of study, the skills presented, and the level at which the development (macro, meso or micro) it is being evaluated [8].

In terms of legislation, implementation and public policies, the studies have shown that the top-down strategy is the best option for the

economic transition, since the supply chains established between the various actors within an urban context will make the inspection and the flow of materials and energy flow smoothly, thus ensuring the efficiency of the main operating mechanism of economic circularity [2,6,11].

The here-cited authors present CE as a concept of sustainability with the greatest probability of favorable economic development. Further research should formulate a case study based on the findings of the present study in order to outline, classify and guide the processes searching CE, using theory for implementation in the field, confirming its applicability or not, and filling the extant gap pointed out by most of the researched authors.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] D. Andrews, The circular economy, design thinking and education for sustainability, Local Econ. 30 (2015) 305–315.
[2] F. Blomsma, G. Brennan, The emergence of circular economy: a new framing around prolonging resource productivity, J. Ind. Ecol. 21 (2017) 603–614.
[3] Bringezu, S., Ramaswami, A., Schandl, H., O'Brien, M., Pelton, R., Acquatella, J., & Giljum, S. (2017). Assessing global resource use: a system approach to resource efficiency and pollution reduction.
[4] G. Ceballos, P.R. Ehrlich, R. Dirzo, Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines, Proc. Natl. Acad. Sci. USA 114 (2017) E6089–E6096.
[5] J.W. Creswell, Projeto De Pesquisa Métodos qualitativo, Quantitativo e Misto, Ed. Artmed, Porto Alegre, 2010.
[6] D. D'amato, et al., Green, circular, bio economy: a comparative analysis of sustainability avenues, J. Clean. Prod. 168 (2017) 716–734.
[7] Dobbs, R. et al. (2011). Resource revolution : meeting the world ' s energy, materials, food, and water needs. McKinsey global institute mckinsey sustainability & resource productivity Practic, n. November.
[8] V. Elia, M.G. Gnoni, F. Tornese, Measuring circular economy strategies through index methods: a critical analysis, J. Clean. Prod. 142 (2017) 2741–2751, doi:10.1016/j.jclepro.2016.10.196.
[9] M. Geissdoerfer, P. Savaget, N.M.P. Bocken, E.J Hultink, The Circular Economy – A new sustainability paradigm? J. Clean. Prod. 143 (2017) 757–768, doi:10.1016/j.jclepro.2016.12.048.
[10] Y. Geng, et al., Towards a national circular economy indicator system in China: an evaluation and critical analysis, J. Clean. Prod. 23 (2012) 216–224.
[11] A. Genovese, et al., Sustainable supply chain management and the transition towards a circular economy: evidence and some applications, Omega (United Kingdom) 66 (2017) 344–357.
[12] K. Govindan, M. Hasanagic, A systematic review on drivers, barriers, and practices towards circular economy: a supply chain perspective, Int. J. Prod. Res. 56 (2018) 278–311.
[13] A.S. Homrich, et al., The circular economy umbrella: trends and gaps on integrating pathways, J. Clean. Prod. 175 (2018) 525–543.
[14] B. Kitchenham, in: Procedure for Performing Systematic Reviews, 37, Software Engineering Group Department of Computer Science Keele University Keele, Staffs ST5 5BG, UK Keele, 2004, pp. 79–83.
[15] J. Korhonen, A. Honkasalo, J. Seppälä, Circular economy: the concept and its limitations, Ecol. Econ. 143 (2017) 37–46, doi:10.1016/j.ecolecon.2017.06.041.
[16] J. Korhonen, C. Nuur, A. Feldmann, S.E. Birkie, Circular economy as an essentially contested concept, J. Clean. Prod. 175 (2018) 544–552, doi:10.1016/j.jclepro.2017.12.111.
[17] M. Lieder, A. Rashid, Towards circular economy implementation: a comprehensive review in context of manufacturing industry, J. Clean. Prod. 115 (2016) 36–51.
[18] E. Loiseau, et al., Green economy and related concepts: an overview, J. Clean. Prod. 139 (2016) 361–371.
[19] E. Macarthur, et al., Towards the circular economy, J. Ind. Ecol. 2 (2013) 23–44.
[20] F. Mathieux, et al., Critical Raw Materials and the Circular Economy, 2017 Background report.
[21] D. Reike, W.J.V. Vermeulen, S. Witjes, The circular economy: new or Refurbished as CE 3.0? — exploring controversies in the conceptualization of the circular economy through a focus on history and resource value retention options, Res., Conserv. Recycl. 135 (2018) 246–264.
[22] R.F. Sampaio, M.C. Mancini, Estudo de revisão sistemática: um guia para síntgese criteriosa da evidência científica, Revista Brasileira de fisioterapia (2007) 1–188.
[23] W.R. Stahel, The circular economy, Nature 531 (7595) (2016) 435–438.
[24] R. Brandau, R. Monteiro, D.M. Braile, Importância do uso correto dos descritores nos artigos científicos, Braz. J. Cardiovasc. Surg. 20 (1) (2005) VII–VIX.