

A Review of History, Definition, and Implementation of Circular Economy

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A REVIEW OF HISTORY, DEFINITION, AND IMPLEMENTATION OF CIRCULAR ECONOMY

ABSTRACT

This review aims to build a narrative about the history, definition and implementation of the circular economy on the researchers view, based on the seminal literature reviews conducted so far. The process of research initially uses the snowballing approach, which identifies relevant papers. Once the seminal reviews were identified, we conducted a narrative approach to understand the differences between the researches. Relevant topics will be analyzed: 1) CE History; 2) CE Definition; 3) CE Implementation and 4) CE Indicators. In summary, the results point out the lack of consensus on terminologies and also that the definitions still require development to consolidate its associated practices especially on managerial view. However, the CE is an interdisciplinary field of research, therefore future deeper studies will be necessary, including new authors and points of view.

Keywords: Circular Economy, history, definition and implementation

1 INTRODUCTION

Circular economy has gained importance on the agendas of policymakers and on debates of companies and organizations. The debate of policymakers becomes evident with the European Circular Package and the Chinese Circular Economy Promotion Law. Ellen McArthur Foundation promoted the debate on practitioners area (Geissdoerfer et al., 2017). Therefore, the CE approach has almost exclusively been developed and led by practitioners, and from a scholarly position it is still in their initial stages (Korhonen et al., 2018).

The circular economy has a wide range of reviews published, including authors such as Ghisellini et al. (2016); Geissdoerfer et al. (2017) and Kirchherr et al. (2017). As the circular economy concept is currently a mainstream topic, its true meaning might be altered. If distorted definitions start dominating, CE concept will no longer accomplish its promise of fundamental change (Kirchherr et al., 2017).

Since the study of CE is still in its early stages, the research possibilities are massive. The need to understand what has already been discussed and conceived, utilizing previous assessments of the phenomenon, helps the researcher generate present answers based on previous analysis. Seminal literature reviews raise issues already discussed so we can use their narratives as baseline to our current studies. Thus, our aim in this review is to build a narrative about the history, definition and implementation of the circular economy on the researchers view, based on the seminal literature reviews conducted so far.

This study is structured as follows: Section 2 (Materials and Methods) provides details regarding the method used for literature mining. Section 3 (Results) presents the studies selected for this review and compares this literature review of CE on relevant topics: 1) CE History; 2) CE Definition; 3) CE Implementation and 4) CE Indicators. Finally, Section 4 (Discussion and conclusions) discusses the main results emerged from literature, the limitations of this review and suggests directions for future research.

2 MATERIALS AND METHODS

The process of research initially uses the snowballing approach, which utilizes the reference list of a paper and its citations to identify additional papers. These processes are known as *backward analyzes* and *forward analyzes*, respectively. This approach aims to identify relevant papers that were not discovered through automated search procedure, thus further enriching the particular study (Wohlin, 2014).

Once the seminal reviews were selected, we conducted a narrative approach to understand the differences between the researches. Relevant topics were analyzed: 1) CE History; 2) CE Definition; 3) CE Implementation and 4) CE Indicators.

3 LITERATURE REVIEW

After a deep dive, we drafted a framework to present the main topics addressed in the reviews. This framework is represented in Figure 1.

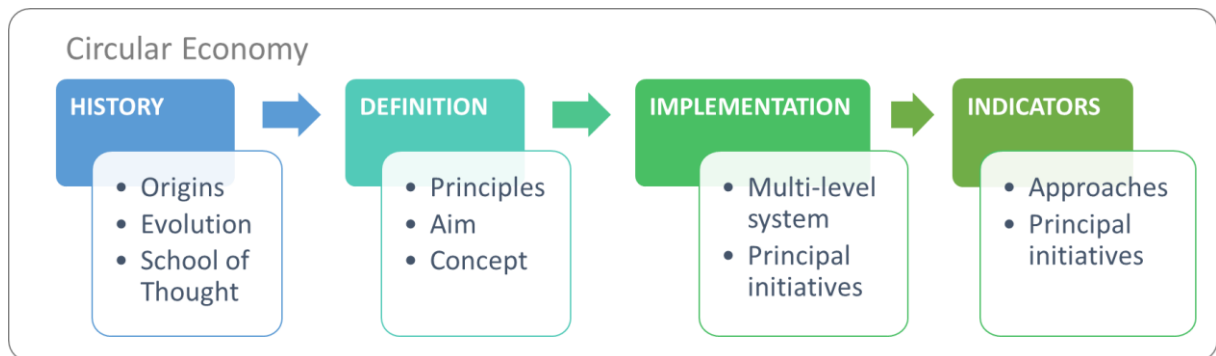


Figure 1: Framework of CE review

3.1 CE HISTORY

This topic is dedicated to retrieving antecedents of the CE's phenomenon, as past aspects could be useful to understanding the present.

3.1.1 CE Origins

The origin of thoughts related to CE can be traced back to 1758, with Quesnay's "Tableau Economique". It addressed issues of cyclical inputs surplus value, while Simmonds, from 1814 to 1897, conducted directed examples at closing material loops (Reike et al., 2018). Over the succeeding decades, the development of General Systems Theory by Von Bertalanffy, between 1950 and 1968, suggests assumptions considered important by the CE, as systemic thinking, that all organisms should be considered systems (Ghisellini et al., 2016).

The ecological economist Boulding, in 1966, pointed out the limitation of natural resources availability for human activities. In addition, he further developed the proposition of a closed system – expressing, thereby, that the economy and the environment must coexist in balance (Geissdoerfer et al., 2017; Ghisellini et al., 2016; Merli et al., 2018). In 1976, the research of Stahel and Reday can be related to CE, due to the fact that they introduced the concept of loop economy (Geissdoerfer et al., 2017).

Environmental economists Pearce and Turner, in their work traced back to 1990, were the first to introduce the concept of circular economic. Considering the reviews we analyzed, Perce and Turner’s particular publication previously mentioned was the most cited of all. They investigated the linear and open-ended characteristics of contemporary economic systems, and they were able to infer how natural resources influence the economy (by providing inputs for production and consumption) and are also portrayed as output disposal of this same economy (Andersen, 2007; Geissdoerfer et al., 2017; Ghisellini et al., 2016; Merli et al., 2018; Reike et al., 2018; Su et al., 2013)

Figure 2 is the timeline that summarizes the CE origins tracked in the papers analyzed.

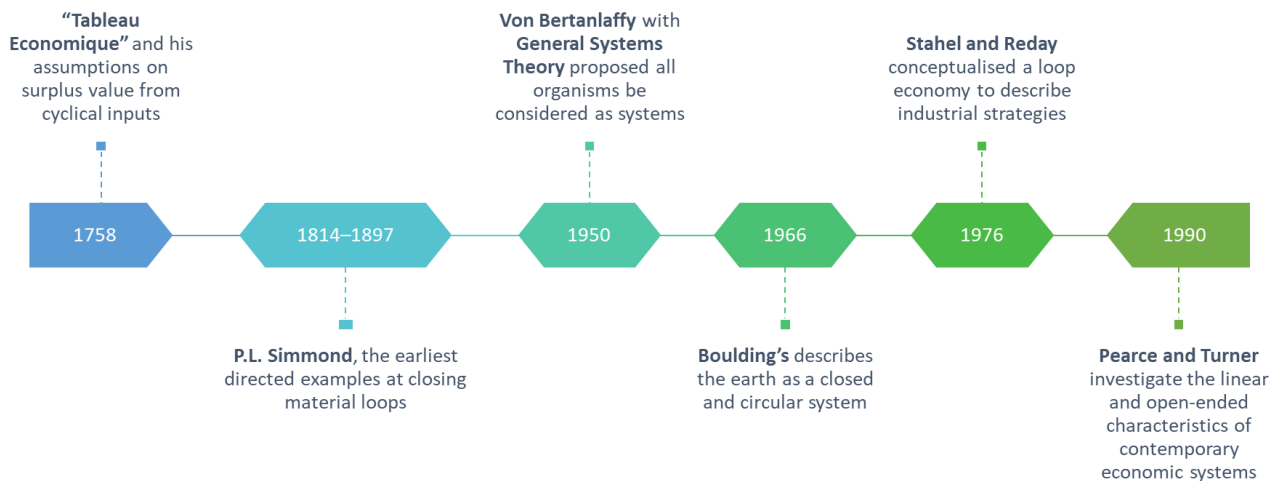


Figure 2: Timeline of the CE origins

The papers that clearly describe the origins were Geissdoerfer et al., (2017); Ghisellini et al., (2016); Merli et al., (2018) and Reike et al., (2018). The most remote origin was identified in the Reike, et al. study.

3.1.2 CE Evolution

Based on history, it is possible to trace an evolutionary process of the circular economy. Prieto-Sandoval et al. (2018) classify the path that society has traveled to reach the CE into three stages: linear economy (18th century to 1970); greener economy (1970 to 1990) and circular economy (1990 to present). In addition to the idea of CE evolution, Reike et al., (2018) named the same period of “greener economy stage” as CE 1.0 and they divided the “circular economy stage” into two phases: CE 2.0 (1990 to 2010) and CE 3.0 (2010 to present). The Figure 3 summarizes the evolution described by the authors.

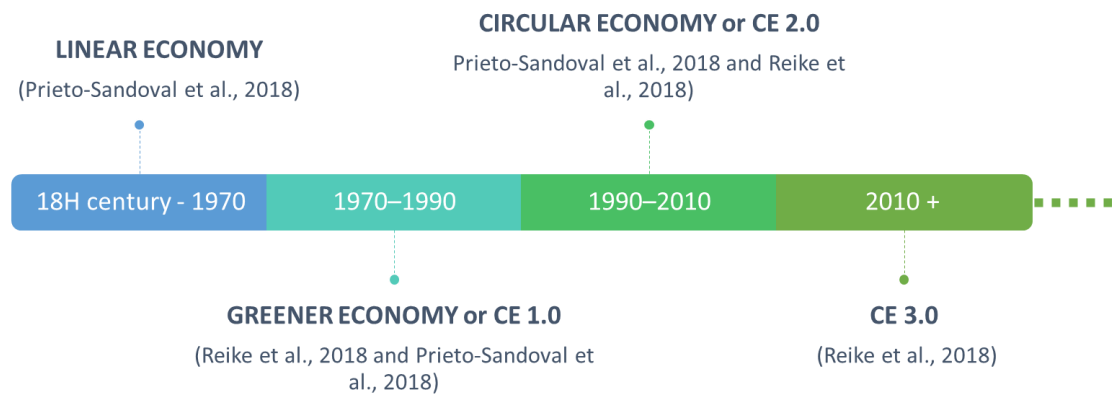


Figure 3: Timeline of the CE Evolution

The *linear economy stage* began with the industrial revolution, when the new dimensions of product diversification and material used emerged, resulting in the over exploitation of resources. After World War II, waste management became problematic and critical to be regulated. As a result, the interest in environment causes increased with the studies of Carson (1962), Boulding (1966), and the publication of the Club of Rome (1972), which modeled the consequences of the rapid growth of the world population and the scenario of limited natural resources. This was decisive in inducing the shift to the next stage. (Prieto-Sandoval et al., 2018; Reike et al., 2018).

The *greener economy or CE 1.0 stage* started with major contributions to thinking of the economy as a system, with the theoretical and practical initiatives of industrial of ecology (Ayres & Kneese, 1969). In this stage, the concept of a greener economy has played a key role in the environmental strategies of governments and institutions. However, governments created regulations and businesses mostly complied with them reactively. Additionally, most of the sustainability actions were weak and with fewer adaptations to people's way of living. (Prieto-Sandoval et al., 2018; Reike et al., 2018)

Finally, there is the *circular economy or CE 2.0 stage*. Although scholars wrote about the concept of CE, as shown in section “CE Origins”, it is only in this phase that CE slowly gains notoriety. It began with the study of Pearce and Turner (1990), which employed the term “circular economy” to explain the environmental recognition in economic flows by closing industrial loops (Prieto-Sandoval et al., 2018; Reike et al., 2018). Only in 2006, with the the Chinese policy, boundaries started to be formalized and defined. CE’s identity started to become notorious and the academic research acknowledged the term CE (Ghisellini et al., 2016).

Reike et al., (2018) unfolded CE’s initial phase to a new stage: *CE 3.0*. In this phase, the CE improved its decoupling growth potential in regards to resource usage (Reike et al., 2018). The new concepts and principles brought in this stage by CE studies – such as collaborative consumption, sharing and performance economy – have begun to enrich the CE framework (Ghisellini et al., 2016). The CE could, therefore, be viewed as an operationalization for businesses to implement the concept of sustainability, with studies engaged on comparing the two concepts (e.g Geissdoerfer et al., 2017).

3.1.3 Schools of thought of CE

An extensive analysis of literature of CE reveal that the concept is rooted in very diverse theoretical backgrounds (Ghisellini et al., 2016). Probably, its capacity to connect strategies from different schools of thought is one cause of CE's expansion (Matus et al., 2012). **Table 1** represents the school of thought of CE found on literature review. We classify it from most to less cited.

Table 1
School of thought of CE

Schools of thought of CE	References that link with CE	Schools of thought of CE	References that link with CE
Industrial Ecology	(Ghisellini et al., 2016); (Reike et al., 2018); (Geissdoerfer et al., 2017); (Merli et al., 2018); (Kalmykova et al., 2018) and (Korhonen et al., 2018).	Industrial Symbiosis	(Merli et al., 2018) and (Korhonen et al., 2018).
Cradle to cradle	(Ghisellini et al., 2016); (Geissdoerfer et al., 2017); (Suárez-Eiroa et al., 2019); (Merli et al., 2018); (Kalmykova et al., 2018) and (Korhonen et al., 2018).	Laws of ecology	(Geissdoerfer et al., 2017), (Homrich et al., 2018)
Looped and performance economy	(Ghisellini et al., 2016); (Reike et al., 2018); (Geissdoerfer et al., 2017); (Merli et al., 2018); (Kalmykova et al., 2018) and (Korhonen et al., 2018); (Merli et al., 2018); (Kalmykova et al., 2018) and (Korhonen et al., 2018).	Zero waste	(Korhonen et al., 2018), (Ghisellini et al., 2016), (Suárez-Eiroa et al., 2019), (Homrich et al., 2018)
Regenerative design	(Ghisellini et al., 2016); (Merli et al., 2018) and (Geissdoerfer et al., 2017).	Bio-economy	(Merli et al., 2018)
Biomimicry	(Ghisellini et al., 2016); (Korhonen et al., 2018) and (Geissdoerfer et al., 2017).	Spaceman economy	(Kalmykova et al., 2018)
Eco-industrial parks	(Merli et al., 2018); (Reike et al., 2018) and (Korhonen et al., 2018).	Limits to growth	(Kalmykova et al., 2018)
Blue economy	(Ghisellini et al., 2016) and (Geissdoerfer et al., 2017).	Industrial eco-systems	(Korhonen et al., 2018).
Steady-state economy	(Kalmykova et al., 2018) and (Ghisellini et al., 2016).	Eco-efficiency	(Korhonen et al., 2018).
Cleaner production	(Suárez-Eiroa et al., 2019) and (Korhonen et al., 2018).	Resilience of social-ecological systems	(Korhonen et al., 2018).
Product-service systems	(Merli et al., 2018) and (Korhonen et al., 2018).	Natural capitalism	(Korhonen et al., 2018), (Homrich et al., 2018)

Industrial Ecology, cradle to cradle alongside with looped and performance economy are the most cited schools of thought related to CE. From the beginning, CE was a concept studied in connection with industrial ecology: it is possible to understand this relevance on the citations. As a result, the variety of scientific disciplines and semi-scientific concepts used to understand CE is notable (Korhonen et al., 2018). Nevertheless, precisely because of this large spectrum

of principles and proposals, the definition of CE has been formulated in the last decades and it is still not a consolidated concept (Merli et al., 2018).

3.2 CE DEFINITION

The literature reveals the dynamic evolution of CE over time and its main theoretical perspectives and research domains. It remains unclear what the authors define as circular economy. Would it be a paradigm, a strategy, a tool? This is what we will try to understand in this topic. To do this, we divided the definition into principles, aims and the concepts brought by the authors.

3.2.1 CE Principles

While the 3R-imperatives of ‘reduce, reuse and recycle’ mold accepted principles of CE, there has recently been emphasis on more hierarchies such as ‘redesign’, ‘refurbish’, ‘repurpose’. Other contrasting numbers of R-imperatives, such as 3Rs, 4Rs, 6Rs or 10Rs, can be found in the literature with different attributes and meanings (Reike et al., 2018). The various R-imperatives are the ‘how-to’ of CE and thus one of its core principles (Kirchherr et al., 2017). In an effort to provide a better idea of these CE principles, Reike et al. (2018) proposed the term resource value retention options (ROs). ROs focus on the technical flows, setting aside services and the biological flows. In this way, the environmental design strategies could act on this as standards for designing products and services which can be reintroduced in the system (Prieto-Sandoval et al., 2018).

Suárez-Eiroa et al. (2019) developed the transversal elements as principles of CE, assuming the role of design and education to reaching goals of CE under the sustainable development framework. In their work, seven operational principles are proposed: “*i) Adjusting inputs (...), ii) adjusting outputs (...), iii) closing the system, iv) maintaining the value of resources (...), v) reducing the system's size, vi) designing for CE, and vii) educating for CE*” (Suárez-Eiroa et al., 2019, pg. 960). They assume that establishing of principles, which arise from theoretical approach of CE, support better practical strategies of implementation.

3.2.2 CE Aim

Analyzing CE under the sustainable development framework could be a useful objective to optimize efforts of policy-makers, organizations and the general society. Thus, “*the aim of the CE under the sustainable development framework should be to decouple economic development from the utilization of finite resources (...)*” (Suárez-Eiroa et al., 2019, pg. 956). Complementing this perspective, Geissdoerfer et al., (2017) identified in their study the most evident similarities and differences between sustainability and CE, and they concluded that the CE is viewed as a condition for sustainability. This was also noticed by Kirchherr et al., (2017): after analyzing 114 concepts of CE, they found links of the CE concept to sustainable development. And they considered that CE “*(...) aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations.*”

On the other hand, the social dimensions have received less interest compared to the economic field, and the environmental benefits have turned into side-effects of economic choices (Ghisellini et al., 2016). Some social benefits derive from implementing environmental objectives, but issues such as equity, gender equality, access to education and others depend on

the social and political decisions. This does not exempt social goals for CE (Prieto-Sandoval et al., 2018).

3.2.3 CE Concept

As noted, CE is presented as a field of study employed by different schools of thought. This feature increases the difficulty to consolidated a singular definition. We identified the authors who developed a concept to the CE on their studies. The concepts are listed in Table 2, from the most recent to the least recent.

Table 2
CE concepts

Author	Year	Concept
Suárez-Eiroa et al. (2019, pg. 958)	2019	Circular economy is a regenerative production- consumption system (...)
Homrich et al. (2018, pg. 534)	2018	CE is a strategy that emerges to oppose the traditional open-ended system (...)
Prieto-Sandoval et al., (2018, pg. 613)	2018	Defined circular economy as an economic system that represents a change of paradigm in the way that human society is interrelated with nature (...)
Kirchherr et al. (2017, p. 224)	2017	A circular economy describes an economic system that is based on business models (...)
Geissdoerfer et al. (2017, p. 766)	2017	A regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops. (...)
Ghisellini et al. (2016, p. 16)	2016	CE as a new economic model similar to growth, degrowth and steady state, with focus placed on the trend of economy's size and performance. (...)

There is no consensus among the authors: some studies characterize CE as a model or economic system, others as a strategy or as a regenerative system – they do not agree on its definition. According to Gallie (1956), a concept becomes essentially contested (ECC) if there is an agreement on the principles and aims but disagreements on how to define it. Korhonen et al., (2018) suggest that CE can fit this concept of essentially contested.

3.3 CE IMPLEMENTATION

CE implementation studies follow a multi-level approach of action: i) macro level, which aims on adjusting industrial composition and structure of the entire economy; ii) meso level, which focuses on eco-industrial parks as systems and industrial symbiosis and iii) micro level, which considers products, individual enterprises and what needs to be done to increase their circularity (Ghisellini et al., 2016; Kirchherr et al., 2017; Merli et al., 2018). To increase essential changes, implementing CE must be simultaneously at the micro, meso and macro systems, enabling a holistic and systemic approach (Khitous et al., 2020; Kirchherr et al., 2017).

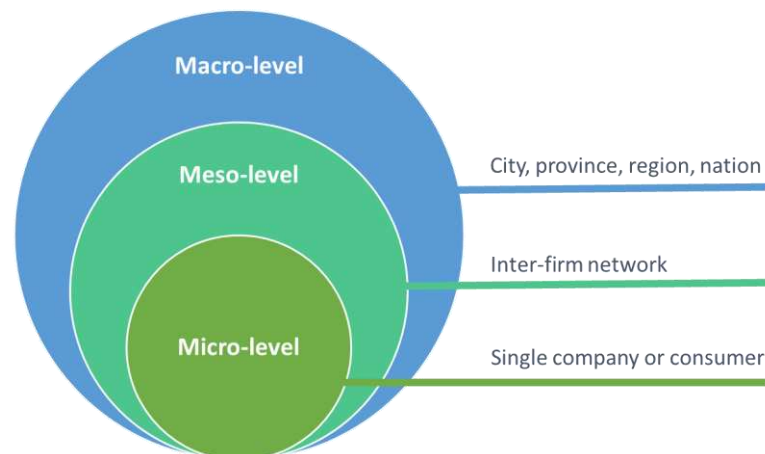


Figure 4: Multi-level framework

In the literature review we found some examples of circular economy implementation initiatives: to illustrate, Kalmykova et al. (2018) developed CE Implementation database, which includes over 100 case studies. Khitous et al., (2020) identify that the level of analysis varies; until 2014, implementation researches were focused on the meso and macro levels in China, while recent research investigates specific industries (e.g., chemical, manufacturing) into micro and macro levels.

At macro level, the legislation is the central instrument of action (Feng & Yan, 2007). Moreover, concepts such as urban symbiosis, regional eco-industrial networks, eco-cities, collaborative consumption models, innovative waste management (among others) can be considered part of this level of implementation (Ghisellini et al., 2016). In their review, Ghisellini et al., (2016) presented some initiatives of this other types of implementation in macro level (e.g. Japanese and Chinese eco-cities, zero waste index and car sharing).

The publications of cases are mainly concentrated in China and Europe, with focusing on some production patterns, sectors and material. China was the first country to incorporate CE as a central objective of the plans for National Economic and Social Development (Su et al., 2013). At the European Community level, CE emerged later as a result of the legislation of the Circular Economy Package (Masi et al., 2017). Other countries adopted CE as a guiding principle with implementation in different ways (George et al., 2015).

At meso level the main implementations mentioned were the Kalundborg Park in Denmark and the industrial parks in China (Ghisellini et al., 2016; Kalmykova et al., 2018). A network does not need to be within the ‘park boundaries’ for it to be considered as industrial symbiosis (Suárez-Eiroa et al., 2019). Notwithstanding, the economic feasibility is a decisive factor in the adoption of symbiosis mechanisms and achievement of environmental improvements (Ghisellini et al., 2016).

The cases of micro level emphasize the role of Product-Service Systems, Circular Design, Circular Business Models (CBMs) and sustainable supply chain strategies (Khitous et al., 2020). The Ellen MacArthur Foundation has, in the context of an emerging research field, a critical role in providing cases of CE practice implementations between firms. This foundation is seen as a reference point in the CE implementation (Merli et al., 2018). Ghisellini et al., (2016) illustrated some initiatives, such as eco-design and cleaner production (e.g. for some

European countries, U.S.A, Canada, Japan and China); CE in the consumption sector (e.g. case of EU Ecolabel) and the CE in waste management (e.g. scavengers).

3.4 CE INDICATORS

Merli et al., (2018) claims scholars focused their attention on circular indicators for macro, meso and micro levels (e.g. Banait, 2016; Elia et al., 2016; Geng et al., 2012; Griffiths and Cayzer, 2016; Saidani et al., 2017). Other publications proposed indicators to measure CE performance (e.g. Herva et al., 2011; Park and Chertow, 2014; Di Maio and Rem, 2015; Ellen MacArthur Foundation, 2015; Elia et al., 2017) according to Suárez-Eiroa et al., (2019).

Currently, the monitoring of the CE implementation is underdeveloped. The problem of establishing metrics and methodologies for measuring the progress towards circularity has three main approaches: Material flow analysis (MFA); Emergy analysis; Input-Output analysis (Kalmykova et al., 2018). Merli et al., (2018) cite the Life Cycle Assessment (LCA) methods and the Material Flow Cost Analysis (MFCA) but, in general, the MFA method, which has been established in Japan and Europe, is the most studied and used. (Kalmykova et al., 2018). Despite this fact, the development of a specific indicators' set for CE is still at an early stage for the micro level of analysis (Merli et al., 2018)

4 DISCUSSION AND CONSIDERATIONS

The reviews agree that the Circular Economy (CE) is receiving increasing attention worldwide among scholars, politicians and practitioners (Geissdoerfer et al., 2017; Ghisellini et al., 2016; Homrich et al., 2018; Khitous et al., 2020; Kirchherr et al., 2017; Korhonen et al., 2018; Merli et al., 2018; Prieto-Sandoval et al., 2018; Reike et al., 2018; Suárez-Eiroa et al., 2019). The growing importance of the circular economy concept has encouraged scholars to propose different ways to understand it. The authors make an effort to propose a consensus view of the circular economy framework (Ghisellini et al., 2016; Homrich et al., 2018; Kalmykova et al., 2018; Merli et al., 2018; Reike et al., 2018)

In summary, the results present some agreement in the origins and evolution of CE. The schools of thought come from different epistemological fields: this reflects on different approaches and multiple fields of application. These facts suggest different interpretations according to the individual analyzing the CE, which reinforces the lack of consensus on the definition: its principles, its aims and its concepts (Geissdoerfer et al., 2017; Homrich et al., 2018; Khitous et al., 2020; Kirchherr et al., 2017; Korhonen et al., 2018; Prieto-Sandoval et al., 2018; Reike et al., 2018). CE studies still require development to establish its associated practices (implementation and indicators). The practitioners are more mature in this phase than scholars. In general, the analysis of scholars are performed in separate levels and it is important to consider systemic interdependencies between levels to help the transition (Khitous et al., 2020). However, CE is highlighted as a developing concept (Merli et al., 2018) and the CE transition has just started. (Ghisellini et al., 2016). The academy must embrace a more active role in attaining consensus when conceptualizing the CE to assist the parties, contributing to an increased in practice (Reike et al., 2018). Thus, the interdisciplinary characteristic of the CE offers good prospects for gradual improvement of the present production and consumption models (Merli et al., 2018).

Finally, the proposal of this work is to enlighten CE discussions from the perspective of seminal review publications. There are some limitations for this study, such as the research process of seminal articles. We only selected articles from specific journals: this can increase the research

bias according to the point of view of the Journals' areas of research. The CE, as we have seen, is an interdisciplinary field of research, therefore deeper study will be necessary in the future, adding new authors and points of view. Although the current review is essential to build a structure of the most cited discussions on CE, there might be a research bias due to the lack of areas exploring this subject, such as managerial perspectives. This is the reason why Khitous et al. (2020) incentive scholars from the Business and Economics fields to investigate the viability and profitability of CE strategies.

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