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Circular Economy: Overview of Barriers

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Abstract

Circular economy has emerged as a way to achieve sustainability. Although interest in the subject is growing rapidly, barriers to its implementation are still in place. In this study, a number of barriers are identified and grouped through a content analysis. The present article adopted bibliometric research as a methodological approach. The research method combined bibliometric, networks and content analysis. The sample is composed of 195 articles extracted from the Web of Science Core Collection and Scopus databases. The main barriers identified in the literature were: (i) technological, (ii)policy and regulatory, (iii) financial and economic, (iv) managerial, (v) performance indicators, (vi) customer and (vii) Social.

Keywords: circular economy; barriers; challenges; qualitativy content analysis; bibliometrics

1. Introduction

The terms Circular Economy and sustainability are increasingly gaining traction within the academia, industry, and policymakers [1]. Many barriers to the implementation of sustainable strategies are still in place [2]. Circular Economy (CE) is a strategy whose goal is to address the challenges of resource scarcity and waste disposal, in a win-win approach from an economic and value perspective [3]. In 1990, CE was conceptualized for the first time in the Economics of Natural Resources and the Environment, a book by British environmental economists, David W. Pearce and R. Kerry Turner. The authors drew attention to how society at the time that work was published did not direct relevant efforts to properly address the waste generated from the consumption of the most diverse products [4]. Policy makers have to address the public concerns prior to promulgating and implementing related regulations [5].

CE is related to different topics. For example, it can offers a new perspective on waste and resource management [6], and the concept brings up diverse themes, like sustainability [3] industrial ecology [7], eco-design [8], cleaner production [9],

eco- innovation [10], closed economy [11], ecological loops [12] and product service systems [13]. Circular Economy can also be understood as a political goal, aiming to replace the linear economic model, summarized in a "take, make, use, dispose" system that places raw materials at one end and exteriorized residues at the other [14], with the circular model [15].

To establish CE, significant barriers in the political, economic, technological and legal areas exist. A country requires strong political support to promote CE [16]. However, lack of incentives to adopt CE still prevails in some [17].

This article aims provide an overview on barriers and challenges for the implementation of the circular economy. To this end, a bibliometric analysis was performed, merging a content analysis of the 195 papers in the final sample. The lack of information regarding the benefits of circular economy is a barrier and a challenge to the implementation of circular economy models in the literature, due to the unfamiliarity of the term "circular economy" [18]. As such, this research can pave the way for a better academic understanding of the mechanisms underlying the barriers and resistance to the

acceptance and propagation of the circular economy, as well as of better ways to address and reduce these barriers [18]. In addition, this literature review of the literature published in 2018 points out CE revisions until 2017. The table presented in the appendix does not present any revision or bibliometric related to the CE implementation barrier [3].

There are significant reports from international organizations that point barriers to EC. For example, the OECD, studies markets barriers, as regulatory and financial barriers thus strengthening economic efficiency and competitiveness. The European Commission also deals with markets barriers (European Commission) lack of knowledge as barriers to solving problems such as food waste, Landfill and lack of investment in circular economy innovation (European Commission, 2011). This study looks for more general barriers, not only of a specific area.

2. Methodology

The research design combined quantitative and qualitative strategies, merging bibliometric and content analysis, since these methods are complementary [19]. Bibliometric research can be used in several areas of knowledge, collaborating to improve trend research and analysis, while content analysis allows an understanding of the research constructs and their relationships [20]. Finally, this approach allows us to identify the stage in which a research front is found [21]. In addition to the bibliometric, the 22 articles with the greatest impact factors, in order to obtain the results.

According to Carvalho et al. [19], an article impact factor can be calculated as follows: (i) extract the average citation per year (taken from the ISI); (ii) Find the impact factor of the sources of publications (obtained in Journal Citation Reports, JCR); (iii) perform the following operation: IF = Average citation X (1 + JCRFI). "It is important to note that, considering this impact index, the article can change the position in the citation ranking" [19]. The 25 highlighted publications were selected by their IF values reached, by means of a boxplot graph to observe the outliers, or points outside the curve. The graph obtained was plotted using the Minitab software (fig. 3.)

2.1. Sample definition and steps for the data collection

The Web of Science Core Collection and Scopus databases were searched to produce this article. The first article identified in these databases was published in 2005, and the most recent was published in 2017. The following data were analyzed: total publications, year of publication, sources, impact factor, countries, network of citations and keywords and hot topics, followed by an analysis of the 25 articles with the highest impact factor.

The first stage of the data collection consisted of searching for the keywords "Circular Economy" AND "Barrie*" OR "Challeng*" AND "Opportunit*" at the Web of Science Core Collection and Scopus databases. A total of 381 publications were found, 141 of which were excluded because they were repeated in both databases. After reading the abstracts,

another 45 were excluded because they were not aligned with the purpose of this research. Thus, the blibliometric study was performed considering 195 papers. Fig. 1. presents the methodological flow for the sample collection.
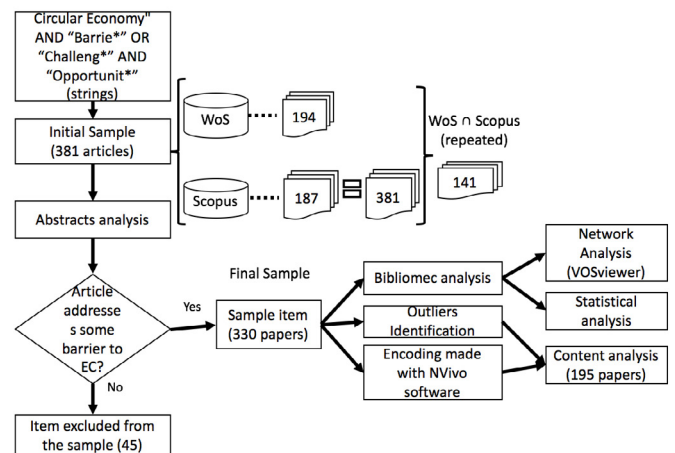

Fig. 1. Methodological flow.

3. Results

3.1. Evolution and main sources of publications

The first article in the sample was published in 2005. However, the theme began to spark academic interest after 2014 (12 papers). The years of 2016 and 2017 accumulated 127 articles on the evaluated subject, suggesting that interest in barriers and opportunity is growing. Concerning the publication sources, Journal of Cleaner Production published 38 papers on the subject, Resources Conservation and Recycling, 10 and Sustainability, 9. The other 138 papers were published in 106 different sources, suggesting the multidisciplinarity of the theme. This information was taken from the databases (ISI and Scopus). About 40% of the sample were shown to be case studies, i.e. articles that evaluate the barriers in practice in order to implant CE.

3.2. Keywords

To complement the overview on the selected sample (195 articles), the circular economy keywords network was prepared using the VosViewer software [22], presented in Fig. 2. These words were categorized into 6 main groups: (1) strategic variables, corresponding to the main drives for circular economy (sustainable development, closed loop); (2) inputs, that are the independent variables within the circular economy research theme (China, challenges, environment and ecology), (3 and 4) outputs, that are the result of the circular economy implementation (recycling, reuse, environmental impact, sustainability, e-waste, waste, resource efficiency and climate change) and (5) cluster of industries investing in CE (industrial ecology, industrial symbiosis, eco-industrial park). This categorization was possible after reading the articles.
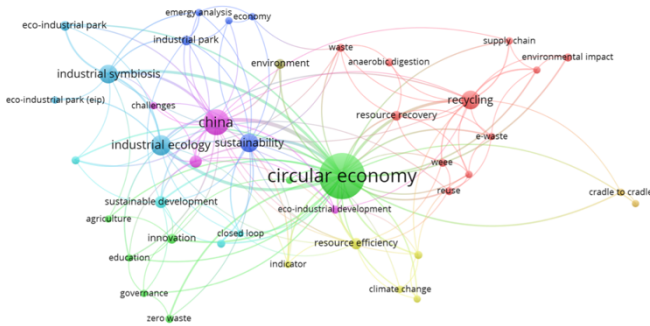
Fig. 2. Keywords.

3.3. Hot Topics

By scanning the frequency of the words in the article titles, abstracts, author keywords, and keywords for more promising research topics that are more likely to appear in the future, it was possible to trace the hot topics related to the study of barriers and opportunities within the theme "Circular Economy", by using NVivo software [23]. An analysis of the hot topics was performed to generate the HB index [24] through the relationship of the most recurrent topics, identified in Fig. 3. Finally, the M index was calculated as the linear relation between HB and the number elapsed years (n = 12 years) since the first publication. Hot topics thus, were calculated as: HB-M * n, in accordance to criterion in [25].
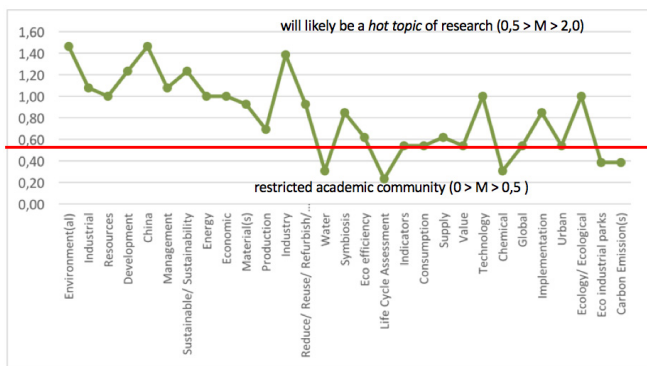

Fig. 3. Hot topics.

The "h index," is a useful way to characterize the scientific output of a researcher [24], while HB is a quick method to aid new-comers to identify how much interest and work has already been achieved in their chosen area of research [25]. The criteria for the interpretation of the M index are presented in Fig. 3. In this sample, the "Chemical" issue is not yet a hot topic within circular economy; however, themes of "Symbiosis" and "Technology" are considered hot topics.

3.4. Impact factor and Outliers

The 25 articles with the highest impact factor were read, allowing for understanding on the main points discussed and which method was applied to this end.

A total of 30% of the papers in the sample were related to CE studies in China, as China exhibits more CE policies than

other countries [26]. The central government of China guaranteed to stimulate the sustainable development of economy and society in 2002 [27].

An initial content analysis for outliers is presented below, in order from highest to lowest impact factors:
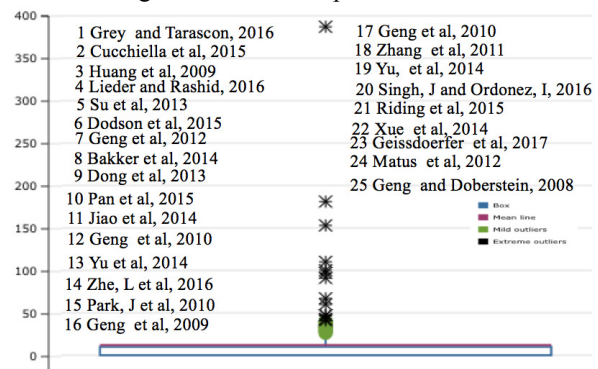

Fig. 4. Outliers.

- Literature Review. The development of improved rechargeable batteries represents a major technological challenge. Sustainability and cost concerns to minimize the ecological implications associated with their wider use are discussed in this article [28].
- Literature Review. A discussion of the economic assessment results as the main challenges in the recycling sector and streamlines some concrete solutions [29].
- Literature Review. This article gives a comprehensive review of state-of-the-art research, carried out to understand different ideas relevant to CE as well as motivation for the research and their recurrence context [30].
- Case study. Barriers and opportunities in the deployment of CE China are addressed in this article [4].
- Literature Review. This article provides an overview of the current research in the area of critical and precious metals recovery using bio sorption, its application to real-life wastes and the potential uses for these metal-loaded materials for catalysis or functional materials. Challenges of elemental sustainability are discussed [31].
- The article studies the system of indicators for CE in China. These national indicators can help to achieve CE goals and outcomes [32].
- Case study. This article maps the environmental impacts of refrigerators and laptops against their increasing energy efficiency over time. One of the main research challenges is to determine when to apply which product life extension strategy [33].
- Case Study. The article evaluates and compares the number, scale and the related environmental/ economic gains of IS activities in iron/steel-centered industrial areas in Liuzhou and Jinan in China, and Kawasaki in Japan [34].
- Literature Review. Authors discussed the dilemma of energy demand, waste management, and greenhouse gas emission for communities globally, the waste-to-energy supply chain as a district energy system should be a viable method towards circular industrial economy [5].

- Literature Review. This article proposes a research agenda to clarify the mechanisms of policy intervention and facilitation of industrial symbiosis based on a comprehensive review of industrial symbiosis literature. For the authors, policies may be major barriers to the deployment of industrial symbiosis [35].
- Case study. This paper first introduces the main initiatives for the promotion of cleaner production in Liaoning and then identifies the key barriers [9].
- Case study. The authors study the reasons for a number of successful and unsuccessful eco-industrial parks [36].
- Case study. The main barriers to the industrial symbiosis of industrial parks are central themes in this article [37].
- This paper explores the challenges and opportunities of how firms and organizations can strike a better balance between economic progress and environmental stewardship in the context of China's emerging 'circular economy' policy paradigm and based on ecological transformation theoretic approaches [38].
- Case study. This paper outlines some of the regional CE initiatives that have been successful to date in Dalian, China. The authors identified several challenges that have held back complete implementation [39].
- Literature Review. This article presents some problems about remanufacturing, and then it points out several barriers, such as restrictive policies and regulations, consumer acceptance, scarcity of technologies, among others [40].
- Bibliometric and Network Analysis. This study analyzes the evolution of the research field of industrial symbiosis [41].
- Literature Review and case study. This paper identifies the practical challenges to implementing a circular economy, based on example categorization and comments from interviews [42].
- Literature Review. The scientific and legislative barriers to the generation of bioenergy derived soil conditioners are addressed in this paper [43].
- Literature Review. The article studies the performance changes during different five-year plan stages for emission control, addressing the major challenges and identifying options for the future improvement of China's pollutant emissions reduction [44].
- Literature Review. The similarities and differences between the terms Circular Economy and sustainability are ambiguous. This research addresses this gap and aims to provide conceptual clarity by distinguishing the terms and synthesizing the different types of relationships between them. Challenges are also discussed [1].
- Literature Review. This paper identifies a series of barriers and challenges to CE implementation in China [38].

3.5. Barriers

To detect the main barriers in CE, the authors read the 195 articles. To find the best coding, the NVivo software was used, and the content analysis was also carried out with the aid of the same software.

To adopt CE as a future economic model, efforts are required to refine existing measures as well as to deploy a wide range of policies to overcome these challenges [4]. Each sector has its specific challenges. The coal sector, for example, lacks of post-decommissioning management, exhibits poor pollution control, lacks of technology to refill solid waste and faces increased socioeconomic and environmental pressure [45].

In the case of recycling, the potential benefits of improving the circular economy are the market value of recycled materials, reduced waste disposal (incineration or landfill) and the decreased extraction of natural resources [46].

The lack of societal pressure, by not knowing the benefits of sustainable products, or CE, is a barrier to the implementation of new policies by business and government [18]. One of the challenges facing societies in the pursuit of sustainability is to find viable strategies and initiatives capable of decoupling economic growth from environmental pressure, within the limits of the available resources [47].

The barriers that appear most frequently within the 195 papers are: technological, policy and regulatory, financial and economic, managerial barriers, performance indicators, customer (interest in the environment issues or lack of information on environmental impacts) and Social (Table 1).

Table 1. Barriers to CE implementation.

Barriers	Authors
Technological	[4], [5], [11], [16], [34], [48]–[53]
Policy and regulatory	[4], [5], [9], [11], [16], [18], [30], [35], [48]–[50], [52]–[58]
Financial/ economic	[4], [5], [9], [11], [16], [34], [49], [51], [57], [59], [60]
Managerial	[2], [4], [53], [57]
Performance indicators	[2], [37], [61], [62]
Customer	[2], [11], [51], [53], [54], [58], [62], [63]
Social	[30], [48], [62], [64], [65]

Many challenges and actions that have been taken to overcome these CE implementation barriers. However, support from governmental and non-governmental entities is needed, as well as organizations that help promote, regulate and monitor CE implementation [4]. Effective performance evaluation is another barriers, found as it can aid in recognizing the key barriers on industrial symbiosis of industrial parks, so that more appropriate policies can be raised by considering local realities [37]. The CE barriers to eco-parks were also identified [53]. The authors divided these barriers into two categories: (1) external (capital support barrier, policy support barrier and information support barrier) and (ii) internal (Tangible Resources, Intangible Resources, Capacities).

A survey of 28 organizations pointed to other barriers: lack of access to sufficient volumes, informal and illegal reuse practices, regulations, product design and patterns, and costs [60]. Any material improperly disposed of may cause environmental contamination [63]. Environmental taxes are considered efficient environmental policy tools for some governments. However, pollutant emission rates are low, and

so companies/institutions prefer to pay these rates, instead of taking measures to eliminate and control pollution [66]. The eagerness for new economic gains can lead companies/industries/cities to reduce environmental standards and accept polluting projects [67].

Rizos et al [18] listed the main barriers to the of CE implantation in small and medium enterprises, namely lack of supply and demand network, lack of capital, lack of government support administrative burden, lack of technical know-how, lack of information and the environmental culture of the company.

"As the global population is expected to reach 9 billion by 2050, humanity needs to balance an ever increasing demand for energy and natural resources with sustainable management of ecosystems and the vital services that they provide"[p.52 47]. As for the management barriers that appear to date, "it is important to establish a clear management structure and procedure for the issue, in order to establish the position of an 'Eco champion' in the organization, who should work on projects and, on a corporate level, to define what environmental terms and issues are exactly meant in a particular organization and to establish, manage and communicate quantitative environmental performance indicators. "[p.46.1]

Metrics and social barriers appear in smaller quantities. The absence of adequate metrics and standards has been a key obstacle to the inclusion of material efficiency requirements [68]. Social barriers include informational, cooperation, community and commitment to sustainable development [65].

4. Conclusions

This article aids in understanding the main barriers to CE implantation. As 40% of the articles are case studies, it is clear that in-site searches concerning CE are of interest to researchers. As presented herein, 2016 and 2017 publications represent approximately 65% of the total of papers in our database, indicating that the theme is emerging, and helping to explain why the term "circular economy" is still considered unfamiliar.

Even so, in the outliers' analysis, few papers apply case studies, surveys or other exploratory research methods; most focus on the literature reviews, helping to identify CE gaps, challenges, barriers, initiatives and motivations, supporting the deeper understanding of this emerging topic.

The analyzed studies aided in understanding the similarities and differences between the CE and sustainability, an increasingly explored relation. Among the barriers identified in the literature, technological, policy and regulatory, financial and economic, managerial barriers, performance indicators, customer and Social are most frequent, being the major challenges for the implementation of CE.

Barriers and challenges from the literature analysis that can help the CE implementation obtained from the literature analysis are highlighted, and future studies can focus on the analysis each identified barrier in-depth, including their mitigation and how governmental and non-governmental entities can support this.

This research has limitations related to the use of search engines and the methodological choices concerning the selected search strings, filters and databases. The choice of method may have guided the search result and findings. As a limitation, CE-related terms were not included in the database search. The inclusion of terms such as closed loop and cradle to cradle are suggested for future research. As the article is an overview on CE, specific barriers of different sectors are present, another study limitation. For future research, studies on CE barriers for specific sectors are suggest.

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